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PROCEEDINGS OF THE CONFERENCE

COMMON GROUND
DESIGN RESEARCH SOCIETY
INTERNATIONAL CONFERENCE 2002

HELD 5 -7 SEPTEMBER 2002, LONDON, UK

Edited by
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Staffordshire University, UK

and

John Shackleton PhD
Brunel University, UK
Common Ground
Design Research Society International Conference 2002

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John Shackleton, Brunel University, UK

Organised (on behalf of DRS) by
Advanced Research Institute, School of Art & Design, Staffordshire University, UK
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Supported by:
Brunel University
Design Issues
Design Journal
Design Studies
European Academy of Design
International Journal of Design and Innovation Research
Japanese Society for the Science of Design
Journal of Design Sciences and Technology
Korean Society of Design Studies
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Introduction

The Design Research Society has organised many national and international conferences and other events since its inception in 1967. These have included one day events around a closely focused theme, as well as larger events addressing broader topics such as design management. Several of these past events have been landmark occasions.

DRS has also been active in helping other learned bodies promote conferences around the world, by measures ranging from tacit support through to direct financing, using the Society’s digital means for advertising events, and a practical approach in assisting with reviewing of papers and giving advice as part of international programme committees.

Following discussions with colleagues in the Asian societies - who host the very successful Asian Design Conferences - DRS decided to organise an international conference with the intention of showcasing excellence in broad based research across all areas of design and from all parts of the world. This event is held every two years. The 2002 conference is being staged in the UK, but thereafter it is expected that it will be hosted in several other countries. The asian design conferences will no doubt continue in alternate years. So - annually there is now a world conference to celebrate the best in international research in design, held somewhere in the world.

The theme for this year's DRS conference is 'Common Ground'. The aim was to bring together many of the sub disciplines and sub-groups of the design research community - to present current work, to explore areas of common interest, to connect, to argue, to integrate, and to celebrate both the commonality and the diversity of our shared interests and strengths. The larger purpose is to take a significant step forward and endorse the new maturity of our international, interdisciplinary community.

In response to the call for papers, we received over three times more proposals than could be presented at the conference. There were therefore many proposals that were otherwise acceptable but had to be turned down, and consequently a number of disappointed authors.

The response speaks well of the health of research in design, and the enthusiasm of researchers both in the academy and in industry. Especially, this conference has clearly struck a chord with the international design research community. It is hoped that future events might be organised to accommodate a larger number of presenters.

The conference has been streamed into a number of parallel sessions with distinct themes. The sessions cover the deep subject matter of several design domains. Some papers have particularly addressed the theme of 'common ground' whereas others have been chosen for a particular viewpoint, or to add to discussion of the issues. All have been chosen carefully to attempt to provide some new and reliable knowledge for our field. Some will challenge deep seated views. Many papers do not necessarily reflect the editors' views!
Many people around the world have co-operated in planning this conference. Our thanks go first to members of the local organising committee - Nigel, Chris, Deana, Victor, Alec, Necdet and Steve - and the DRS Council. They have all been constantly supportive, and have helped us through many difficulties over some two years of planning.

Thanks equally to the international review committee. Several have freely given advice and support at every stage in the conference’s development. All have been involved in reviewing proposals for papers - often at short notice - and, where necessary, have provided sometimes copious explanatory notes and advice on improving the papers, for both successful and unsuccessful authors.

Thanks to Linda Marshall who, as the professional organiser, has been a backbone of support for the co-chairs in organisational and financial planning, and in interacting with authors and delegates.

Thanks to all the session chairs, for taking on this task and for managing their sessions.

Thanks to the authors, who kept their sense of humour throughout the technical difficulties in transmission of their papers to us, and following our occasional harsh judgements on their hard work.

Thanks also to many colleagues in the School of Art and Design at Staffordshire University and the Department of Design at Brunel University. We appreciate the efforts of the editing team, Anna, Jaqui, and Caroline, and Uzma for the CD-ROM.

These proceedings have been compiled for delegates as a handbook to gain an overview and to choose from the different themes, sessions and paper presentations. The book provides the necessary overview and help for delegates attending the conference, and the enclosed CD-ROM has the full papers together with search facilities.

The CD-ROM is intended to be a no-frills approach: there are no ‘designerly’ gimmicks. You will find clarity, freeform searching of contents, and the contents lists grouped in several ways to make location of papers easier. It may be viewed on screen or printed to paper. Please see the instructions on the CD-ROM for details.

We hope you enjoy the conference and find these proceedings a valuable resource in the years to come.

David Durling, John Shackleton
Co-Chairs
Keynote speakers

Three keynote speakers were invited to address issues of concern to themselves and the conference audience.

These topics ranged across theory, practice and research, and cultural aspects of design.
"The uses of theory in design"

As we explore the new common ground in design research, it is important to reflect on the long-term goals of our work and the diverse ways in which our work may be used to advance the understanding and practice of design. More than most fields, design depends on an intimate relationship between theory and practice. This paper will address how theory consolidates existing design knowledge and how it may profitably extend our understanding into new areas and forms of practice.

Biographical sketch

Because I am invited to many venues around the world to discuss design, design education, and design research, I would like to provide some biographical information that may help to explain my goals and the perspective that I bring to the field. Personal information of this kind has little place in the substantive discussions of our field, and it certainly cannot substitute for the ideas and methods that I explore in my work. But the environment within which we are formed does bear some relationship to our work, so I share this much about my background.

I received my A.B. and Ph.D. from the University of Chicago, where I studied with distinguished teachers, each of whom strongly influenced different aspects of my thought and work: philosopher Richard McKeon, literary critic Wayne C. Booth, art historian Joshua C. Taylor, and philosopher of education Joseph J. Schwab. They were important intellectuals in the twentieth century with great accomplishment and influence in the United States and abroad, and I owe them a great debt for their mentorship and friendship. My degree is from one of the uniquely Chicago interdisciplinary committees, the Committee on the Analysis of Ideas and the Study of Methods. Within this Committee, the focus of my studies was philosophy and rhetoric.

My work was formed in the tradition of American pragmatic philosophy, particularly as shaped by John Dewey. Under the influence of my teachers, I have explored the philosophy of pragmatism, participating in the development of what is sometimes known as "radical systematic pluralism." My concern for pluralism is "radical" in the sense that I seek principles to explain the diversity of views on design or any other subject in our culture, rather than espouse a vague, benign tolerance of other views that amounts to being dismissive. The pluralism I investigate is "systematic" in the sense that I seek reasonable patterns in what unites and divides individuals in their beliefs and actions. I have come to regard such pluralism as the "ecology of culture," and my work could be regarded, in one sense, as part of the philosophy of culture.

Since the early 1980s, I have focused my work in the field of design because I came to recognize that the creation, planning, and realization of the human-made world has been surprisingly, almost tragically, neglected in our culture. We have explored nature through the natural and mathematical sciences; we have explored individual and collective behavior through history and the social sciences; and we have explored literature and the fine arts through history, criticism, and theory. But we have neglected the domain of practical human production the domain that, in fact, affects most of what we experience in daily life and often determines what we can and cannot do in exploring the other aspects of culture that I have just mentioned. Our understanding of design and the human-made world remains only a whisper. A surprisingly small group of individuals in the twentieth century has taken up the challenge of consciously designing the human-made world. And a much smaller group has attempted to consciously understand the nature of design, the work of practicing designers, and the problems of educating new designers. This situation is changing, but there is a long way to go before design is commonly regarded as more than a trivial embellishment of daily life.
Since entering the field, my work has been directed towards establishing design as a field of theory and practice. This has involved work on three closely related problems. The first problem is design knowledge and the foundations of the field of design. My objective has been to help build the field through several activities: my own research; organizing and participating in conferences that draw together the community of those who practice and reflect on design; and serving as an editor of a journal that provides an international forum for reflection on design by individuals who hold sharply different ideas about design and design practice. Currently, I also serve as President of the Design Research Society, an international learned society founded in the United Kingdom and supporting a multi-disciplinary network of researchers in thirty-five countries around the world. The second problem is design education. My objective has been to influence the direction of design education in ways that strengthen young professional designers who must practice in new circumstances that are far different from the circumstances in which most of our schools were formed. At the same time, my objective has also been to prepare a new generation of individuals who can contribute effectively to serious reflection on design in what many of my colleagues and I now call "design studies." The third problem is cultural understanding. My objective has been to explore the cultural significance of design, with particular attention to pluralism and the international dimension of design thinking, where cultural differences are vivid and strongly influence the place of design in daily life.

In the course of my work I have given special attention to communication design and industrial design. However, I am now deeply involved in the development of new areas of design thinking and design practice. The focus of this work is human-centered interaction design, which I regard as a fundamental change in the way design is practiced and understood in the contemporary world. Interaction design is often associated with design for digital products, but it is much more. Interaction design is fundamentally concerned with how people relate to other people, sometimes through the mediating influence of digital products but more often through other kinds of products in the analog world. To me, interaction design is more than a new branch of professional practice. It is a foundational critique of design and the role of design in culture. I have developed a variety of concepts that are relevant to interaction design, including a new concept of the nature of products that embraces the traditional products of graphic and industrial design but also includes services and structured activities as well as human systems, organizations, and environments. I often employ concepts and methods drawn from the art of rhetoric, as that intellectual art has expanded from a traditional art of words to a central art in the philosophy of culture. In essence, I am interested in how products make arguments about how we should lead our lives. There are, of course, many other ideas in my work, but these are some of the most important. The central motivation of my work is a belief that the liberal and humanizing arts - the arts by which we connect and integrate knowledge from many specialized subject matters, preserving continuity with the past yet adapting our understanding to new problems and circumstances - are undergoing a revolutionary transformation in world culture. I believe that design is one of the central places where a new "Battle of the Books" is taking place between the old learning and the new learning. Through our understanding of design we will contribute to the discovery of the new liberal arts of technological culture, helping to form a new circle of learning that will shape world culture and the possibilities of human experience in the twenty-first century.

I am certain there are many others who have more interesting personal accounts to give, and perhaps with more relevance to the issues we hope to address in the field of design. However, this is the perspective I bring, shaped by education, work as an editor of Design Issues, service as Head of a school of design in a major research university in the United States, and my own research, writing, and conference work, as well as consulting work with governmental organizations and industry. What I believe is significant in this account is not my own life but how the cultural circumstances of my environment have affected me, offered opportunities to grow and explore, and allowed me to find a place in the field of design. Before anything else, design research begins in a personal story and in a personal desire to understand and act responsibly in the world.

Richard Buchanan
Carnegie Mellon University
Pittsburgh, Pennsylvania
USA
"Worlds apart: An international agenda for design"

Biographical sketch
Peter Butenschön is currently president of the International Congress of Societies of Industrial Design (ICSID) and has interests in practice and research.
"Design and Culture Revisited"

Biographical sketch
Penny Sparke is the Dean of the Faculty of Art, Design & Music and Professor of Design History. She studied French Literature at the University of Sussex from 1967 to 1971 and undertook research for her PhD at the Polytechnic of Brighton between 1972 and 1975. Her thesis was on the subject of British Pop Design in the 1960s. Since 1975 she has taught the History of Design to undergraduate and postgraduate students at Brighton Polytechnic and, from 1981 to 1999, at the Royal College of Art. She has also, since that time, participated in conferences, broadcast and published in the field of Design History in the late nineteenth and twentieth centuries. Her key publications include An Introduction to Design and Culture in the Twentieth Century (1986); Design in Context (1987) Electrical Appliances (1988); Italian Design from 1860 to the Present (1989); Japanese Design (1989); The Plastic Age. From Modernity to Post-Modernity (ed) (1990); and As Long as it's Pink: The Sexual Politics of Taste (1995).
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Teaching the writing and role of specifications via a structured teardown process

T. Abe Akita Keizai-Houka University, Akita, Japan
P. Starr University of Minnesota, USA

Abstract

The research objective is to develop teaching materials for learning engineering design at the college-level where students are required to have basic engineering knowledge, but where no design experience is needed. The method has the following features: Students realize that communicating with a design specification is a core part of design tasks; that a hands-on exercise is crucial to understanding the product’s features and functions; that to design a product is not only to create a new product, but also to apply existing ideas; that by taking apart a real product, they can easily realize the physical and mechanical principles imbedded therein; that to learn design principles is not just to memorize them but to experience them. The method structures and interprets the take-apart activities from the perspective of the design process steps, with special emphasis on the writing of specifications at increasing levels of detail. The take apart activity assists in identifying technical descriptors or design variables, which are then given values, ranges or qualities that become specifications. It employs a common consumer product of which many variations are available.
Teaching the writing and role of specifications via a structured teardown process

Introduction
Take-apart activities are becoming an accepted part of introductory design-oriented courses (Niku 1995) (Eggert 1996) (Sakamoto, Kusukawa and Jorgensen 1999) (Otto and wood 2001:197-257) in Engineering. Such exercises provide students with hands-on experience with how things work and how things are made. They illustrate how selected physical principles are employed in consumer products and can motivate the application of an analysis method to describe phenomena such as wear, fatigue, force amplification, motion, transfer, etc. Justification is sometimes related to the idea of Experiential Learning (Kolb 1984:39-60) but it is also rooted in the realization that not too many years ago, students entered engineering schools with much informal knowledge of how things were made, gleaned from tinkering with consumer products such as radios, televisions and automobiles. This informal knowledge provided a common hands-on backdrop that could be referenced as meaningful examples in coursework and laboratories, but it is largely absent in the undergraduate student of today. So, the take-apart activities fill a need of providing hands-on experience with tools, functions, materials and assembly methods, and it is assumed that such experience assists in developing design skills.

However, in the literature, there is rarely an explicit connection between take-apart activities and the Design Process. It appears that the attitude is that “it cannot hurt, but we are not sure how it helps”. In this work, the Design Process is used as a format to structure and interpret take-apart activities, with special emphasis on the Design Process step of creating specifications.

1. Identify Needs
2. Define Specifications
3. Generate Alternate Solutions
4. Evaluate and Select an Alternative
5. Detail the Selected Alternative
6. Build and Test

Figure 1. Typical Design Process

Figure 1 shows a representative Design Process which is used as the format for the take-apart activities, showing a sequence of six steps that are typical in a broad range of literature and have stood the test of time (Asimov 1963) (Ulrich and Eppinger 1995: 14-32). The forthcoming ideas and methods are not dependent on this particular diagram, but do require a process where there is a statement of needs, creation of specifications, generation of alternatives, a selection and a manufacturing step. For beginners, the process is comforting, showing the overwhelming task of “Design” as a sequence of steps that transforms a need, expressed in words, to a physical product that can meet the need. Each step is described with a verb-noun task format that gives direction as to what to do and what to produce as the outcome. Certain skills are necessary to perform each step, and in a typical curriculum with a capstone design project course, it is presumed or hoped that various prerequisite courses provide some of the needed skills such as:

Course ----------------------Design Step
Materials Science --------------- Create Concepts, Detail the Design
CAD-------------------------- Detail the Design
Description of Physical Processes--- Create Concepts
Whether or not such courses actually contribute to the skills is an ongoing discussion in our field, but here we simply point out that none of the usual pre-capstone courses contributes to the step of Defining Specifications. The capstone course may be the first time a student is asked to create specifications.

categories are suggested such as Figure 2 (Hurst 1999:16-31), and the QFD (Ullman 1992: 112-133), Quality Function Deployment method, which provides an effective format for naming the specification, identifying their relationships to customer needs, prioritizing, and setting target values. The problem for student designers is that the QFD procedure requires communication between those who express the needs in non-technical terms and those who will design, manufacture and pay for the manufacture of the proposed product. A design team that has expertise in the relevant technologies and their manufacture and costing is not comprised of beginners. When students in a capstone project write specifications, they may be coached through parts of the QFD process, but it is generally seen as an isolated exercise, to be completed and handed in before one can start the “interesting” part of designing, and never referred to again unless specifically required.

The central role of the specifications in guiding the development of concepts, in screening the concepts to identify a promising alternative and in setting performance standards for testing is not appreciated. Part of the difficulty is that we learn by repetition: it is unrealistic to expect students to develop skills in utilizing the Design Process by being coached through it once in a capstone course. The method described herein provides three opportunities to reinforce the connection between specifications and product features.

We hypothesize that the product to be taken apart is the result of the Design Process of Figure 1, for which the product is the outcome of the manufacturing step, and the sales material, which accompanies the product and describes its features, expressing some of the needs. That is, we presume to see the outcome of the first and last steps of the Design Process. We offer a method in which the take apart activity is imbedded in a series of exercises, through which students develop plausible specifications for the product. The method consists of six phases and is summarized in figure 3. Each phase has specific Tasks for the students to perform and Outcomes to be produced. There are also structured forms for the students to report selected outcomes. The take-apart activity is one of the phases. Some outcomes correspond to Design Process steps, including a Bill of Materials (BOM) and some detailed sketches, which are plausible outcomes of the Detail the Design step, but other outcomes include identifying materials, loads and stresses, which would be part of the Evaluate and Select outcome. Less obvious outcomes are descriptions of function and structure and their relation to the BOM. The accompanying sales materials have phrases such as “easy to use”, which are textbook examples of need statements, and serve to initiate the creation of specifications.
The following sections will describe the phases in more detail, including numbering the outcomes. Figure 3 shows how the numbered outcomes of each phase contribute to the development of specifications, which are categorized as in Figure 2 as PR (Performance Requirements), MR (Manufacturing Requirements), OR (Operating Requirements) and OT (Others). As students proceed through the phases, more detail is added to the specifications by identifying functions, metrics, units and values that are plausible technical descriptors (design variables) of the product features that are described on the accompanying sales materials. The phases, Tasks, and Outcomes of figure 3 have evolved through several take-apart experiments with small groups of students using familiar consumer products such as a stapler, can-opener, electrical drill. These products have a primary function, which students have experienced as customers, and the products have variations such as the “lightweight” or “compact” versions, which are examined in the Benchmarking phase.

The first experiment (Abe 1996) was to examine the idea of “Translation” that is to convert customers needs to an engineering requirements. It is considered to be core tasks of designing. An
experienced designer can write design specification easily. The translation tasks then are organized as a systematical procedure for design education purpose. It initially had three phases, which corresponds to the Phase II to IV in Figure 3, and the exercise in Phase IV were arranged stepwise with more detailed examples in 1997(Abe 1997), and the version was tested for other product (Stapler) (Abe 1998). Some improvements have done to the previous procedures in 1999 (Abe 1999), and was tested using an electrical drill in 2000 (Abe 2000). Figure 3 shows the latest version, which introduced two phases: learning specification and redesign phases, and was tested in 2001. The main features of the current version are to put more effort to communicate with specifications, and to add a redesign phase to confirm the outcomes of studying all phases.

The following sections describe each phase in more detail followed by some remarks on outcomes produced by students in the most recent experiments.

Phases, Tasks and Outcomes of the Design Structured Teardown Process

Initial Specification Phase
Students are introduced to the Design Process of figure 1 where the central role of specifications in guiding the development of concepts, in the evaluation and selection of a concept and in evaluating performance is introduced. The categories of specifications in figure 2 are discussed, and the background required to effectively contribute to each requirement is described.

It is pointed out that the limited background of the students will necessarily limit the scope of the specifications to a subset of figure 2. Students are shown a summary of results of Phases I-IV from a previous group of students on a different product, where it is emphasized how the specifications evolved as tasks were carried out.

The Tasks are: 1) Discuss the role of the specifications in the Design Process of figure 1; 2) Identify the categories and typical phrasing of selected specifications of figure 2; 3) Study an example which shows the outcomes of the first four phases applied to a different product.

The Outcomes are: 1) Narration of role of design specification in the Design Process; and 2) Rephrasing the specifications from the example.

Observations and Practice Phase
Students are given the product and accompanying marketing material and create an initial version of the specifications by interpreting the marketing material as “needs” that the product meets, by examining how the product achieves its overall function and by operating the product. Comments are expected on appearance, ease of use, comfort, standards that apply, weight, storage, possible weaknesses, and a description of how the overall function is achieved.

The Tasks are: 1) Identify product features and categorize according to the relevant items of figure 2; 2) Sketch and describe the mechanism(s) that provide its primary function; 3) Operate the product and comment on performance and weaknesses.

The Outcomes are: 1) Initial specifications; 2) Narration of product use; 3) Explanation of how primary function is achieved; and 4) Possible weaknesses.

Tear Down Phase
The aim of this phase is to discover how the individual components of the product combine to provide its overall function and how they form the basis of detailed specifications. A teardown form provides a means of recording whenever components are separated and includes a part name
and role, a dimensioned sketch, material description, comments on the method of manufacture and the teardown sequence.

The Tasks are: 1) Propose a sequence of teardown steps; 2) Take the product apart following the steps; and 3) Record all information on the teardown form.

The Outcomes are: 1) Description of each component; 2) Diagrams of how components fit together; 3) Comments on the means of joining components; and 4) Comments on how the product was assembled.

Identify Design Variables Phase
This phase consists of six steps, each with its own Tasks and Outcomes. On figure 3, the contribution from each step is identified with the letter “s”.

Step 1 Create a Bill of Materials (BOM) with associated functions.
The Tasks are: 1) Develop a BOM from the individual components, following general instructions for its construction; 2) Identify sub-assemblies on the BOM and write a description of their functions.

The Outcomes are: 1) Components and sub-assemblies arranged as a BOM and; 2) Functions of sub-assemblies.

Step 2 Analysis of Mechanism and Structure
This is a closer examination of how the components are combined to provide sub-functions, which then combine to provide the overall function for the user. This is a source of confusion and forces the distinction between the overall product function as seen by a consumer, and the technical functions of the components and assemblies. The functions that were identified with the BOM assemblies are one view of this exercise, but they use the BOM structure to combine functions, which may not be appropriate. Here, we define a “structure” as consisting of more than one part that can transmit force or motion among parts, and a “mechanism” as a structure that provides a function.

The Tasks are: 1) Express the overall function and lower level functions in written form; 2) Identify the corresponding structures or mechanisms that provide the functions and diagram the flow of force or motion; 3) Conceive of three other means of providing the same function, without regard for practical implementation; 4) Develop a function tree by following a set of instructions similar to those for the BOM.

The Outcomes are: 1) The functional structure of the product; 2) The structures and mechanisms that contribute to the overall function; 3) The internal flows of force and motion; and 4) Descriptions of alternative means to provide the functions.

Step 3 Structural Integrity Analysis
This step focuses upon the physical interconnections that allow the product to achieve its overall function by annotating the BOM with symbols representing joint interfaces between the user and product, between parts and assemblies, and between the product and its environment of application. The Task is to: Annotate the BOM with different symbols representing the various interfaces.

The Outcome is to: Comment on the integrity of the interfaces in terms of wear, material properties, force levels, friction, etc.
Step 4 Analysis of Performance Requirements
This step formally connects the information on mechanisms, structure, and function to the general performance as expressed in the initial specifications.

The Task is to: Express the functions of all mechanisms and structures in terms that relate to the expected performance as stated in the initial specifications.

The Outcomes are: Statements of the relationships between mechanisms, structures and performance.

Step 5 Generate Design Variables
Plausible design variables are identified from the information created in the previous steps. The design variables could be in a wide spectrum from very detailed ones, like factors describing a part, to generic ones, like performance factors of the product itself. Here we confine the variables to: 1) Those which define and control the function and the performance of a mechanism or a structure; 2) Those which control the structural integrity of any connecting points.

The Task is to: Generate design variables out of the statements defined in the previous steps.

The Outcome is: List of plausible design variables and units.

Step 6 The Analysis of Design Variables.
This step creates specifications for the product by assigning numerical values or ranges or identifiable qualities to the design variables. This may include performing tests to measure the strength or other physical properties of selected components. For the simple products chosen for these exercises, there are usually only a few components that need to be tested, so the students are allowed to “discover” the need and procedures for such tests.

The Tasks are: 1) Define plausible values, ranges and qualities of the design variables; and 2) Create a final version of plausible specifications.

The Outcome is: A plausible set of specifications for the take-apart product.

Benchmarking Phase
In this phase students examine a product that has the same overall function as the original product, but is either an earlier version, a competitor or one that capitalizes upon a major feature such as “small and light weight” (for camping), or low cost. The focus is to do an abbreviated pass through Phases II, III and IV, and trace the connection between the features of the alternate product and its corresponding design specifications. That is, it is presumed that the alternate product followed the same Design Process as the original one, but due to slightly different needs and specifications, it achieved the same overall function with different functions, structures, mechanisms and design variables. Thus, students gain a second experience with developing specification in a now familiar context.

The Tasks are the same as for Phases II, III and IV, but students now have experience with the details of the individual tasks.
The Outcomes are: 1) Recognition of different structures and mechanisms providing the same overall function; 2) Revised specifications for the alternate product; 3) Description of how the revised specifications led to the alternate product.

Redesign Phase
Students are assigned the task of creating a variation of the original product that performs the same overall function but is to accommodate additional needs, such as “operable by a physically handicapped person.” The intention is to experience the connection between specifications and product features on something that they have created. They are asked to perform the following three steps, though they may not proceed in order. That is, the Design Process of figure 1 is not yet part of their thinking process, so when asked to create a product variation, they respond with ideas which are expressed as sketches and narratives of how it works. This is all right. Then they are asked to explain how their concepts can meet the need, and they respond by naming the “features” of their concept, and are then encouraged to rephrase the features as initial specifications. In the final step they use the reporting formats from Phases III and IV to summarize their selected concept and revise the specifications. This provides a third experience of writing specifications.

Step 1 Create Initial Specifications
The Tasks are: 1) Clarify the new need statement; and 2) Write revised specifications.

The Outcome is: Revised specifications for the student designed product variation.

Step 2 Develop, Select and Describe Product Concepts
The Tasks are: 1) Conceptualize and sketch the three design ideas for the new engineering requirement and explain their features; 2) Choose the best idea and explain the reasons; 3) Make a function tree of the selected revised product; 4) Describe the changes of the structure or mechanism from the original product; 5) Diagram the flow of force or motion while the product is operated, with emphasis on the connections.

The Outcomes are: 1) Sketches of the new concepts; 2) Functional structure of selected concept; 3) Changes from the original product and 4) Internal force and motion flows.

Step 3 Detail the Design and Write Specifications.
The Tasks are: 1) Create a Phase III teardown form for the new product. This forces students to think through many details including new design variables; 2) Revise the specifications.

The Outcomes are: 1) Teardown form for the new product; and 2) Revised specifications.

Analysis of the experiment
Two mechanical engineering students have performed the experiment and the teaching method is to do a short instruction of each exercise with the sample answer for a stapler. Then students begin the exercise. The experimental conditions are: 1) The subjects are sophomores in Japanese college; 2) The location is Akita Prefecture Technology Center; 3) The period of experiment is six hours per day for six days (August, 2001); and 4) The experimental teaching materials are U.S.-made can openers (Jr. Portable, Swing-A-Way). The outcomes of the exercises are not analyzed here but firstly the specifications written by the students are analyzed by focusing on the relations between the content of specification statements and the exercise’s answers in the each phase. Secondly, the results of the revised design assignment are evaluated.
The analysis of the specification
Because of the limited words, we analyze a crucial item in each category of the design specification (Figure 2).

Function(s) in performance requirements
The functions in the design specification must be stated with specific performance statements so that the designer can generate concrete concepts for the specification. Otherwise the design concept will diversify. The two students answered “To cut a can’s lid” as the primary function. And as for the performance statements one student wrote “It must be easy to use, reliable, nickel body and steel cutter, soft grip and handy” at the end of Phase II and the student added “It must have a proper shape of handle.” This was revised a little at the end of the Phase IV as “It must be easy to use, reliable, the cutter for a small and middle size can, rustproof and the maximum opening of the handle is twenty degree.” Most of the performance statements are rather vague like customer’s requirements, but after doing exercises the performance statements became a little more specific. Many exercises are supposed to give hints for answering the functional requirements with their performance rate in the specification. The step 6 in Phase IV does help students to describe the variables in numerical terms but might not enough to test all items in analytical sense.

Method of assembly in manufacture requirements
Here in-house manufacturing facilities and outsourcing for production, and the method of assembly are specified. The materials to be used and packing and shipment are specified too. A student specified the facilities and outsourcing factors at the end of Phase IV but it is usually difficult for the students since many of the factors are company policy and depend on the facilities that a plant owns. In the experiment, students answered the item of materials, the method of assembly and packing. A student, for example wrote about the method of assembly “Crank and gear are attached to the handle by a rivet and cutter is also attached to the other handle by a rivet. The two handles then are jointed by a rivet at the fulcrum, and assemble a rivet for the guide lastly.” The statements are not changed at the end of the Phase IV because the method was clarified in the teardown form. Students are asked to write in the new version of specification.

Safety in operation requirements
Here students specify any legislations and codes of practices in the area, which refer to all safety aspects of the product. One student said, “The parts edges should be rounded and have an explanation sheet attached.” The other student said, “Even if users grip the handle too firmly, the cutter should not harm anyone’s hand.” Students are supposed to define any legislation but they did not do so since they did not survey any regulations regarding safety. They think that the SG mark designate a safe product. As a safety concern, students proposed to cover the gear, and made the body section of the handle wider, shown in figure 5, section 3.2.3.

Disposal standard of others
Here students specify individual country or international standards for disposal. Especially in order to reuse materials, almost all plastic materials used must be identified. One student said, “The grip cover is made of petroleum resin and the other components are all inflammable materials.” The other student made almost the same statements. They could have shown the kind of grip materials to be used and checked the handbook of international standards for disposal since the product will be sold internationally.

Conclusive remarks
There are many unfilled items in the acceptance standards and disposal headings in the figure 2. These will be filled out if students do a data search from other sources such as standards books,
related product legislation and so forth, and there are unnecessary specification items depending on the product for teardown. As teaching materials for beginners, it may not be necessary to go into minor factors unless items are closely related to the product features and are considered to be important to in redesign exercises. The instructor should judge whether the item is necessary or not.

The evaluation of the revised design
The additional need was to have the can opener be operable by a physically handicapped person.

Create initial specifications
Students rephrased new customer needs of the handicapped as “the person who has minimum eyesight for daily life and grasping force, and has same comprehensive ability as child.” Revised items of design specification are as follows: The weight of the performance requirements is changed such as “lighter than 150g” and the materials of it such as “larger diameter of the gear and cutter, longer handle and crank” These statements should be stated more clearly as design specification.

Develop, Select and Describe product Concepts
The example of three sketches of the revised design are as follows: 1) Almost same design as original one but has a longer crank; 2) The handles have the same shape as ordinary scissors; 3) The gear is motor-driven one. The student selected the first one because of the product weight.

Detail the design and write specification
The students created a revised teardown form that had much more detailed information than the original one, indicating that students skill at describing functions, structures and mechanisms, had increased. In the detail design, figure 4 and figure 5 show the form written in Phase III and VI.
The same student wrote figure 4 and figure 5. Although the student did not specify the numerical values in his specification, he expressed the revised design concept and specified the design variables in his teardown form numerically. As the revised concept is stated in the initial specification, he lengthened the handle from 150 mm to 195 mm and the crank from 70 mm to 75 mm, and made the handle wider and thicker for an easier grasp.

Conclusions
This work described an approach to teaching 1st and 2nd year engineering students how to create design specifications using the context of a take-apart exercise of a familiar consumer product. We call the approach the “Design Structured Teardown Process”. It consists of six phases, with associated Tasks and Outcomes, and selected outcomes produce information that contributes to the writing of specifications. The specifications evolve in scope and detail as students work through the phases, operating the product, dismantling it, measuring, drawing, computing and identifying materials, components and functions. In this way, information for design variables and their quantitative and qualitative measures, is gathered and phrased as plausible specifications. Students also analyze an alternate product with the same overall function, and create concepts for a new product, having the same overall function but with different constraints. Thus they gain three experiences in writing specifications and see how specifications can guide the development of three different products, each providing the same overall function. The authors encourage instructors who
are using a take-apart exercise to consider adopting this six phases approach to integrate the exercise into a larger design context and provide experience in writing specifications. The method has been tested for several consumer products but we believe that the approach can be applied for any product that has an assembly structure such as electrical and architectural artifacts.
References


Understanding design iteration: representations from an empirical study

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Abstract

Design is a cornerstone of the engineering profession and a prominent feature in how we educate engineers and accredit engineering programs. Design problems are often ambiguous, ill-structured, and may have multiple solutions. As a result, a designer’s understanding of the problem or possible solutions evolves through a process of iteration. Iteration is a symbolic feature in design models that represents a process of revisiting and resolving design conflicts. Although iteration is considered an integral part of design activity and a natural attribute of design competency, there is little research that explicitly operationalizes or represents iterative activity. The purpose of this paper is to provide and discuss theoretically meaningful representations of iteration in engineering design. Representations were generated from empirical data from a comprehensive study of cognitive processes in iterative design activity. The utility of these representations is evidenced in their ability to emphasize empirical findings, highlight qualitative trends and patterns of behavior, and distinguish differences in design success and levels of engineering experience. In addition, these representations may be useful pedagogical tools for engaging design students and design educators in discussions about effective iterative behaviors.
Understanding design iteration: representations from an empirical study

Introduction
Design is a cornerstone of the engineering profession, a prominent feature in how we educate engineers and accredit engineering programs, and one way of describing the competency of our engineering graduates as practitioners (ABET, 1998; NRC, 1995; NSF, 1995; NSPE, 1992). Iteration is a fundamental feature of design activity that signifies a goal-directed process of revisiting aspects of a design task in which the goal is a solution that is internally consistent with an understanding of the problem. Iterations mark an awareness that neither the problem nor the goals are well-defined, and are the result of attempts to reconcile ambiguities and contradictions. In cognitive models of design aspects of this process it is described as problem and solution co-evolution (Adams; 2001; Braha and Maimon, 1997; Hybs and Gero, 1992). As such, the mechanisms underlying iterative cycles can be described as transformational and evolutionary processes that mark a designer’s journey from an under-specified starting point to an elusive target goal (Hybs and Gero, 1992). For each adjustment, the designer must analyze not only the effects of the change but also reevaluate the design task. From our own experiences, we refer to iterations as “another pass”, “moving in a new direction”, “the next version”, “inspiration”, “optimizing” or even “starting over”.

Iteration has been found to constitute effective design practice (Adams, Turns and Atman, in press; Bucciarelli, 1996; Radcliffe and Lee, 1989) and provide mechanisms for supporting design innovation (Dorst and Cross, 2001; Suwa, Gero and Purcell, 2000). For example, Suwa et al (2000) found a significant relationship between invention and unexpected discoveries during design sketching. In a comprehensive empirical study of iteration in engineering student design processes, Adams (2001) found that iteration is a significant component of design activity that occurs frequently throughout the design process; and measures of iterative activity were significant indicators of design success (e.g., “effective behaviors”) and greater engineering experience. Examples of effective iterative behaviors include: 1) more time iterating and more iterations, 2) more time in iterative processes that involved a conceptual shift in understanding (transformative processes), 3) more time in iterations triggered by self-monitoring and examining activities, and in iterations that resulted in revisions coupled across problem and solution elements, 4) more time iterating within and across conceptual design and problem setting activities, and 5) a greater awareness of iterative strategies and processes for monitoring, detecting, and resolving design failures. Observations from study data suggest iterative activity may facilitate learning by allowing the designer to continually revisit and reflect upon each aspect of the design task (Adams, Turns and Atman, in press).

Representations of iteration
Few studies operationalize or denote iterative behavior in engineering design, in particular how iteration relates to experience or performance. Representations from studies of design activity indicate iteration as cyclical processes of revisiting previous design decisions and these processes occur predominantly during conceptual design. In a substantial study of engineering student design processes Atman et al (1999) found that seniors made more transitions between steps of the design process than freshmen, and that transition behavior related positively to final solution quality. Representations of these design processes suggest iteration may be described as transitioning backwards to previous design steps. Tjandra (1998) utilized representations for analyzing iteration in design teams and observed both probabilistic or unplanned iterations and parallel task activities of analysis and synthesis; however, no correlation between the quality of the solution and the number of iterations was found. Goldschmidt (1996) created a graphical means to measure design
productivity as the “interlinkability” between conceptual aspects of design. Although greater productivity was not an automatic consequence of a higher ratio of interlinkability, Goldschmidt notes that the technique might be useful for indicating repetitive clarification and evaluation processes. Badke-Schaub and Frankenberger (1999) utilized a graphical framework based on critical situations to study factors that influence collaborative design work in practice. Critical events were defined as situations in which the design process takes on a new direction on a conceptual or embodiment design level. The authors found that critical events accounted for 88% of the situations observed and identified mechanisms responsible for positive and negative outcomes of different critical events.

A question remains: what does iteration look like? Representations of iterative activity may help answer this question. Researchers have utilized graphical representations of data as a mode of inquiry (Chimka and Atman, 1998; Larkin and Simon, 1987) and suggest that representations may increase the variety of questions about educational situations (Eisner, 1997). Representations have also been used as pedagogical devices (Turns and Atman, 2000). This paper was motivated by representations derived from a comprehensive empirical study of iteration (Adams, 2001). In this paper, representations generated from study measures are provided to emphasize and explore iteration in engineering design (e.g., where iterations occur, relative frequency and duration, and patterns of behavior). Representations include timelines of iterative cycles and processes and web diagrams of iterative transition sequences. The utility of these representations is demonstrated in their ability to illustrate theoretically meaningful measures and patterns of iterative activity. The utility of these representations may be extended as educational tools: to educate students about iteration in design and to engage design educators in discussions about improving the teaching of design.

Extending an empirical study of iteration
The representations discussed in this paper were generated during a comprehensive study (N=32) of iteration in engineering design (Adams, 2001). The purpose of this study was to 1) empirically explore and identify iterative behaviors in engineering students’ design processes based on a cognitive model of iteration, and 2) compare measures of iterative activity across differences in performance and engineering coursework. The research design was a strategic comparison of freshmen and senior engineering undergraduates and included exploratory and confirmatory components. Pre-engineering freshmen completed the research task prior to enrolling in an introductory engineering course, and seniors completed the task during their final semester before receiving a baccalaureate degree in engineering. The purpose of the exploratory component was to develop and utilize a coding scheme for analyzing iterative activity; hypotheses generated were tested in the confirmatory analysis.

Methods
This study utilized a subset from an existing dataset of 50 engineering students solving a complex design problem (Atman et al., 1999; Bursic and Atman, 1997). Eight subjects were selected for the exploratory analysis (4 freshmen, 4 seniors) and 24 subjects for the confirmatory analysis (12 freshmen, 12 seniors). The research method was verbal protocol analysis in which subjects think aloud as they perform an experimental task (Ericsson and Simon, 1993). The experimental task was administered in a laboratory setting. Subjects were given three hours to design a fictitious playground and all requests for additional information were catalogued. Existing data utilized in the iteration study included: 1) protocols previously coded for design step activities, 2) final quality scores based on criteria from expert playground designers, 3) information requested, and 4) background information.
**Operationalizing iteration**

The framework for coding iterative activity was based on a cognitive model describing underlying mechanisms of iteration as well as schemes for classifying iterative cycles and processes (Adams, 2001; Adams and Atman, 1999; 2000). Attributes of this framework were drawn from a synthesis of research in design and complex problem solving. As illustrated in Figure 1, iteration is operationalized as a goal-directed cognitive process that is triggered by an information processing activity and concludes with a change to a design state (i.e., process, problem, or solution element).

![Figure 1: A cognitive model of iteration in engineering design.](image)

Information processing activities describe how information is being accessed, utilized, and generated. Example triggering activities include monitoring self-understanding or progress, clarifying the nature of the design problem, conceptualizing design elements, and evaluating solution quality. Changes to a design state (the outcomes of an iteration) include redefining problem requirements and evaluation criteria, proposing or modifying new solution elements, and coupled changes across problem and solution elements. Information processing activities that culminate in changes are defined as resolved or successful iterations; situations in which the process does not yield an outcome are defined as unresolved or unsuccessful iterations.

Classifications for successful iterations were coded in terms of *iterative cycles* and *iterative processes*. Iterative cycles are signified by the main outcome of the iteration and codes include: problem scoping, solution revision, coupled cycles in which problem and solution elements are simultaneously revised, and self-monitored cycles in which the iteration is triggered by an explicit plan to revisit a previous design decision. As shown in Figure 1, iterations that connect information processing and decision activities are defined as either diagnostic or transformative processes. Diagnostic processes are defined as incremental revisions in which no major conceptual shift in understanding occurs (e.g., result in corrective actions). Transformative processes are defined as conceptual innovations in which new information is integrated into the process (e.g., result in synthesis or generation actions). For example, iterations that included redefining the problem or coupling revisions to problem and solution elements were coded as transformative; iterations that included only reviewing the problem (without revision) or modifying a solution element (without revising an understanding of the problem) were coded as diagnostic. A complete description of the coding process is provided in previous work (Adams, 2001; Adams and Atman, 1999; 2000). Interrater reliabilities for coding protocols averaged greater than 85% and all differences were arbitrated to consensus.
Figure 2: An idealized model of iterative transition sequences.

Because protocols were previously coded for design step activities there was a unique opportunity to combine descriptive and cognitive models of design into an integrated framework for analyzing iterations as *movements located within a design process*. Design step activity codes for the descriptive model are shown in Figure 2 (see Atman et al., 1999; Atman and Bursic, 1998). The links in the idealized web diagram represent iterations as transitions to previous design step activities (e.g., Feasibility to Modeling, Modeling to Gather Information). Iterations can also occur within design steps (e.g., Modeling). This combined framework provides a mechanism for analyzing iterative activity in terms of where iterations are likely to be triggered as well as the direction of an iterative sequence: links begin where an iteration is triggered and the direction of the arrows signifies the goal of an iterative transition sequence.

**Representations of iteration**

Graphical representations of iteration in engineering design were generated in the process of analyzing empirical measures. These representations include *timelines* of iterative cycles and processes and *web diagrams* of iterative transition sequences within a model of design processes. Timelines of iterative cycles and processes display coded behaviors from a chronological perspective and were used to explore the history of iterative activity as well as the relative
frequency and duration of iteration. Web diagrams of iterative transition sequences illustrate relationships between coded design step activities and coded cognitive activities that trigger and resolve an iteration (see Figure 2). These diagrams provide insight into where iterations occur within a model of design and the direction (or goal) of an iteration.

The following sections provide examples of iteration timelines and web diagrams for three subjects. Subject A (a senior) is an example of subjects that received high quality scores and had greater engineering experience. The representations for Subject A illustrate iterative behaviors that correlated with higher quality scores (effective behaviors); and illustrate, although to a lesser extent, patterns for freshmen that received the highest quality scores. Subject B (a canonical freshman) is an example of subjects that received lower quality scores and had less engineering experience. In general, representations for Subject B illustrate a reduction in time spent in effective iterative behaviors as compared to those for Subject A. The representations for Subject B also exemplify patterns for seniors that received the lowest quality scores. Subject C (a freshman) is an example of subjects that received the lowest quality scores as well as had less engineering experience. The representations for Subject C generally illustrate a dramatic reduction in effective iterative behaviors as well as an increase in iterative behaviors that significantly correlated with lower quality scores (ineffective behaviors). Freshmen and senior subjects in this study did not differ significantly across academic and personal backgrounds on the following measures: high school grade point averages, math and verbal scores on standard achievement tests (SAT), and parents’ technical background. Therefore, it is not likely that differences in the representations can be attributed to personal characteristics.

Illustrating iteration: timelines of iterative cycles and processes
Timelines of iterative cycles for the three example subjects are provided in Figure 3. Codes for iterative cycles are listed on the left side of the timelines and the tickmarks represent time engaged in coded activities at that point in time. In the timelines, time is presented as hr:min:sec:msec. Codes for iterative cycles include: Problem Scoping (PS), Monitored Problem Scoping, Solution Revision (SR), Monitored Solution Revision, Coupled Problem and Solution Revision (Coupled), and Monitored Coupled Problem and Solution Revision. Coupled cycles refer to iterations in which revisions to problem and solution elements are occurring simultaneously. Characteristics of coupled iterations observed in the protocols include gathering information on a “just in time” basis, qualifying or quantifying problem requirements by justifying or describing how a solution functions or behaves, and evaluating solutions while clarifying evaluation commitments from multiple perspectives.
A: High Quality Senior—Total Time Iterating (39.9%), Quality Score (.585)

B: Canonical Freshman—Total Time Iterating (29.8%), Quality Score (.409)

C: Low Quality Freshman—Total Time Iterating (23.0%), Quality Score (.373)

Figure 3: Representations of iteration timelines for (a) a senior with a high quality score, (b) a canonical freshman, and (c) a freshman with a low quality score.

The timelines in Figure 3 reveal that iteration occurs frequently throughout the design process (an average of 8 iterations every 5 minutes) rather than at specific points in the process such as optimizing a design solution at the end of the process. The representations also communicate that iteration occurs a significant portion of the time regardless of differences in quality or experience. Freshmen and seniors, respectively, spent an average of 31.4% and 39.8% of their total design time iterating. Comparing across Subjects A, B, and C these iterative cycle timelines emphasize a general reduction in known effective iterative behaviors as levels of design success and engineering experience decrease. These include a reduction in 1) the frequency (and number) of iteration, 2) the levels of coupled and self-monitored coupled cycles, and 3) the likelihood of any self-monitored iterative cycle.

The timelines in Figure 3 also highlight patterns of iterative activity associated with greater success and engineering experience. Comparing from Subjects A to C illustrates a general reduction in iterative problem scoping cycles early in the process. In addition, these cycles appear to be replaced with iterative coupled cycles relatively early in the process suggesting that many students...
(particularly freshmen) did not create a stable representation of the problem prior to developing solutions. The timelines also indicate a relationship between the amount of iterative problem scoping and solution revision cycles. In particular, those who spent a greater portion of time in problem scoping cycles as compared to solution revision cycles received higher scores and generally had more engineering experience. In addition, a pattern is evident in the timeline for Subject A (but not for B and C) in which large “packets” of iterative coupled and self-monitored cycles are closely grouped together. These may be design strategies in which iteration plays a fundamental role.

In addition, the timelines draw attention to a noticeable pattern of iteration at the end of the design process. From the protocols these were observed to be efforts to verify and optimize the quality of final solutions (e.g., verification cycles). For Subject A these verification strategies were more likely to be self-monitored solution revision cycles. Self-monitored cycles are driven by an explicit plan to revisit design decisions and were observed in the protocols to be markers of metacognitive strategies. For Subjects B and C these cycles were more likely to be coupled iterative cycles in which new information was generated and integrated into the task during the final stages of the process. Observations from the protocols suggest these may be efforts to rationalize design solutions by justifying a new understanding of the design task. Finally, by comparing the size of the tickmarks in the timelines it is evident that Subjects B and C were more likely to have iterations of longer duration, whereas Subject A was more likely to have iterations of relatively short duration (average of .68 minutes). As such, this suggests that levels of experience may play an important role in how quickly designers can respond to critical situations.

Timelines of iterative processes for the three example subjects are provided in Figure 4. Codes for iterative processes include Diagnostic and Transformative and are listed on the left side of the timelines. Iterative processes were coded as transformative when revisions involved a conceptual shift in understanding; otherwise, iterative processes were coded as diagnostic. From the empirical study, time spent in transformative iterative processes positively related to higher quality scores and correlated significantly with a higher number of information requests across more categories. Transformative processes also highly correlated with the level of coupled iterative cycles.

The timelines in Figure 4 reveal that the bulk of iterative activity involves transformational processes. This suggests that much of iteration can be characterized as generating and synthesizing information into the design task rather than optimizing relatively stable solutions. The timelines also suggest patterns regarding time spent in diagnostic and transformative iterative processes. Comparing across Subjects, the ratio of time spent in transformative in relation to diagnostic iterative processes approaches unity as the level of success and experience decrease. For Subject A the ratio of time spent in transformative processes is noticeably greater than time spent in diagnostic processes; for Subjects B and C the ratio approaches unity.

The timelines in Figure 4 also highlight differences regarding when diagnostic and transformative processes occur. For the high quality example (Subject A), the timeline shows a high level of transformative processes that decreases dramatically about an hour into the task and a related increase in diagnostic processes for the remainder of the task. Such a pattern seems logical: as an understanding of the problem stabilizes it would be more likely that later revisions would be at a syntactic (e.g., diagnostic) level rather than a semantic (e.g., transformational) level. In other words, for these revisions it would be less likely to require or elicit a conceptual shift in understanding. In comparison, subjects with lower scores and less engineering experience were more likely to spend time in transformative iterative processes later in the design task. From the protocols, large quantities of diagnostic iterative processes early in the process were associated with reviewing the design task and difficulties with bringing new information into the task to guide
design activities. Finally, the timelines in Figures 3 and 4 highlight a difference across final quality scores and experience in the nature of final verification cycles. Whereas Subject A was more likely to spend time in iterative diagnostic cycles at the end of the task, Subjects B and C were more likely to spend time in transformative iterative cycles.

**A: High Quality Senior—Total Time Iterating (39.9%), Quality Score (.585)**

**B: Canonical Freshman—Total Time Iterating (29.8%), Quality Score (.409)**

**C: Low Quality Freshman—Total Time Iterating (23.0%), Quality Score (.373)**

Figure 4: Representations of iterative process timelines for (a) a senior with a high quality score, (b) a canonical freshman, and (c) a freshman with a low quality score.

Overall, the timelines of iterative cycles and iterative processes bring to light empirical findings and reveal patterns of iterative behavior associated with levels of design success and engineering experience. For example, they are useful for emphasizing known effective iterative behaviors, the relative amount of different kinds of iteration in design, and identifying strategies such as final verification loops and early problem scoping activities. As such, these representations highlight the importance of iteration in design as well as effective iterative behaviors that may be useful in the teaching of design.

**Illustrating iteration: Web diagrams of iterative sequences**

Web diagrams of iterative transition sequences within a model of design processes for the three example subjects are provided in Figure 5. The web diagrams illustrate time spent in iterative activities in relation to design activities (e.g., iterating within Modeling and iterating across Feasibility to Gather Information). The percentages shown in the diagrams refer to the amount of total iteration time engaged in that activity. For the case of iterating within a design step, percentages are located within the associated design step symbol. For iterating across design steps, percentages are located on the arrow and the direction of the arrow is towards the goal of the iterative transition sequence.
Figure 5: Representations of iteration web diagrams for (a) a senior with a high quality score, (b) a canonical freshman, and (c) a freshman with a low quality score. Percentages represent percent of total iteration time engaged in that activity. Percentages signified with "**" represent known effective iterative activities and those with "*" represent known weakly effective activities.

The web diagrams emphasize the variety of possible iterative transition sequences and reveal the significant and positive relationship between the number of iterative transition sequences (and time spent in effective behaviors) and greater design success and engineering experience. For example, the web diagram for Subject A shows 14 different sequences; for Subject B there are 11, for Subject C, only 3. Although the empirical findings identify that a greater number of iterative sequences relates to design success and greater experience, the measure is not a powerful indicator on its own—but rather is limited by the number of sequences present in the web diagrams known to be
effective (e.g., the amount of time in effective iterative activities). As shown in Figure 5, effective iterative behaviors from the empirical study (signified with “**”) include iterations within problem scoping activities, within conceptual design activities, across conceptual design and problem scoping activities, and across implementation and conceptual design activities. Subject A spent 35% of their total iteration time in effective activities; whereas Subjects B and C spent 20.4% and 29.6% of their total iteration time. Also, Subject A spent time in 7 of a possible 9 effective iterative activities, whereas Subjects B and C spent time in 4 and 3.

The web diagrams also highlight the trade-off between time spent in known effective iterative activities and iterative activities positively associated with success but not statistically significant (weakly effective activities). Weakly effective iterative activities are signified with a “*” in Figure 5 and examples include time spent iterating within Modeling and Feasibility, and from Modeling to Generate Ideas. Subject A spent approximately equal times in effective and weakly effective activities (35% and 37.6% respectively). Subject B spent more time in weakly effective as compared to effective activities (37.2% and 20.4%), and Subject C spent almost twice as much time in weakly effective as compared to effective activities (58% and 29.6%). These trends suggest that the process of acquiring design expertise may be associated with replacing weakly effective strategies with considerably more effective strategies.

A comparison across web diagrams indicates a general increase in known ineffective behaviors as quality scores and engineering experience decrease (e.g., iterating from Generate Ideas to Problem Definition). Similarly, the web diagrams clearly reveal a relationship between an excessive level of iterating within Modeling and lower quality scores and less engineering experience. Although time spent iterating within Modeling was found to be a weakly effective iterative activity, an excessive level was associated with lower quality scores. For example, Subject A spent 13.2% of their total iteration time within the Modeling design step whereas Subject C spent 58% of their total iteration time.

Finally, the web diagrams highlight the relationship between where iterations are triggered and the goal driving the iterative activity: the goal of iterative sequences is more likely to be related to problem scoping activities, in particular transitioning back to Gather Information. This indicates that problem scoping activities represent not only a significant design goal but also occur throughout the design task in qualitatively different ways as solutions are developed. An interesting finding suggested in the empirical study but best represented in these web diagrams is a pattern of iteration that can be characterized as a conversation across representational spaces: between conceptual design and problem scoping, communication and conceptual design, and communication and problem scoping. Aspects of this iterative activity may be conceptualized as design discourse (Adams, Turns and Atman, in press; Mandershetty, 1995). For example, Mandershetty (1995) created a cognitive model of design in which problem and solution representations developed during conceptual design activities set up a universe of discourse that encourages the generation of novel ideas or design breakthroughs. Observations of such conversations in the protocols were described as problem scoping in context. As an example, a student begins with an abstract sense of the design constraint “be safe” and as they move through the design process and develop solutions they generate an understanding of safety in specific solution contexts and revise solutions based on this new understanding. In the process they elaborate or expand a conception of safety at a more generalizable level which can then be used to guide the improvement of other solution elements for which safety might be an important constraint.

Such a dialectic is indicative of more expert like strategies found in other complex problem solving domains and is believed to be a hallmark of expert task performance. In the context of expertise in reading and writing, Scardamalia and Bereiter (1991) developed a model of skill acquisition as a
dialectic process between particular and general conceptualizations. In a study of writing as a complex problem solving process Bryson et al., (1991) found that experts interpret the significance of the topic on a more abstract level and transform it so that it can be placed in a more meaningful epistemological perspective. The authors describe this as a dialectical interaction between content and rhetorical goals in which a representation of the problem evolves recursively as cognitive operations bridge the gap between initial and final states. In the context of expert actors, Noice and Noice (1997, pg. 69) remark “throughout, it was obvious that the participant (the expert) examined the written text for the purpose of turning it into a living conversation.”

Conclusions
Representations of iterative activity are effective and useful mechanisms for communicating theoretically meaningful empirical findings and revealing qualitative characteristics of iteration in engineering design related to performance and engineering experience. These representations clearly indicate the extent to which design is an iterative process as well as the variety of iterative strategies designers utilize. Similarly, activities captured in the representations help articulate the meaning of empirical findings from a confirmatory study of iterative processes in design. From a theoretical perspective, qualitative patterns evident in the representations illustrate design iteration as a conversation across representational spaces. As a hallmark of expertise in the solving of complex problems, aspects of dialectic iterative activity may be useful as markers of design learning. The means for capturing these dialectic patterns may be extended to support similar studies in other complex problem solving domains.

From a practical perspective these representations have high utility for encouraging a dialogue on iteration in engineering design. For example, design educators could use the representations presented in this paper to engage their students in a conversation about the role of iteration in design and effective iterative activities. The representations also suggest that iterative activity should be strongly encouraged in the teaching of design. Educators could use these representations to justify pedagogical decisions such as increasing opportunities for students to iterate frequently in their design activities, as well as offering instruction in iterative strategies and promoting an awareness of iteration as a successful design strategy.

Acknowledgements
This research was made possible in part by a National Science Foundation grant RED-9358516, the Engineering Coalition of Schools for Excellence in Leadership and Education (ECSEL), a National Science Foundation Engineering Education Coalitions program, as well as a grant from the GE Fund. I would also like to thank all of the students who participated in this study, Cindy Atman who allowed me to use her data to tackle a unique and substantial project, Jennifer Turns for her irreplaceable insight, and Jana Littleton for assisting in the coding of the transcripts and improving the coding scheme.
References


Design for the urban poor in Egypt: satisfying user needs or achieving the aspirations of professionals? 
The case of the Mubarak National Housing Project for Youth

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Abstract

As a result of the criticism of the conventional Western-inspired prototypical designs for low-income public housing in Egypt, a new trend in design for this sort of housing, represented by the “Mubarak National Housing Project for Youth”, has been adopted by the professionals in recent years. If the main objective of any housing project is to meet user needs and preferences, has the design of the Mubarak housing project achieved this goal? and to what extent does this project differ from previous public housing schemes?. In an attempt to answer these questions, and speculate on an appropriate design approach for low-income people in Egypt, multi research methods have been adopted within the research discussed in this paper. The research reveals that the Mubarak project is, to a large extent, designed in the same rigid way as previous public housing schemes. The design process, in which any real changes should take place, remains intact. While it has been argued that users' needs could not be met without their active participation in the design process, this research indicates a wide gulf between this notion and the attitude of designers. Despite this, a considerable percentage of the users involved in the research believe that their participation in the design decision-making process is fundamental.
Design for the urban poor in Egypt: satisfying user needs or achieving the aspirations of professionals? 
The case of the Mubarak National Housing Project for Youth

Introduction

Egypt is one of the developing countries that suffers from an acute housing problem, especially for low-income people. To cope with this problem, since 1950s until the present, the Egyptian government has adopted a policy of building mass housing for low-income people. The conventional design of low-income public housing projects in Egypt is usually based on typical housing units consisting of one, two or three roomed apartments, [Fig. 1(a)], in five story blocks arranged in monotonous rows or round open spaces (Wilkinson and Tipple, 1987). These typical housing units were designed according to predetermined standards for the size of units, number of rooms, room size, plumbing fixtures with areas generally varied from 25 sq. m. to 85 sq. m. The public housing neighbourhood layout, in contrast to the tightness and lack of space inside the dwelling, normally has wide public open space between the blocks [Fig.1(b)]. (Wilkinson, Khattab, Majo and Kardash, 1991).

"Figure 1a: Typical public housing unit plan, Cairo"
Source: Tipple, A. Graham. 1991. p.36
The design of these projects has been criticized because their designers seemed overly concerned with physical features, building standards, and economic factors, whereas the socio-cultural needs of the occupants were widely ignored (Salama, 1998). Greger and Steinberg (1988) believe that the static, behaviorist design of mass housing and neighbourhood planning were meant for the people but not intended to change with them. Additionally, most of public spaces between the blocks have been characterized as ‘no man’s land’. These spaces have obviously failed to attract the typical Egyptians' outdoor life. (Steinberg, 1991; Hyland, Tipple and Wilkinson, 1984).

These shortcomings have been blamed on Western-inspired designs based on high building standard and codes that usually do not coincide with the way of life which Egyptian people, particularly low-income stratum, normally lead (Wilkinson 1991). Choguill (1995: 406) maintains that “Whereas developed countries may well be able to afford high standards in construction and layout to achieve perfectly understandable aims, it does not necessarily follow that a Third World nation should adopt these Western standards which might be totally inappropriate to its own climatic, cultural, and economic circumstances”.

The dominance of economic aspects over other determinants in the design process was identified as another cause of the shortcomings of low-income public housing in Egypt. Tipple (1991), Mohd., Mahtab-uz-Zaman and Ganesan (1998) argue that low-income public housing has been handled through a dominant economic approach rather than a comprehensive perspective that takes into account the different aspects and needs of users. Thus, under the pressure of the need for mass housing to satisfy housing provision, little effort has been exerted in design process to produce user-responsive designs.

As a result of this criticism, a new approach to design for low-income housing, as represented in the “Mubarak National Housing Project for Youth”, has been adopted by the Egyptian government and its professionals since 1996.
The “Mubarak National Housing Project for Youth”: an alternative design approach for low-income housing in Egypt

The Mubarak national housing project is a mass low-income public housing project aimed at producing more than 70,000 housing units in more than 15 new and existing cities in Egypt. The beneficiaries of this project were to be the youth who belonged to disadvantaged, low-income groups in Egyptian society. The project, which was completed in December 2000, aimed at constructing housing units with areas of 100m² in its first phase and 70m² and 63m² in its second and third phases respectively (Ministry of Housing, Utilities and Urban Communities, 2001).

Named after the Egyptian President Mubarak, this national housing project received a significant degree of political support from the outset. In its reports about this project, the Egyptian ministry of housing (1997) frequently announced that it was a direct commission from the President for the ministry of housing to provide an appropriate and modern dwelling for low-income youth in Egypt. GOPP [General Organization for Physical Planning] (2000) claimed that the Mubarak housing project aimed at providing function, comfort and aesthetics as well as maintaining a balance among cost, economic efficiency and socio-cultural requirements in a civilised residential environment. President Mubarak announced his intention to continue this project so the Egyptian ministry of housing began to develop a fourth phase (The Executive Agency for The Mubarak Youth National Housing Project, 2000).

If the main objective of the design of any housing project is to meet its users' needs and preferences, has the design of the Mubarak Housing project achieved this goal? In an attempt to answer this question, and speculate on an appropriate design approach for low-income people in Egypt, multi research methods have been adopted. Firstly, documentary research that aimed at defining the process of the design of this project and defining its similarities and differences with previous designs applied to low-income public housing. Secondly, semi-structured interviews were undertaken with some of the key designers involved in the design of the Mubarak Housing Project. Also, structured interviews were conducted with a random sample of one hundred and twenty households selected from three case studies representing the three main prevailing patterns of low-income housing environments in Cairo, namely, public housing, transformed public housing and informal housing.

Design of the Mubarak housing project

The designs of the housing units and blocks for the Mubarak project were chosen through national architectural competitions held among Egyptian architects. The Ministry of Housing (2001) argues that the chosen designs fulfill the targeted requirements of gross residential density of 120 person/acre and a maximum height of five floors for the residential blocks to allow for ample green areas, parking spaces and various social services [Fig. 2]. In contrast to the ‘attached blocks’ type utilized previously in public housing projects, all residential blocks in Mubarak housing project are separated from each other to give more room for larger façades. Thus each housing unit has two or three façades. The building density in these cases does not exceed 50% and, in some cases, it could be as little as 30%.
The Executive Agency for the Mubarak Youth National Housing Project (2000) argues that the typical housing units were designed in accordance with the social characteristics and behaviour codes of the typical Egyptian family. But actually the areas of the housing units were significantly affected by economic circumstances and not the users needs. The design of the housing units began with the three bedrooms 100m² unit, which was envisaged as the most appropriate for the low-income Egyptian family. Under changing economic circumstances the 100m² units were built only in the first phase of the project. Then, in the second phase of the project the government decided to reduce the unit's area to 70m² with only two bedrooms instead of three. To cope with this significantly limited area and to achieve the ultimate use of internal living spaces the designers find no way but to reduce the areas of corridors and lobbies inside the unit to a minimum. In an interview with Dr. Hazem El-Queedi, who designed 9 of the 17 housing units prototypes in the project [Fig.3], he stated that 'we began to look for ways of reducing the cost of public housing units. There was no real choice but to reduce the housing unit area. The more the designer can reduce the area of lobbies and corridors inside the housing unit the more he can enlarge the living spaces. I managed to reduce the area of internal lobbies and corridors to be only 1 or 1.5 m². As a result I managed to reduce the total housing unit area to 73m² without affecting the areas of living spaces'.

President Mubarak asked the ministry of housing to decrease the housing unit area because not all low-income people could pay 28 to 32 thousand pounds for the 73m² unit. The ministry of housing asked the designers to reduce the unit area to 63m² in the third phase of the project. To achieve this further reduction El-Queedi stated that 'this demand was a real challenge. Actually, we, as designers, found that the only solution was to decrease the thickness of the external walls to 12cm...
instead of 25cm. By doing so we saved about 10m$^2$ from the housing unit reducing its total area from 73m$^2$ to 63m$^2$. Thus we managed to keep the advantages of the external form and internal spatial organization of the 73m$^2$ units in these smaller units'.

"Figure 3: Plans of housing model unit 'C', the Mubarak housing project"


As a result for these significant reductions the housing units of the Mubarak project ended up with the same areas as the housing units in previous public housing schemes. As they are irresponsible to the users needs most of the public housing units built in the 1950s and 1960s have been transformed and changed by their users in order to increase their areas [Fig. 4]. With units of only 63m$^2$, the Mubarak housing project will inevitably face the same situation especially when the residents became the owners of their units. Users’ actions taken in order to meet changing needs will lead, unavoidably, to physical changes which would affect the interior and exterior of their housing units.
At the same time, in response to political demands more design thought has been given to forming architecturally distinguished façades for residential blocks. GOPP (2000) claimed that the Mubarak housing project is designed in a style inspired by authentic Arabic architectural traditions and at the same time reflecting contemporary urbanism and architecture. This has been achieved through the tailoring and adoption of a set of modern architectural elements and vocabularies, such as windows, balconies, cantilevers and solar shades, which are originally derived from the Egyptian architectural heritage and meant to express the tradition of Arab and Islamic architecture and urbanism. El-Queedi added that 'In my designs I used light and shadow to create visual character for the residential blocks. While the structural system of the residential blocks is constant I created this visual effect only by alteration of the slab forms'. [Fig. 5].
In order to maintain the architectural form of the residential blocks, residents are not legally allowed to change their housing units either internally or externally. El-Queedi mentioned that in many cases he avoided making balconies over one another, or to make their length similar to the width of the rooms behind them, in order to prevent the users from using them to enlarge the room space. He claimed that 'the design therefore is not flexible for users’ changes. These housing units were, I believe, aesthetically successful. Therefore, through my designs I intended to provide the user with his needs while preventing him from affecting the aesthetic aspects of the residential blocks'.

Furthermore, no resident is allowed to change the function of the domestic unit to either a commercial or an administrative activity. Flexibility was only considered in the formation of the residential blocks where each housing unit was designed to provide orientation from more than one direction. This, it is claimed, permits the best climatic orientation for the blocks depending on where the housing project is to be developed. Additionally, this provides more variety in treatment of the blocks' façades (The Executive Agency for the Mubarak Youth National Housing Project, 2000).

It appears that the intensive use of architectural features in the façades of the Mubarak project has produced a more rigid housing environment than those previously built. The residents of the public housing schemes of the 1950s and the 1960s managed to enlarge their units to accommodate their changing needs, whereas the residents in the Mubarak housing project will likely face resistance to any changes they may wish to undertake.

Providing shops on the ground floors is a new trend in the design of the public housing blocks in this project. Previously all shops were gathered in one central neighbourhood shopping center. The number, size, location and commercial activities of these shops were determined by the local authorities. According to the general conditions set out by The Authority of New Urban Communities (1998), the owners of these shops, or their successors, do not have the right to change the predetermined commercial activity.
As a result, this research suggests that the Mubarak housing project is, to a large extent, designed in the same rigid way as previous conventional public housing projects. The major changes are superficial and cosmetic. In its 'expert-based' design process all the power of design process is still in the hands of professionals. Ward (1987) believes that architects’ ordinary self-esteem and the imperative to be socially useful, as well as their academic education and training for long years have convinced them that they have something unique and indispensable to offer to the advantage of housing design. This, according to Ward, was fine in the world of symbolic structures like town halls, opera houses, etc., but in the housing it has been disastrous. Hamdi (1991) quotes J. M. Richard's argument about architect’s persistent search for novelty, claiming that this has helped to prevent the growth of an informed body of public opinion – something on which a healthy profession depends. The result has been the architect’s habit of only looking to each other for approbation. Dayaratne (1991) maintains that when dwellings are designed in the conventional expert-based approach of architect-designed, contractor-built, and people-consumed situations, dwellings are perceived largely within the experiences of the architects themselves.

Design process for low-income housing in Egypt: the need for user involvement

It has been widely argued that users needs could not be met without their participation in the design process. Bhatt and Navarrete (1991:11) argue that "For a built environment to be socio-culturally appropriate it should have, as primary element, the contribution of its future residents." According to Wilkinson (1999) and Rice (1995), the involvement of users in the housing design process had the potential for producing environments which were not only safer and cared for but also tailored to the needs of users by the very fact that the residents were involved in making decisions relating to the house and the direct dwelling environment. The importance of involving the local community as a participant in housing decision-making process springs out not only from the short-term benefits for this community but, most of all, from the future need to develop, operate and maintain its settlement, such that it is fit for the new generation (Cockburn and Barakat, 1991). According to Towers (1995), user participation, frees up the design process producing more appropriate and sensitively designed housing. Housing that expresses a greater diversity of personal taste and cultural identity. Cooper and Rodman (1991:5) quoted John Short's argument that "Better cities can be created if all citizens are both empowered and engaged".

Designers’ attitudes towards user involvement in the design process of low-income housing

Chait and Siep (1999) believe that an increasing numbers of planners and designers are embracing participation as a means to assure and improve the outcomes of their work. In this research, the 'grounded theory' analysis method adopted for the semi-structured interviews conducted with the designers has revealed that there is a wide gulf between the notion of user participation in design processes and the attitude of the designers of the current low-income public housing in Egypt.

Regarding the interviewed designers' attitudes towards user participation in the urban design process of low-income housing schemes many of them argued that the urban design of residential neighbourhood should remain the task of the urban designers without direct involvement of residents. They believe that Low-income people and professionals are not able to work together and users' needs could be deduced from fieldwork research and by the analysis of relevant case studies. In their opinion, by doing so, researchers could provide designers with very important indicators concerning user needs. In justifying their opinion some professionals believe that low-income people should not be consulted in the urban design process because they do not have the required knowledge to be involved in this process. One of professionals claimed that “You can not gain helpful information through direct involvement as respondents will never give you clear responses. They are not able to express themselves effectively”. Some professionals argued that lay people
should only be asked about their opinions regarding the public utilities and services that need to be considered in urban design but not about the urban design itself.

Other designers interviewed seem to be in favor of seeking user opinions and comments only on their finished planning and urban designs. They mentioned that according to planning law in Egypt any planning scheme must be approved by the local council in the area in which the scheme is to be developed. Furthermore, the local council would not authorize any planning scheme before it had been presented publicly for a whole month. During this period, any citizen can object to, or comment on, anything in the considered scheme. Therefore, any citizen has the right to participate by expressing his or her opinion and comments on the planning scheme. One of the designers argued that, “In my opinion this is the best way to involve users in planning and urban design processes”.

Regarding the designers' attitudes towards user participation in the design process of their dwellings, professionals interviewed generally claim that they design what the users need so there is no need for their direct participation. One of the designers mentioned that “I am originally an ordinary citizen. I was not one of the elite. Therefore, when I design, I design for my neighbour, my sister and my father. I mean I am familiar with the real needs of low-income people because I am one of them”. Another added that “In general, low-income people ask for no more than two bedrooms housing units and this is what I design. We even made an assumption for the furniture of rooms and baths. By doing so we consider the appropriate cultural and design criteria. People participation would not enhance design. I believe that as long as we are not talking about luxury houses people can live in one housing model as they have no practical opportunity for choice”.

For other designers identifying user needs in the housing units designs should be through social research and case study analysis. One of them argued that “the best actions taken by the government in terms of the design of low-income housing projects were those which commissioned a research agency, such as our center, to design some housing 'models' for low-income people.” According to these designers, this is because lay people usually do not have sufficient knowledge or an appropriate educational background, which is essential for their productive involvement in the design process, or because they are unable to articulate their opinions and values. According to them, this has resulted from government adopted political and social systems. They added that user involvement in the design process is difficult practically. One of them asked “how can users be involved if you are designing for more than 70 thousand users. With whom can I sit down and discuss the design?”.

Users’ attitudes towards their involvement in the design process of their residential environment

As opposed to attitudes of the designers, a considerable percentage of the users interviewed in the research believe that their direct participation in the design process, particularly in the housing unit design, is essential. In terms of the design process of urban spaces, 40.8% of the respondents disagreed with the professional dominance of this process because they believe that designers had committed technical mistakes, which could have been avoided if they had participated. For example, one respondent said that “They [professionals] made very wide streets and open spaces while the open spaces between residential blocks are mostly narrow violating the privacy of residents”. Another resident added that, “it is essential to link technology and science with the real life experience. The planner or the architect has academic experience put lay people have the real life experience and feeling towards these issues. That is why their opinions should be considered”.
One the other hand, 59.2% of the respondents felt that the urban design process should be left totally to the professionals who are educationally and professionally qualified to carry out the design for urban spaces believing that residents have no particular knowledge that can contribute to this process. One of the residents argued that, “it is essential to have professional intervention in the determination of streets widths and locations. Government professionals do the right thing. They make wide streets that could accommodate vehicle traffic and people’s activities. Wide streets are also appropriate for ventilation”.

In terms of the design process of dwellings, a significant number of respondents prefer to be involved directly in the design process with professionals. 55% of respondents preferred to design their dwellings with help from professionals because they think that professionals will give them effective technical advice and support. Meanwhile 24.2% preferred to design their dwellings by themselves without help from professionals. Many residents think that design alternatives might not satisfy their preferences completely so that only 20.8% of the respondents preferred to choose from design alternatives designed by professionals.

Towards a genuine change in the design for low-income people in Egypt: a discussion
Many architects interviewed in the research argued that they could learn more about user needs through the methods of social science researches and case study analysis. For them, the study of man-environment relationship and the analysis of human behaviour in residential environments have been the tools to develop methods for putting users' considerations into the design process. In fact, it has been claimed that the outcomes of these trends were not as promising as had been envisaged. Social architecture has been criticized by scholars such as Roonrakwit (1999: 40) who argues that “It can be an interesting exercise for architects to study the housing needs of low-income communities, and to then produce ready-made house models designed to meet the needs and affordability of the poor, based on that research. But ‘standard’ designs produced in this way often end up being scrapped by the poor.”

According to Lawrence (1982), the socio-cultural values of users are implicit in nature, therefore, they are rarely revealed by traditional environmental psychological research methods. Lawrence criticizes deterministic design methods used to interpret the relation between the social and the physical worlds of people. He maintains that no series of ‘paper and pencil tests’, which have been adopted by social scientists and designers to generate checklists or recipes for design, can successfully define the diverse nature of physical cues, or the various social and personal roles which serve as codes in the definition and use of architectural space. He adds that it is obvious that there is no single design recipe, which can respond to the complex nature of the relationships between people and their built environment. Sanoff (1990) claims that people have different needs, hence, any attempt to create a single standard ‘ideal’ environment works to everyone’s disadvantage. Housing design programs, relied on such an idealised stereotype about the occupants’ needs and preferences, do not always produce satisfactory projects. Even when institutional clients rely on building committees to advocate the user’s point of view, unfortunately, these committees are often far removed from the actual needs of those who actively use the housing units.

Accordingly, the design of low-income housing projects should be considered as a process and not as an artistically rigid product. Such a process should give a real chance for the poor to participate and not only be merely impressed by architecturally superficial expressions. In Egypt, as in most developing countries, user needs have to be politically and professionally addressed as significant in developing a new paradigm in low-income housing design. It is envisaged that user participation could be achieved through a particular framework derived from the Egyptian socio-economic context and related to its cultural heritage. At the same time, it has to benefit from the contemporary
expertise. Antonio (1985: 45) argues that "Egypt is part of the world community and its intellectual resources argue that specific solutions should be found, compatible with both, its cultural traditions and contemporary issues."

Conclusion

The Mubarak housing project, which the professionals have claimed to be a significant design success, is, to a large extent, designed in the same rigid way as the previous conventional public housing projects. The major changes are superficial and cosmetic. The 'Expert-based' design process adopted in this project, in which any real changes should take place, remains intact. It is proposed that these changes have originated substantially from the ambitions of politicians, which architects have realized through their artistic expression, rather than as a reaction to real user needs.

Although it is argued that users' needs cannot be met without their direct involvement in the design process, many designers of low-income housing in Egypt believe that user needs could, and should, be deduced from field work research and by the analysis of relevant case studies without the necessity of direct user involvement in the design process. In fact, the outcomes of social and environmental behavior studies were not as fruitful as it has been anticipated. On the other hand, a considerable percentage of the low-income residents involved in this research believe that their direct participation in the design decision-making process is fundamental to satisfy their real needs especially in the design of their dwellings.

As in the case of Egypt, most of the governments and design professionals in the developing countries have adopted similar top-down design processes for housing the urban poor. Thus it might be argued, not only in the case of Egypt but in most of the developing countries, that the results of this research reveal a crucial need for developing a low-income housing design paradigm that enables the poor to participate in decision making processes and not become mere recipients of a housing product, which reflects superficial architectural expressions.
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A control based approach to artificial design and plan generation

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Abstract

In this paper we discuss artificial plan designing as a research field that deals with the development and use of computational models to support the generation of design descriptions in architecture and urban planning. We discuss some crucial methodological issues and we present a model for artificial design generation based on learning control methodologies. The design problem is defined as a search for "coordinated" solutions (changes) that satisfy distributed domain requirements and views expressed by human or artificial agents. The model is simulated for a land use and layout plan design problem seen within the context of a hypothetical urban development assignment.
A control based approach to artificial design and plan generation

Introduction
Designing is recognised to be a natural human activity and thus inherent in professional practice, irrespective of the scientific domain (Simon 1996:111). In this paper, we are interested in designing as it is seen in architectural and urban planning practice. In engineering and architecture there is a significant body of research around different aspects of the design activity, but urban planning practice seems somehow disconnected from research in design methods and processes. However, a lot of researchers do suggest that design is an integral part of good planning, mainly underlining the need for producing and evaluating alternative plans (Batty 1974, Harris 1998, Hopkins 1998a, Alexander 1992, Schlager 1965). Urban development problems are typically in between the architectural and urban scale and so are seen as a good paradigm for investigating common routes in design methodologies and techniques developed in the different disciplines.

On the other hand, designing is also recognised to be a potential "artificial" task. Despite the complex and elusive character of design, formal models and their computational counterparts have been developed, for some 40 years now, to simulate or to support design – "both as a cognitive activity and as a domain"(Liddament 1999: 43). The use of computational models to generate design descriptions seems to be a common ground among different research fields although their meaning, the methods used and their scope varies. Different terms have been used to describe the purpose or the nature of these models such as automatic (e.g. Steadman 1970, Cross 1977, Eastman 1973), generative (e.g. Brill, Flach, Hopkins and Ranjithan 1990, Chien and Flemming 2002) or creative (e.g. Gero and Maher 1999). In urban planning a typical application addresses the problem of land use-transportation plan design (e.g. Feng and Lin 1999, Aoki and Muraoka 1997, Anderssen and Iven 1992), while in architecture the dominant example is in building layout design (e.g. Mitchell, Steadman and Liggett 1976, Liggett 1985, Chakrabarty 1990, Jo and Gero 1998). In this paper a model for simultaneous generation of facility location and building layout plan design is presented. In the following, the terms "artificial plan designing" or "plan generation" will be used as umbrella terms to refer to all these models.

Designing, whether it is based on "artificial constructs" or directly on human decision-makers, points typically to the formulation of plans. Looking at the definitions of "plan" in different disciplines (Alexander 1992, Schlager 1965, Hopkins 1998a, Dorst and Cross 2000, Houkes, Vermaas, Dorst and de Vries 2002, and Kroes 2002), however diverse, can help us distinguish a common view. A plan by and large represents decisions to be implemented in order to satisfy current and future goals (and/or constraints); a plan is the design of actions that will lead to future changes. However, the relation among designing processes, design artefacts (plans) and real world artefacts varies across disciplines and according to the nature of the system to be designed (e.g. if it is a building or a city). This variation reveals different interpretations of designing. In some cases, designing is coupled directly with the real world artifact without the explicit mediation of a plan. Christopher Alexander's (1979) work on "pattern language" actually sets up a plan that works more like a social knowledge source, rather than a blueprint that is well established before its implementation to the real world. More recently, research on the field of intelligent (kinetic) buildings and robotics (e.g. Fox 2001), anticipate - to some degree - the reality of a tight coupling between designing and real-world reformulation (Brazier, Jonker, Treur and Wijngaards 2001: 470). In parallel, plans in the context of urban development are very much part of the problem they attempt to solve and the designing activity tends to be seen more as a positive-descriptive rather than a normative-prescriptive activity. Naturally, formal design models mirror the discrepancies
among various interpretations of designing and thus a wide range of different methodologies have been developed in relation to different views of the design problem.

In the following section we will discuss some theoretical and methodological issues pertaining to artificial plan designing. The attempt will be to provide a broader picture in artificial plan designing as a vehicle to discuss some key issues, which form the basis of the argumentation for the development of the proposed model (presented in the last two sections). In this model, the simultaneous generation of land-use (facility location-allocation) and layout plan design is elaborated. The design problem is defined as a search for locations and physical layout proposals that satisfy distributed and time-variant requirements or targets. Expert knowledge for this search is not explicitly incorporated in the model but a Neural Network (NN) architecture is used instead to discover and represent knowledge captured as interdependencies among decision variables expressed by distributed sources (decision makers or their domain models). We present a model-tool that learns from user interaction and then uses this knowledge to search and generate design proposals. For the simulation of this model we take a hypothetical urban development assignment that aims to the development of a housing and retail unit. The attractive point in this framework is that we have to consider a simultaneous and constant generation of alternative plans, both in the architectural and the urban scale, from the preliminary stages of the plan design. Additionally, requirements and targets are typically distributed among different teams and vary in time according to the emergence of new conditions (Cadman and Topping 1985).

Artificial plan designing
Before we proceed with the presentation of the model it would be useful to see the broader picture in artificial designing and discuss some crucial theoretical and methodological issues. We will discuss in more detail three key hypotheses that form the basis of our argumentation: distribution, coordination and learning.

Some typical methodological approaches in artificial plan generation
Optimisation has been the predominant approach to automated plan design, in urban planning as well as in architectural and engineering design (Gero 1985, Harris and Batty 1993). The design problem is translated into a search for design(s) that represent optimum solutions. Thus appropriate methodologies need to be devised to generate and choose solutions that optimise some utility or cost function under a number of constraints. There are different formulations that fit to this paradigm which employ techniques ranging from mathematical programming (e.g. Anderssen and Ive 1982, Mitchell et al 1976) to multi-objective (e.g. Balling, Taber, Brown and Day 1999, Chakrabarty 1990) and genetic programming (e.g. Aoki and Muraoka 1997, Caldas and Norford 2002).

An extended view of the above paradigm includes the development of search-based or heuristic models. The design problem and formulation emphasizes the exploratory view of designing. Those approaches might include optimisation concepts and techniques but are mainly associated to the concept of "systematically navigating in a space of possibilities" (Akin and Sen 1996: 421). For instance, Akin's et al (1992) search based model puts into practice a quite comprehensive interpretation of design problem solving based on a "generate and test" search paradigm. Another early but lucid example includes Steadman's work (1970) on small-scale layout plans based on the exhaustive search of all possible topological dissections of rectangular layout plans. Other heuristic methods vary from the simple overlay of spatial constraints (Alexander 1962) to its more sophisticated weighted analogue -the so-called potential surface technique- (e.g. Haubrich and Sanders 2000), and to averaging conflicting factors based on probabilistic Markovian processes (Batty 1974).
A third paradigm emphasizes the fact that plan design is a creative process. Evolutionary search, based on the biological analogy of the natural evolution of species, has been the predominant approach on creative design in architecture, art and engineering (e.g. Bentley 1999, O'Reily, Testa, Greenwold and Hamberg 2001, Frazer 1995). The emphasis here is on replicating the creative process of designing rather than replicating the searching activity, which more formally is associated with a process of evolving the number of the decision variables together with their values (Gero 1994, Bentley 1999: 38-42). Unfortunately, in the planning domain - as far as the authors are aware - not much attention has been paid to creative aspects of plan generation. Evolutionary algorithms in planning have been used mainly for optimisation rather than for creative search. For example a tool called Sketch Layout Model (Feng and Lin 1999) combines a genetic algorithm with multi-objective programming in order to produce a set of alternative land use plans. In the context of planning the search for alternative plans that satisfy multiple criteria or objectives comes as a consequence of the social nature of decision-making rather than as a quest for creativity. However, research on sketch planning does signify an attempt to support in some formal way the intuitive and innovative aspects of plan designing (Harris 2001, Hopkins 1998b, Singh 1999).

Shape grammars constitute a distinctive approach in artificial plan generation, based on generation rules expressed as algebras or formal grammars. Typical shape grammars are founded on a "vocabulary of shapes and arrangements of these shapes into spatial relations" (Knight 1994: 705). This is another potential plan generation process based on selection, creative exploration and emergence (Stiny 1994) but unlike the above paradigms the emphasis is on the morphology and attributes of the design artifact itself rather that on the design or decision making process. Arguably, creativity and innovation are important issues in plan designing which usually relate to a task of employing known solutions to a new context (Gero 2000). Case Based Reasoning (CBR) deals with such issues of creativity. CBR as has been used in design automation, starts from the recognition that knowledge is distributed to design cases which can be adapted and reused in similar contexts to support creative reasoning (e.g. Maher and Pu 1997, Yeh and Shi 1999). In this sense, learning is also an implicit function supported by the continuous adaptation and re-evaluation of cases.

Research in Multi-Agent Systems (MAS) has brought to light another critical issue in design; that is the distributed and collaborative nature of the design activity. In most design projects, the interaction of different experts and stakeholders, or more generally, the concurrent interplay among different knowledge sources, is paramount. Even though other models such as CBR systems deal with issues of design reasoning and knowledge distribution, these models do not "explicitly model the reflective reasoning required for multi-agent distributed design" (Brazier, Moshkina and Wijngaards 2001: 138). The concept of agency and the ideas behind MAS have been adopted to model design activity (e.g. Gero and Fuji 2000, Brazier, Jonker, Treur and Wijngaards 2001, Liu, Tang and Frazer 2001), usually by integrating knowledge level models. The focus is on the development of autonomous design agents capable of reasoning about their own plans and targets, and capable of reflective reasoning about other agents and needed interactions. A wide range of issues is associated with the development of MAS such as emergence of new structures from local interactions, coordination of conflicting partial plans, and learning.

The plethora of methodologies briefly reviewed in this section discloses a plethora of ways to understand designing. In this paper we will consider plan designing as a search for "coordinated" solutions (changes) that satisfy distributed domain requirements and views. Learning control is seen as a method to search for solutions that direct partial descriptions to follow their (dynamic) targets despite conflicting requirements. There are three hypotheses behind this view: the first is that decision making is distributed among multiple agents, the second is that some kind of coordination needs to be reached among these diverse requirements and purposes; and the third is that domain
knowledge cannot be defined a-priori in this context, but some learning mechanism needs to be
devised to capture distributed knowledge and effectively use it to generate plan designs.

**Three critical hypotheses for the proposed model**

The first hypothesis is related to methodological issues. Current practice in research related to
design and planning support indicates a shift from designing based on individual action to designing
based on collective-distributed action. Designing is a distributed activity that involves multiple
agents (human or artificial) which are sources of diverse and often conflicting knowledge, and
express individual views and goals. Design and planning as social phenomena have been typically
discussed in positive-descriptive terms. On the other hand, designing from the viewpoint of the
individual designer has been mainly addressed through normative approaches (Batty 1984: 280). As
Batty (1984) suggests, these two viewpoints are not necessarily in opposition. Designing as a
process of collective or distributed decision making implies that the normative activity of change is
set under the weight of a collective dynamic, which also underlines the fact that plans are not only
prescriptions for the future but they are also descriptions of future changes.

In this sense, it is probably fair to notice that we have moved from the use of computational models
and machines as automatic design devices to the use of computational models that support the
generation of designs through user interaction. In the context of multi-agent design this interaction
is distributed in networks as can be documented by current interest in collaborative design and
planning and Computer Supported Collaborative Work (CSCW) (e.g. Coyne, Sudweeks and
making suggests that knowledge is also distributed, not only because plans are collectively formed
by communities (or multidisciplinary groups), but also because even expert reasoning is fragmented
into diverse goals, criteria and evaluations.

Naturally, in the context of distributed decision-making, plan design involves searching for
configurations that reduce or resolve conflict among distributed goals. Broadly speaking we can
distinguish three typical structures in distributed systems. The first appoints a collective function
that needs to be optimised for the sake of a "social welfare", the second leaves the dynamic among
the involved parts to determine the distribution of welfare, and the third directs the distribution of
welfare equally among the involved parts. In decision sciences formal definitions include concepts
of bargaining, negotiation, conflict resolution, social choice, consensus or cooperation (Kleindorfer,
Kunreuther and Schoemaker 1993). Similar approaches have been developed in the context of
artificial intelligence (Ossowski 1999) and some relevant examples in operational research can be
found in Batty (1984).

In this research, plan designing, in the light of distributed decision-making and conflict resolution,
is seen as a coordination problem. Coordination is extensively discussed in the context of
organisational decision support systems (Grandori 2001, Malone and Crowston 1990) and is a
recurring issue in the literature on distributed artificial intelligence and multi-agent systems
(Ossowski 1999, Jennings 1996). Whether talking about actors or agents, human or artificial,
coordination is what makes them act as a distributed system and reach solutions on the basis of
managing interdependencies among individual requirements. In the following we will introduce the
idea of coordination as a learning control problem. Learning corresponds to a process of capturing
interdependencies among decision variables, while control corresponds to a process of using this
knowledge to generate control actions (plans) that meet time-variant individual targets, despite
endogenous uncertainties or exogenous disturbances expressed by distributed agents. In this context
creativity and innovation lies in the possibility of unforeseen solutions emerging through agent
interaction and learning.
Finally, the third hypothesis relates to the question of how domain or descriptive knowledge about the system to be designed is incorporated within the model. Very often, domain knowledge is seamless with the proposed model. For instance, facility planning has been extensively addressed with respect to studies on user behaviour, thus building models (e.g. gravity based models) that represent this behaviour. So the design of optimum location-allocation plans is strictly depended on this predefined formulation of user behaviour. On the other hand, in MAS this knowledge is distributed to local agents and global patterns of behaviour emerge by local interaction. Thus, knowledge about the system behaviour is not a priori defined but rather it emerges as the collective design process progresses. In CBR systems domain knowledge is incorporated in cases and it is also dynamically updated by user interaction. In those two last paradigms learning is an implicit function of the system that supports the maintenance, reuse and adaptation of knowledge (Liu et al 2001). In parallel, learning is also an implicit function of design especially when it is conceived as a problem of coordination among distributed plan formulations. So, learning is a source of plan actions for design, which is enhanced in the course of the design process. In this research, learning is seen as a natural way to reduce conflict in distributed systems. Learning associations among decision variables that keep design descriptions of individual agents (human or artificial) within their dynamically defined targets, can be used as a mechanism to produce plan descriptions that coordinate conflicting requirements and views. We use distributed neurocontrol as a paradigm for artificial plan generation based on learning.

**Plan description**

We consider that plan descriptions are built on distributed domain problems and/or partial proposals developed and controlled by agents (human or artificial). For instance, a trivial location and space layout problem may involve various groups of agents: one that defines the appropriate location, another that designs a suitable distribution of volumes, a third that designs a potential spatial distribution of rooms and a last one that is involved in the structural engineering of the building. Each agent is self-interested and represents a partial component of the overall description. Agents’ proposals are considered to be partial not only because they convey domain-specific knowledge about the design problem, but also because these proposals are incomplete and change in time according to changing situations and new knowledge gained in the process.

In the context of this paper, plan descriptions are generated within a virtual reality (VR) world and are composed by aggregated objects introduced by users. Objects are justified on the basis of a "purpose" for the design assignment. For the simulation described in this paper we used three objects (initially in the form of three cuboids) located in a hypothetical virtual city, which represent the preliminary development goals for a housing unit, a retail facility and an open space. Plan descriptions (figure 1), and hence object specifications, are dynamically generated and modified through the interaction between human actors (or their computational models) and artificial agents that act as controllers. Controllers-agents are also justified on the basis of a "purpose" (namely the "purpose" of the corresponding objects) and will be described in more detail in the next section. So, plan descriptions work as an interface among human operators and artificial controllers-agents. The extent to which the overall model for plan generation is working autonomously from human operators, depends mainly from the degree to which formal models are incorporated as domain knowledge sources. Apparently, another issue that relates to the autonomy of the model is the definition of the objects. The way to which objects are defined determines the subject of control wielded by human operators or their models. In other words, the "granularity" of the objects may determine the scale to which we study the design artefacts, and the depth to which we manipulate their characteristics through human-model interaction.
The objects within the VR environment are built on three classes of information: Structural, Behavioural and Functional (SBF). The meaning of the SBF framework for the plan design has been extensively discussed in literature and in a variety of different contexts (e.g. Gero 2000, Gorti, Gupta, Kim, Sriram, and Wong 1998, Szykman, Racz, Bochenek and Sriram 2000, Narasimhan, Sykara and Navin-Chandra 1997). In this paper we will only discuss briefly how this framework is adopted in the context of urban development.

Formally, each object is specified as a row matrix: \( A_i = [S_i, B_i, F_i] \). The overall plan description is the column matrix \( P = [A_i] \) of all these objects. Structural information specifies the elements of the proposed plan, their attributes and their relations. For the simulations presented in this paper structural information depicts the physical components of the objects and their topological relations. So, for instance, for an object \( A_h \) (housing), structural information includes location \([x, y]\), volume dimensions \([z_x, z_y, z_z]\) and relations with other objects such as: distance to other facilities - like retail and open space - \([d_r, d_o]\) and adjacency to north, south, east and west, with other buildings.

Behavioural information specifies the way each object reacts to changes of its state and its environment. Behaviour is a description of change of the design objects in order to reach their intended functions. For instance new land uses tend to be developed close or far from other existing land uses in order to fulfil their functional requirements. The Newtonian function of "motion" has been used to model this behaviour, as will be described later. Also, other formulations (like fuzzy inference systems) have been used to describe the tendency to develop more extended, detached building surfaces facing south, or the tendency to maximize ground floor area for retail uses. Development cost is also used in some cases to describe tendency to profit from cheap land prices and exploit larger floor area. Finally, we consider that functional information represents the ontology and purpose of the proposed objects expressed as land use – in our case housing, retail, and open space. The above formulations are given mainly as examples rather as strict definitions of the SBF framework in the context of urban development.

**Artificial plan designing as control-based coordination**

The design problem is formulated as a coordination problem among self-interested agents (which are represented as cuboids in the VR world) and is addressed via a distributed learning control methodology. In general the idea can be summarised as follows: a learning algorithm is used to train a neural network to discover associations among Structural, Behavioural and Functional
attributes (in this paper we use off-line training). This knowledge is then used to generate plan descriptions, based on partial information presented to the NN, which will satisfy a temporal (preliminary) reference target for the SBF attributes. For each agent we assign a control architecture which seeks to stabilise SBF interdependencies under internal variations and external disturbances presented by the other agents. Even though there are several different control-based formulations that might be reasonable for coordination problems (for a different formulation refer to Alexiou and Zamenopoulos 2001), we will present here one, which addresses coordination as a self-control problem aiming to satisfy temporal targets, despite conflict expressed as disturbance in the control framework.

More analytically, each self-interested agent carries out two combined control-based activities: the first alludes to a synthesis-analysis-evaluation route expressed as a function among Structural Decisions S, Expected Behaviour B_e and Actual Behaviour B_s. The second activity alludes to an evaluation-formulation-reformulation route expressed as a function of Actual Behaviour B_s, Expected Function F_e and Actual Function F_b.

The objective of each agent is to find a suitable path of structures S that lead the behaviours B_s, to follow a reference (expected) behaviour B_e, despite uncertainties and despite exogenous disturbances Sd produced by other agents’ decisions. The expected behaviour B_e is defined by a reference model, which is developed following a similar control process. The objective in that case is to find the appropriate behaviours B_e that lead the function F_b, to follow a reference (expected) function F_e, despite uncertainties and despite exogenous disturbances Bd (figure 2). Hence, the desired performance of the synthesis-analysis system is evaluated (denoted by E in the figure) through the reference model (formulation-reformulation) which is defined by its input-output pair (F_e, B_e). The control system attempts to make the plant model follow the reference output B_e asymptotically:

$$\lim_{t \to \infty} |B_e - B_s| < \varepsilon, \quad (1)$$

where _ is a positive integer.

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**Figure 2: Plan generation as a control process**
To sum up, what we call synthesis is the control process that aims to stabilise the state space (behaviour) of an agent according to a reference value for the behaviour $B_e$; and formulation is the control process that aims to stabilise the state space (function) of an agent according to a reference value $F_e$. Evaluation is the process of measuring the degree of "matching" between the two control systems. The control signals $St_1, \ldots, St+n$ produced by this combined control process consist a set of evolving plans (proposals) for the design and planning problem in hand. The process of artificial generation of plans based on learning control is a process of self-adaptation of agents that leads to coordination of their distributed descriptions. Going back to the methodological issues discussed in the previous sections, we visualize here the possibility to formulate plan descriptions using knowledge acquired and learned through the interaction of human and artificial agents. This can potentially extend the role of "design tools that learn" (Gero 1998) to support collaboration and coordination in distributed decision making environments.

**Simulation**

The above model is developed and simulated in a MATLAB-SIMULINK (Mathworks, Inc) environment. We are experimenting with Adaptive Backthrough Control architectures. These structures typically use two neural networks: the Controller (the system that controls) and the Plant Model (a model of the system to be controlled) (figure 3). First, the plant model is trained to approximate the plant by learning, on-line or off-line, input-output patterns of the agent behaviour. Then, these patterns are used "backwards" as a guideline for the controller (Kecman 2001). In our case the plant has been implemented as a compact block of three objects that represent the design and planning reasoning of the three agents that stand for the different development goals. For the purposes of this simulation we do not introduce human operators but we rest on formal descriptions to represent them. The plant model identifies the behaviour of those agents and this knowledge is used to train the controller to find appropriate patterns that can be used to satisfy the goals directed by the reference model. The reference model is essentially a prototype of the system that produces time-variant goals (target behaviours) for the controller, and corresponds in our case to the formulation-reformulation phase of the design description. The structure of the reference model as described previously, is a control architecture similar to the one focused on the synthesis-analysis process.
We have experimented with mathematical formulations that model agent behaviour (like motion, shape transformation and costs) based on state space methodology, as well as with fuzzy systems. As an example, the "moving behaviour" of the land use $j$ is described by $n$ equations (for $n$ land uses) as follows:

$$m_j x_j'' = \sum_{i=1}^{n} k_{ij}(x_i - x_j), \quad (2)$$

where $m_j$ is the floor area of the land use $j$, $x_j$ is position, $k_{ij}$ is the interaction matrix between land use $j$ and $i$, and $x_j''$ is the second derivative of the distance. Fuzzy systems are built on the basis of fuzzy IF-THEN rules, which for example may represent qualitative evaluations about the fitness of a specific location based to criteria of proximity with neighbouring facilities (figure 4).
Figure 4: Agent reasoning as a fuzzy system

The Virtual Reality toolbox offered the possibility to visualise the evolution of the design-decision space. We can directly retrieve and manipulate the location and shape variables of the three objects and view the conflict as it evolves in the three dimensional space (figure 1).

So far we have focused on the interaction among the three objects within a neutral (void) space, so the next step is to build an environment that allows interaction to be extended beyond the three objects alone and poses further restrictions and requirements. We are currently working towards two different directions: one is to connect the VR world with a spatial database, and the other is to attach sensors to the three objects so that they can recognise their environment. Those two directions represent two alternatives: to incorporate a model of the environment in a knowledge base for the agent, or to equip agents with the ability to recognise their environment at any given time.

**Conclusions**

We presented a model for artificial plan designing in architecture and urban planning based on learning control methodologies. The control-based approach in artificial plan designing is developed with the intention to address three crucial issues pertaining to current research on the field: distribution of knowledge and decisions, coordination and learning. The work presented here is a first attempt to develop a model that supports decision making and generation of design descriptions using knowledge captured dynamically through agent interaction. The aim of this paper is not to understand human design cognition or explain the design process, but rather to explore the meaning and the scope of artificial plan designing in architecture and urban planning. To this end common methodological routes are explored from the computational intelligence perspective. Testing and validating such computational constructs is an important issue. One approach is to have the resulting plan descriptions evaluated by domain experts. Another possible approach is to stage different conflict scenarios and review the rationality of the results for each specific case. The efficacy of the model is very much related to its learning performance and mode (e.g. on-line or off-line), so further research has to be done to this direction.
References


Developing a method to support human centered designers in forming arguments: intertwining practice and theory

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Abstract

This paper describes a design research project that was undertaken using a human-centered design approach. We first discuss why we believe our project combines an interesting mix of theory and practice. We then establish the locus of our research around one piece of the human-centered design process. To address a problem we call the "analysis-synthesis gap," we present the Elito method as a solution. We then describe our process and results of testing a prototype of this new method. We conclude that our approach was one way of coming to rich conclusions about the theory and practice of the Elito method in a short period of time.
Developing a method to support human centered designers in forming arguments: intertwining practice and theory

Introduction
While candidates for the M.Des. degree at the Institute of Design, IIT, we spent fourteen weeks researching and developing an immediately applicable design method for developing user-centered design arguments. We refer to the method by its developmental code name “Elito”.

Our research and development process combined design practice with design theory. Accordingly, we asked two questions: “What activities occur as people use Elito?” and “Why does Elito support those activities?” To answer the first question, we employed human-centered design practices. With an extended test of a contextual prototype, we looked for patterns of how Elito was used. To answer the second question, we took our insights from the patterns of practice and used them to direct our search for theories in design and other disciplines. We integrated research from the fields of cognitive psychology, narratology and rhetoric. These theoretical works were influential in developing the Elito method as was the practice of observing designers using a prototype of the method.

We begin the review of our development process by discussing the specific area of human-centered design process in which we are interested and for which we propose the Elito method.

In discussing important issues for the future of “new design thinking” Richard Buchanan has offered the following:

“It is no longer useful or appropriate to consider the audience of design as passive creatures who may be manipulated by “messages.” We seek the active engagement of human beings in experience, and we see communication as the creation of “arguments” which human beings are called upon to evaluate and judge for themselves” (Buchanan 1999: 4).

For the human-centered designer, the “audience” includes many people. It is essential that other designers, teammates and clients be able to follow the logical arguments the designer constructs. Human-centered designers construct stories or arguments that present a concept that solves a human need. The outcome of this work is often a story or argument which describes the relationship between a real user and the concept. In practice, these stories are about innovative businesses, products, services or approaches; they must be evaluated and weighed against real business constraints like cost and time. If a human-centered designer does not present a sound argument, then people cannot judge the feasibility of the concept.

Analysis-synthesis gap
We conceptualize the process of user-centered design as a progression through four stages: research, analysis, synthesis, and realization as pictured in Figure 1. It is important to note that “understand” and “create” are on opposite sides of the horizontal axis. This implies, and our experience supports, that the process of analyzing data is fundamentally different from the process of creating ideas.
Human-centered design is defined, in part, as seeking to understand by way of observation the day-to-day lives of people and then creating products and services that extend from this understanding. In keeping with these goals, building sound arguments to support these concepts with observation and insight is critical, but difficult to do well.

Analysis methods that operate directly on observations are fairly well established and understood, not only by designers, but also by anthropologists and ethnographers, who traditionally seek understanding and description of human behavior. Synthesis methods for incorporating user research are rare by comparison. Designers have identified difficulty in integrating social science research into design practices (Melican 2001). We call this the “analysis-synthesis gap.” We hypothesize that the analysis-synthesis gap contributes to the creation of unsound design arguments.

Figure 1: Human-centered design process

Human-centered design process

1. Analyze
   - Understand complexity through structured methods
   - Use graphical tools for insightful results
   - That leads to a synthesis of ideas

2. Realize
   - Outcome oriented process for communicating finalized plans
   - In a compelling way to inspire implementation

3. Research
   - A process to gather information through primary and secondary sources to build a rich context

4. Synthesis
   - A solution oriented process using structured methods to generate patterns for problem solving which lead to new concepts and plans
and seek to examine how Elito aids the designer in creation of sound arguments for concepts derived from observation.

Methods linking analysis to synthesis
In the initial phase of formulating a method, we looked for other methods or theories that attempt to address the analysis-synthesis gap. Through interviews with experienced design practitioners, we found that when faced with the integration of user research they improvised a personal ad hoc method. While there were a variety of implementations, most of these improvised methods followed a simple process to make explicit the links from observation to concept or prototype. We also found two formalized approaches that link observation to concept in use at the Institute of Design.

The first of these examples is the User-Centered Case. The User-Centered Case is a theory for the structure of a human-centered design argument, taught and researched by Associate Professor John Grimes at the Institute of Design. It offers a rigorous outline for an argument drawn in part from the study of rhetoric. The outline specifies the components of the argument and ideal relationships between components. When a designer completes the outline, the resulting argument sets up a sound rationale for a concept by building up from observations, contentions, and values. Elito deliberately accommodates the core of the rhetorical elements of the User-Centered Case. However, it should be noted that the full case is more comprehensive, containing many additional components, specifying discussions such as scope, scale, competition, and solution scenarios (Grimes 2001).

The User-Centered Case does not prescribe a working method for capturing and refining an argument. In contrast, the use of the Elito method proposes a table structure in which to capture ideas and to guide the refinement of those ideas. The structure promotes the separation of an argument into its theoretically specified components, improving the ability to isolate and thus improve the weaker elements in their context.

The second formal method that incorporates mechanisms for creating sound human-centered design argument is Structured Planning. Structured Planning is an extensive and rigorous method of developing a design plan, developed and taught at the Institute of Design by Research Professor Charles Owen. The method is well respected for its ability to tackle very large-scale design problems and for the use of custom computer programs for clustering ideas. Structured Planning is implemented as a series of documents, each an empty form to be completed by the designer. Perhaps the most important element, the Design Factor form, requires a discussion of insights taken directly from observation and links these insights explicitly to named concepts (Owen 2001). The Design Factor form thus documents the human-centered motivation for concepts in a holistic manner.

Analogous to a Design Factor, Elito proposes to locate observation, insights and concepts close together. In doing so it captures and documents the core of the human-centered design argument. For designers who are engaged in building large systems, the Structured Planning process is one of a few viable options, but for more routine planning exercises, Elito makes accessible the same holistic approach to developing and supporting a concept found in the Design Factor.

Introduction to Elito
In Elito, the designer places the content generated by the four phases of the design process (research, analysis, synthesis, and realization) into a single table, which gives the designer a holistic view of his or her design problem and solution space. The content may have been gathered using other methods and tools. For example, observation might have been gathered through video or field notes, and early concepts might have been generated through brainstorming or culled from
secondary research. Elito helps designers make the links between these bodies of content explicit during development and presentation of design concepts. The links are both visual and rhetorical.

In table format, the Elito method creates a visual field for the design content. By collocating the stages of the design process, the grid creates a “deeper structural view of the situation” which supports problem solving in two directions, “getting a whole consistent picture, and seeing what the structure of the whole requires for the parts” (Wertheimer 1959: 212).

This table structure is also a device for creating a rhetoric. When the designer conscientiously creates links between elements, he or she authors a line of thinking that can be considered a design argument or narrative. The content of one row of the table can be likened to a classic syllogism (Roberts 1994). To further this storytelling aspect, designers assign metaphoric labels to the row.

Figure 2: Example of student work in Excel spreadsheet
Using Elito

Elito is currently arranged as a table in Microsoft Excel as pictured in Figure 2. The columns are defined as key metaphor, observation, judgment, value, and concept or criteria as described in Figure 3. The designer’s task is to fill the rows and columns with content and then assign a short evocative label to each cell he or she creates. We refer to the content of each cell as an “entity” and the relationships between entities as “links”. An entire row is called a “logic line”. Although the table format never changes, we have observed designers’ work in Elito very differently depending on the stage of the design process in which they are engaged. Conceptually, Elito can be thought of as simultaneously housing many activities of the research, analysis, synthesis, and realization stages. Although for the purposes of this paper we discuss these phases as though they formed a linear progression, we recognize that in practice designers move in and out of these stages non-linearly.

Figure 3: Elito entities and relationships
Getting started in Elito
At the start of a design project, Elito serves as a repository for observations collected from primary and secondary research. It allows the designer to collect early, undeveloped ideas, judgments and values.

The designer should strive to capture every thought in coherent short phrases or sentences. A single phrase should occupy a cell. These should be written so they are comprehensible to an outside audience. This heuristic will help the designer share his or her work with other teammates and clients. In addition, it helps the designer recall his or her own train of thought later.

During the early stages of using Elito, designers should avoid placing unrelated content in adjacent cells. An Elito table makes a visual field of the design process; designers should be conscientious of the visual gestalt. A line which is full from left to right may feel complete because it offers visual closure, not because it is well considered (Wertheimer 1959).

Research to analysis
During analysis, designers begin to extend observations toward concepts. In Elito, the focus now is on linking observations to judgments and values. During this phase, designers label entities and build relationships between them. These critical exercises may inspire generation of new content as the designer divides cells into smaller chunks or moves, repeats and cuts existing cells.

Labeling each entity with a compelling and metaphoric phrase requires designers to think critically about the content of each entity. The quality of labeling is enhanced by working in teams. This activity promotes communication between team members and contributes to a shared team vocabulary for the duration of the project. Creating evocative labels at this stage recodes these entities as “chunks,” enabling designers to better hold, compare, contrast, mix, and match ideas simultaneously. As Miller suggests, “the simplest (way to recode) is to group the input events, apply a new name to the group, and then remember the new name rather than the original input events” (Miller 1956: 81-97).

Analysis to synthesis
When moving from analyzed data to synthesized concepts, the method and structure of Elito support designers in a manner consistent with the non-linear design process. The burden of trying to get from observation to concept is lessened by “staging” the creation of the logic line. Staging eases the cognitive load required to solve the problem because designers may focus on the entity, the relationship between two entities or the relationships across the entire line (Cooper 1998).

Synthetic activities in Elito include creating labels that link all the way across a row in a thematic manner, exploring multiple user perspectives, and examining simultaneous value sets. Any of these activities may yield new concepts or other entities.

During synthesis, designers should be critical of how complex logic lines are created. As illustrated in Figure 4, a complex line is a logic line that has multiple entities in any one column. One observation may yield several judgments and each judgment may have a different value or concept. To preserve clarity of argument, the method requires every complex line to have a single entity for at least one column.
Complex logic lines are characterized by links that diverge and converge from any single entity.

Figure 4: Examples of complex logic lines

Complex lines may be constructed by examining multiple user perspectives. Design solutions affect many people. In developing concepts for any particular product or service, the influencer, purchaser, and user are not always the same person, nor do they always share the same point of view. Marking these points of view can help the designer ensure that the different needs are considered.

Grimes’ User-Centered Case examines the scale and scope of the problem by considering multiple and possibly conflicting zones of values—personal, social and cultural values (Golden 2001). Elito gives minor attention to this by asking designers to explore opposing or simply different values. This activity may generate new ideas, validate existing ones or help prepare for counter-arguments.

The visual field of Elito serves two purposes during synthesis. The rows encourage completion and the lack of visual hierarchy between entities serves to level the hierarchy of the content. At this
phase the only way to place more emphasis on the favored idea is to build it out by exploring complex logic lines.

**Synthesis to realization**

In Elito, logic lines constitute a design story or argument. If the designer is generating a plan or presentation, the content of a well-refined logic line can be used directly to create a compelling story.

Once a set of lines has been completed, the designer can cluster lines to form a larger concept or several larger concepts. We adopted two frameworks from the Doblin Group to help designers compose these larger collections or systems of stories.

The Compelling Experience Framework organizes logic lines in chronological stages. Concepts are clustered into the five chronological phases of Entry, Attraction, Engagement, Exit, and Extension (Doblin Group 2002).

The Mutually Exclusive and Collectively Exhaustive framework describes relationships between categories where no two are expressing the same idea, yet all of the categories together create complete coverage of the problem. To use this framework in Elito, the designer clusters similar values together and then names the higher-level categories (Doblin Group 2002).

**Prototype testing and results**

**Description of Elito test subjects and context**

In order to find out more about how the method works in practice, we tested our prototype version of Elito (using Microsoft Excel) with graduate students at the Institute of Design, Illinois Institute of Technology, Chicago. Our central research question for testing the prototype was “What activities occur as people use Elito?”

An associate professor at the Institute of Design invited us to share the Elito method with students in a communication workshop for 15 weeks. The project for the semester was centered on improving the experience of voting in United States national elections. Students were required to use Elito in order to earn credit for the class.

The subjects for the prototype testing were candidates for the M.Des. professional design degree, a 2-year program. There were nine students in the workshop class, each at different points in the graduate program. Figure 5 outlines student profiles. If a student has completed the yearlong Foundation Program this indicates he or she did not have a strict design background prior to entering the main M.Des. Program. Students #1 and #7 were part of the development team for the Elito prototype and are authors of this paper. The table also shows the make-up of the teams for the semester.
Description of testing
We completed two phases of testing the prototype version of Elito and gathering results. Each phase included teaching the subjects how to use the method, letting them apply the method to their project and then collecting the spreadsheets they had filled out. Results include insights on three sets of data: our observations of their activity, the contents of the spreadsheets, and interviews with the subjects.

Hypotheses
Our general hypothesis was that the Elito method would help human-centered designers move quickly from having a collection of raw observation data to forming a point of view about that data and then creating strong design arguments to support that point of view.

Specifically, we hypothesized Elito would holistically support the following analytic and synthetic activities: capturing, generating, refining, and linking observations to concepts.

Testing results
Teaching by example
At week 7 of the workshop, we realized that we had not trained our subjects well enough to use the method in the manner we expected. We decided to facilitate a working session with each team to walk them through the method step-by-step using content teams had generated themselves. During the sessions, designers reported better understanding of how the method was supposed to work. Student #3 from Team B was even able to help build a line of logic with content from Team E. Following a facilitated work session, student #2 immediately applied Elito as the primary synthesis method for generating a deliverable in another class. This indicated a new found deep understanding of an ability to generalize the principles of Elito. Teaching by example was a crucial element in fostering adoption of the method.
Capturing
We had several observations about the use of the Elito spreadsheet as a capture tool.

Although the inclusion of sketches and diagrams was encouraged, we observed only one designer include one sketch. Excel provided an excellent prototyping tool for quick data capture in the form of text; it is not designed to readily capture images.

Team C reported that revisiting an Elito spreadsheet they had filled in was like going back to that moment “to see exactly what you were thinking.” The Elito spreadsheet captured a kind of “design memory.”

At week 7, there was uneven use of the Elito spreadsheets with perhaps one student on each team using it on an individual basis. One designer reported difficulty in typing and staying involved in discussion at the same time. We speculated that asking designers to use Elito through a digital spreadsheet might have been biased toward designers who already used personal computers for much of their work.

Generating
Designers conducted generative activities by adopting the Elito method in a way we had not anticipated. Teams B and C used the observation column to speculate on how the key metaphor might be appropriate for thinking about voting (an “observation” on the key metaphor). These designers used Elito to support free association exercises. Elito became a metaphor-centric brainstorm tool. It is a result that seems to be a clear case of insufficient training and systematic, if inaccurate, use of the spreadsheet template.

Nonetheless team C reported this as an enjoyable and productive method of working. They generated over 150 rows of content. This indicates that the form of Elito was effective for generating and capturing. It is also possible that the students derived some sense of security from believing they were following a “method” and so did not censor themselves—a common stumbling block for early generative activities.

Refining
We saw mixed results for the use of labeling as a mechanism for refining arguments. Teams applied labeling to widely varying degrees. Teams B and C relegated the use of labels to the key metaphor column while teams A and D used labels for every entity. Labeling requires creative energy and effort toward team communication. Teams making the effort to complete labeling reported the experience as important for helping them refine their content.

Linking observations to concepts
Team B was able to apply Elito to a set of data collected from primary field observations. Team B presented over 20 well-defined observations-judgment-value sets and started clustering these rows into four higher-level categories. Other teams that tried to put secondary research into the observation column met with less success in developing design arguments quickly.

Teams B and C tried to fill the Elito spreadsheet out from left to right, beginning with the key metaphor. This resulted in spreadsheets that were heavily populated on the left hand side and was a barrier to creating links to concepts. The tendency to fill in from left to right could easily be attributed to cultural bias for reading and writing from left to right.
Insights on the theory and practice of the Elito method

Observing the practice of the Elito method has lead to insights on our theory of how Elito works. In addition, taking our theory and examining associated theories from other disciplines has led to insights on why Elito works in the way it does. These insights in turn suggest future research directions for creating new prototypes for testing.

Practice informs theory

Observing students using Elito spreadsheets as a structure for free association suggested two principles in our theory about some of the ways in which Elito works concerning the relationship between syntax and meaning and the way in which linked content creates rich meaning.

Syntax and meaning in Elito seem to work independently of each other. Placing content in the surface structure of the spreadsheet does not guarantee the creation of a “sound” design argument. Stephen Pinker (1994: 88) discusses a similar phenomenon in his book *The Language Instinct* when he notes that it is possible for sentences to make no sense but still be recognized as grammatical. The meaning of each entity is enriched, or weakened, by every other entity to which it is linked. When a reader comes across separate entities of content that are structurally linked, for example by proximity, yet whose content appear unrelated, the reader may assume the link is creating a metaphorical relationship between the entities. In *Page to Screen: Taking Literacy Into the Electronic Era*, Nicholas C. Burbules (1997) writes about the importance of carefully authoring links in hypermedia to help readers make decisions about the soundness of an author’s argument. Burbules goes on to suggest that hypermedia authors borrow from traditional literary theory and use tropes to organize sets of links.

Practice informs theory to inform practice

We still have little insight into the mechanisms designers use in order to come up with labels. The labels designers generated suggest directions for future research into related theory from different fields; this could help us establish our own theory about how labeling works. We can then start the process of creating and testing a new prototype specifically aimed at observing the way in which labeling works in practice.

We observed creative applications of labeling such as the use of colloquialisms and nursery rhymes. Research into theories in the fields of metaphorical thinking and narratology may uncover some insight into the generation of labels and their function in telling part of a story as an effective tool for persuasion.

We observed designers using labels to successfully create short, memorable referents to their design arguments. When a designer presents an argument using labels, he or she engages an audience in a form of persuasion resembling a form of argument Aristotle called the enthymeme. “The enthymeme must consist of few propositions, fewer often than those which make up the normal syllogism. For if any of these propositions is a familiar fact, there is no need even to mention it; the hearer adds it himself (Aristotle 1994).” The field of narratology refers to this act of “adding propositions” on the part of the “hearer” as a construction called “metaphoric metonymy.” The construction of metaphoric metonymy is such that certain elements of communicating a narrative may be omitted and yet the omissions do not confuse the audience. This indicates “the reader is engaged in a filling-in activity (Bal 1997:42).” These observations suggest further study into the relationship between rhetoric and narratology.
**Practice informs practice**

In two observations of practice, it is the case that practice indicated new prototypes to be developed directly.

Our results indicated that facilitated use of the method was required before students were independently able to use the method as intended. We would like to minimize the cost of acquiring the working knowledge of the method as part of improving the overall return on effort invested.

Overall this may have stemmed as much from a failure of the teaching tools as a requirement of the method and further study of alternate learning strategies could be explored through developing new prototypes.

The method, in its current Excel prototype, often required collaborating over conventional keyboard and screen computer interfaces. Subjects for whom this was less of a regular practice, reported that the method seemed more of a chore and were less likely to use the method or more likely to work alone. We encourage collaboration, especially for naming, and thus would alter a next generation prototype to ease the restriction on collaborative behavior.

**Conclusion**

Elito started as a theory extrapolated from practice. We applied the theory as a loose practice in our own work. Moving into a formal investigation, we attempted to specify its form and prototyped the method with an appropriated generic software tool. This prototyped method was then characterized through the work of students in an academic communications design project. Results have lead us to conclusions about the method itself and the process we used in our investigations.

With such a small sample size, the best indication we have of the success of the method is the number of designers (6 out of 9) who reported that they would use this method again in their future work and/or have already started doing so. Also, two additional design practitioners and educators (outside of this study) have adopted the method for use in teaching their graduate design classes.

This research project resulted in providing us with a large, general impression of the method in both theory and practice. As next steps, the Elito method could be modified or decomposed into smaller aspects that could be tested in the more quantitative manner of cognitive psychology for verification of a model of the mechanisms that guide designers.

Extrapolating from the practice results, further secondary research could be pursued to explain the mechanisms at play and in general to shed further light on what mechanisms would best help designers effectively cross the analysis-synthesis gap.

**Acknowledgements**

We warmly thank our advisor, Skip Walter, for his patience, guidance, depth of knowledge, and flexibility with working across long distances. We would like to thank Eli “Elito” Blevis who was the early architect of the practice that we adopted. His teaching and insight were invaluable. We thank Professor Sharon Poggenpohl for allowing us to introduce our unproven method into her workshop. We would also like to thank Professors Charles Owens and John Grimes for their contribution to our understanding of design and their clear answers to our earliest questions. Over the months, we have had many conversations with many people while working on Elito but would like to thank the collective network of professionals who helped us gain real world understanding, especially Dr. Richard Beckwith, Dr. Kevin Brooks, Chris Edwards, Tom Mulhern, John Pipino, Mark Rettig, and Jeff Tull. Lastly we thank our fellow communications students, who worked openly with us as we conducted our investigation and disrupted their normal academic flow.
References


Examining the transformation of the visual characteristics of the Nubian ethnic motif using computer aided design

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Abstract

This paper is relevant to how the discourse of doctoral research can be circulated through a range of platforms. It will pose the question: ‘Is there a creative space where ethnic identity can be preserved along with the production of new art forms?’

The central point of this doctoral research is to discuss whether the culture’s visual identity - Nubian art in particular - can be preserved, since it may be absorbed, developed or combined within a variety of influences of the modern melting pot (CAD). Also, in terms of experimental design using new technology, it shows how such images can be integrated into areas of innovative design and creativity. Ultimately, the main concern is to be able to produce new creative work without changing the essence of Nubian visual culture.
Examining the transformation of the visual characteristics of the Nubian ethnic motif using computer aided design

Introduction
This paper focuses on the development of the research project entitled, ‘An Investigation of the Potential Use of Nubian Motifs Through CAD in Textile Design’.

The central points of the field of investigation focus on four main activities:

1. Examining the Nubian cultural context and the meaning and use of the palm tree, in the material culture and in rituals and symbols with emphasis on visual aspects.
2. Looking comparatively at the symbolic use of the palm tree in western, Egyptian and Nubian visual cultures.
3. Conducting interviews with everyday practitioners of Nubian crafts (especially house decorators) and with experts on culture.
4. Exploring the possibilities of using CAD in design work with Nubian motifs.

The Nubian cultural context
Bernard tried to express visual culture by looking at how visual experience, what is seen, may be defined and conceptualised (Barnard, 1998).

A visual culture has to be understood and charted, in terms of its historic way of life and the wider cultural context. Nubian [1] culture and history is characterised by complexity brought about through different historical experiences, from the Pharaonic to the Islamic period, mixed ethnic origins and different languages. These elements are so tightly woven together into the fabric of contemporary Nubian society that specific debts to the past can scarcely be identified (Fernea and Gerster, 1973:8). In addition, Nubians [2] have lived in relatively isolated communities which were poor in resources, but which abounded with the ruins and monuments of past civilisations. Pharaonic temples, Christian churches, and pre-historic sites dot the Nubian landscape, providing a storehouse of cultural resources for inspiration. The Nubian arts mirror this physical and social landscape (Jaritz, 1973:49-50).

The palm tree in Nubia
Palm trees are part of the Nubian way of life: they represent property and wealth. The palm tree was one of the most important flora of old Nubia, and hence, of Nubian culture. It not only provided Nubians with one of their main type of food, dates, thus signifying life, but it was also used for building homes and beds, weaving baskets and mats, making ropes and for many other crafts. No part of the palm tree remained unused. The palm tree is also a symbol in Nubian rituals and mythology (Kennedy, 1978), therefore it pervades Nubian material and cultural life.

For centuries Nubian houses have traditionally been decorated with drawings on their facades and interiors. However, from interviews conducted in Nubia, in January 2001, it was discovered that the palm tree is not always found in Nubian drawing. It does not appear where palm trees themselves are plentiful, among the Fadija tribe for example. Rather it appears more often where the palm tree is absent or lost in the immediate environment, as is the case with the Kenuz tribe, forced to move to rocky marginal land even before the building of the Aswan Dam. In other words, it was not so much the presence of the palm tree, as its actual absence and the desire for it, that underlay its decorative use.
After the flood, the symbol united the Nubian people, as a whole, inasmuch as it is now a symbol of loss; since the Aswan High Dam was completed in 1971, there has been a unity of feeling and nostalgia in Nubia.

Finally, the aesthetic appearance of this motif justifies its use. It is a rich, elegant motif and is also uplifting. It is recognizably a Nubian motif and has the potential to transform without losing its visual character. The motif has variety in the thickness and length of lines, textures, and in the diagonal and vertical directions of the form. The eye, instead of staying in one area, wants to explore the whole form, like a journey of discovery.

The palm tree is central to this study for three main reasons: its centrality in Nubian material and visual culture, its role as a symbol of loss and its aesthetic qualities.

The different characteristics of the palm tree in different visual cultures have been explored, for example in Western art (e.g. Matisse, Edward Lear and David Hockney), its use in western decoration and textiles (e.g. British Chintzes) and in Egyptian representation (e.g. Ancient Egyptian art and folklore). This was important in order to define the specific visual character of the Nubian palm tree motif.

**The characteristics of the palm tree motif in different cultures**

What is the specific visual character of the Nubian palm tree motif? Does it have different characteristics compared with representations of palm trees in other cultures?

This part of the paper will discuss various examples of palm tree motifs, such as those used by European painters, British textiles, ancient Egyptian decoration, and the Egyptian Tattoo. The conceptual treatments of the shape and texture of the palm tree leaf and trunk are the principal features that differentiate each style.

**Palm trees in ornamental art in general**

The palm tree is tall with radiating foliage; it grows in warm or tropical climates. There are five main types of palm, the date, the coconut palm, the kentia palm, the fountain palm, and the phoenix palm. Some of these can be used as decorative houseplants in a low to medium light area. In this research, the palm tree is synonymous with the date tree, as befits the Nubian and Egyptian tradition.

This motif is used in various ways in ornamental art not only in the Middle East and Nubia, but also in southern and eastern parts of Europe. Sometimes its branches were used as a symbol of victory, righteousness and peace (Fontana, 1993). Also, Meyer (1987;1894: 48) gives further details about how the palm leaves were used as a symbol of peace in Christianity, in feasts in ancient Egypt, as decoration in the late Renaissance, and in modern art on tombs.

**The palm tree motif in western art**

A few western artists used palm tree motifs. They can be classified into two categories. The first group, e.g. Matisse, visited the east and viewed palm trees as a new source of texture and strong colour. Edward Lear visited southern Egypt and painted ‘Philea on the Nile’ (see fig.1). He painted palm trees in the foreground and used strong colours to emphasise the natural phenomena of Philae (Stevens: 1984).
The second category includes David Hockney who was inspired by palm trees when living in Los Angeles in 1973. He made two images (see fig.2) one of which depicts the tree emerging from surrounding mist (Gilmour, 1981:70).

In the other, he uses a silhouette to depict the tree by drawing it without any details of the trunk and leaves. His transformation of the motif includes a rigidity of the body of the trunk with the organic or natural features of the leaves. The silhouette of the palm tree motif is sometimes used as a logo on T-shirts, web sites and advertisements, changing the character of the trunk into a more ‘elastic’ form. These western versions of the tree do not show many natural features or details, including the date.

The palm tree motif in western textiles

In the west, the palm tree motif is classified as one of the symbols of ‘ethnic’ culture, various designs, including Egyptian, Hawaiian, and South American, have an ‘ethnic’ character.

Meller and Elffers noted a vogue in British chintzes of about 1815, where palms often appeared incongruously with game birds, such as the pheasant (Meller and Elffers, 1991:348) (see fig 3).

British designers adapted this ethnic motif to their style and transformed it in inventive ways to their taste. They repeated festoons on the body of the tree to express the texture of the trunk, not using bright colours. The leaves were in an artificial style with a greater emphasis on richness. They were more curvy than the real tree and looked like the Akanthos leaves found on Roman relief or Renaissance ornaments.
The palm tree in ancient Egyptian art

The ancient Egyptians and Nubians relied on inspiration from the natural world for decorative motifs. The palm tree motifs were developed from plants, which also had an important role in their lives as they provided essential material and food.

The Egyptians aspired to express the essential nature of objects, rather than impressions from a particular angle (Wilson, 1997:12). There is an enormous variety of ornaments with which the Egyptians decorated the temples of their gods (Jones, O., 1988 (1856): 22), carving, painting, or moulding the motif (see fig 6).

The Egyptian style is close to the tree’s natural form, with a wider base to the trunk and with the emphasis on pure symmetry. As Jones noted, ‘they could hardly fail to observe the same laws which the works of nature ever display and we find, therefore, that Egyptian ornament, however conventionalised is always true’ (Jones, O., 1988(1856):22). Their motif is more ornamental and also combines geometrical and natural form, especially when they draw the dates.

Sometimes they use different types of lines to draw the ‘spikes’ to express the trunk which is different from the Egyptian Nubian style, where palm trees are drawn in a group of three. They are equal in height, include minimal details of the trunk, and have a less authentic representation of the leaves.

Nubian drawings

Fahim (1983) observed how Nubians decorated the outside walls of the house with bright, bold, colourful designs, along with modern symbols as trains and ships alongside natural symbols, such as desert animals, insects, birds palm trees, stars, the sun, and the crescent.
To summarise a wide range of comparative material, the researcher has identified the following key characteristics of the Nubian palm tree.

- The drawings make a clear contrast between the motif being used and its background. Usually, the motif is painted in white on a dark background, generally the mud of the wall. Occasionally, the entire facade of a house is painted white (lime), along with one of the available colours of the region.

- The colours used come only from the oxidised colours of the natural environment. Bright colours are not part of the Nubian palette.

- Most walled surfaces are not smooth because of the very simple tools used in building. Therefore, the surface texture is an integral part of the Nubian style.

- It is the women who draw the designs and motifs, using rudimentary feather brushes, wooden sticks, and other available implements. Although the lines look sharp from a distance, on closer examination they are less precise.

- The Nubian style is geometric, although most of the motifs come from the natural environment. Perhaps unintentionally, the women traditionally work along the lines of embroidery so their work can look more like a piece of needlework than painting.

However, these characteristics cannot completely describe the infinite variations in Nubian house drawings. There are several variations in the palm tree trunk and different ways of depicting the branches and fronds. Sometimes the patterns are repeated horizontally, sometimes not. Some recorded drawings show ducks or birds between the palms; a zigzag is occasionally used to depict the Nile. Finally, the drawings vary with each woman’s taste and character.

Generally, the Nubian palm tree motif emphasizes the top of the palm tree by drawing upward or through rising lines ending in a filled circle. There are only a few examples where they do not emphasise the top of the trees in this way, but they express the dates in a creative fashion.
So to summarise:

- Nubian style uses the palm tree as an ensemble with a duck that is sometimes repeated between the trees or in separated stripes at the top or bottom of the repeated trees and zigzags.
- It uses sharp, fine lines to outline any type of motif. Also, sometimes the motif is filled with the same colour (or a different one). The tree bottom is sometimes put in a decorative container or in a geometrical shape, such as a circle, triangle, or zigzag.
- The branches in the Kenuz area are more curved and naturalistic in form, albeit simplified. In Arab areas, diagonal lines are repeated on both sides to express the branches without details.
- The palm tree as an individual motif style is used with other motifs in a harmonious way.
- Perhaps, without intention, the traditional women work along the lines of embroidery or stitching, so their drawing looks like a piece of needlework rather than painting.
- There is no detail on the palm tree trunk and occasionally a few festoons are added or some rough short lines included on the trunk.
- The Nubian women mainly represent the dates in their drawings as dots, abstract lines, or as creative flowers. However, in the Arab area, they never draw dates with a grove of trees.
- The colour of the palm tree is normally white in the Arab area and sometimes blue washing powder is added to draw the dots. However, in the Kenuz area between one to three colours are used to colour the trees.

**Interviews**

Visual culture can only be understood in the context of everyday experience. Hence, it was believed to be necessary to understand the way of life of the Nubian people, and the values, beliefs, and experiences which inform their art. The researcher conducted several interviews to discuss the meaning of these motifs.

The first interviews took place in London in July 2000 with four people from the Kenuz area. The aim was to ascertain: the meaning of the palm tree motif in the Nubian community; its role in old Nubia; why it is drawn on houses; and whether this is exclusively women’s work.

The researcher’s response to the first set of interviews, particularly to the lack of information obtained about the style of decoration in some villages, was to plan a visit to a Nubian village in Kom Ombo in January 2001.

The second set of interviews were conducted in Egypt in January 2001 (3 weeks of fieldwork). Most of the interviews took place in Nubian villages in Kom Ombo with Nubians from different tribes.

In each interview, photos from pre-flood Nubia, a list of questions, a small tape recorder, and a notebook were used. The questions were modified according to people’s attitudes, customs, and the researcher’s position inside the community. They were, thus, flexible and informal. The interviews were conducted in Arabic.
The researcher’s central interests as a designer was to understand the practice of drawing as it affected the visual character of the image; the kind of techniques and tools were employed; the sources of inspiration and how the women create drawings with limited resources.

The importance of these questions is to define the characteristics of the Nubian motifs. Two important questions are, ‘How did the Nubian women correct their mistakes whilst drawing?’ and ‘Why is their drawing so neat, without fault or blemish, given the inflexible surface of the wall?’

An astounding description was given, answering both questions, by four women in the village of Qurta (Kunz area). They explained how the whole village helped each other decorate and plaster their houses before their resettlement. One of them added that, when she started her drawing, there was another woman behind giving instruction and direction. If she noticed any mistake or blemish, she immediately ordered the painter to erase the drawing by scraping the motif and the background. The background was then painted again using white (as was the custom in this village) and the drawing was restarted. This helps to understand the clarity and freshness of the line as a feature of Nubian decoration.

Nevertheless, this method helped the researcher to unlock some of the mysteries of the old Nubian culture.

**Practical work**
The aim of this section is to explore the relationship of traditional Nubian visual culture with contemporary textile design. A central question is ‘Can computer technologies help us to create a new aesthetic without sacrificing the value and meaning of the original motifs?’

The researcher’s aim is to use the benefits of CAD technology to preserve something of the Nubian heritage, even in a new context. Tables can be produced, of original motifs and a wide range of variations can be created, from which the designer can select motifs and as many variations as s/he wishes for textile printing. The fast and accurate methods of image repetition available using CAD is ideally suited to the repetitive nature of textiles (Bunce, 1996:33).

**Background and initial work**
Firstly, my background is in manual textile printing in Egypt, where textile design traditionally looks to history or nature as a source of inspiration. My work as a lecturer in Art Education was to teach printing methods such as batik, stencil, tie-dye, block printing, and silk-screen to create innovative pieces of design, but my own practice has tended to be painting, rather than printing, where the dyes are directly mixed onto the fabric.

I was not familiar with CAD and the potential of different software, and needed to decide which functions of the available software to use. This section describes initial work done and its development through two stages, on the basis of my personal response at the end of each stage.

Exploring the potential of the new technology added new dimensions to the ethnic motifs, and the tables help to experience their aesthetics. These steps helped the researcher to engage gradually with the visual experience, as well as to transform the shape, textures, and colour of the Nubian motifs.

**Stage 1**
At the beginning of this stage, I dealt with the motif as a singular case in each cell. Rather than following rules, I operated intuitively. I developed my motif using the possibilities of Photoshop to enhance the line and texture qualities, for example by altering the colours, shapes, shadows, and
textures. I found that, if I exaggerated using the filters, the work produced tended to be artificial and less of an ethnic representation (refer to the characteristics of the Nubian motifs). I think this work is more ‘graphic’ than conventional textile designs (see the example in Baba:2001).

The advantage of this stage was in shaping my awareness of the identity of the motif. In other words, it crystallised the definition of the Nubian motif in my mind.

An important evaluation of this initial work with Photoshop concerns how far I could go with this fascinating software without losing the essential identity of the motifs.

Stage 2

Table 1: Shows transformations of the motif with two diagonal lines and flowers.

Intention: To experiment and explore the potential of raster [3] and vector [4] programmes. This stage was used to become more acquainted with the CAD and to define what the specific functions of the software are.

<table>
<thead>
<tr>
<th>Table 1: the tree and two diagonal lines and flowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process: After using different software individually Photoshop was used to build these tables. Also, it was easier to compare the other programmes to control the possibilities of this software, such as in modifying the colours or adjustment layers. Also, Painter brushes (different sizes/types) were used and the outline with textures was filled to re-shape the motifs and apply the filters.</td>
</tr>
<tr>
<td>Response: This stage explored the line and texture qualities of the motif by using different software. Also, the table was created as a block print motif which could be repeated. It was discovered that most of the raster software considered had the same functions, but each one had one or more different features.</td>
</tr>
</tbody>
</table>

There are many similarities between the filters on Photoshop and Photo paint (see 1E and 1F), but these differences are to do with application. All of them, even the CorelDraw (vector) software, offer the same possibilities of changing, replacing and adjusting colours. However, the array of brushes in Painter is greater than any other software, so too is art material, such as paper, wave and
textures. The Textures library in CorelDraw and Photo paint is varied but the mask function in Photo paint is more effective than Photoshop and gives more possibilities. It was found that the Photoshop’s layers were more powerful than the others and the replacement of colour using filters was much easier and more straightforward.

At the beginning of this table (1A and B), I started to use the same line quality as the original motif. After this, the thickness of the lines was changed using the Painter brush to explore changing the motif’s features. Also, as in the previous stage, the identity of the motif was lost when the researcher exaggerated it using filters or changing its characteristics totally as in 1F, G and H. The mixture of different software possibilities creates an exciting development in the motifs which can be repeated for conventional designs. Before these applications were combined, each one was used separately and the motif was developed and an acceptable result was gained. This decision gave more variety and the researcher worked more intuitively, following my aesthetic responses, and this gave a more satisfactory result.

**Stage 3**

As a textile designer the researcher naturally concerned with final applications, so motifs were systematically repeated, since one of the benefits of CAD is the ability to visualize designs in repeat (Phillips and Bunce, 1993:14).

Two types of design repeating motif were produced. With the first the aim was to create a traditional textile design using simple repeats and with the second the aim was to create wall hanging designs.

**Intention:** To explore the possibility of using simple repeats of developed motifs and to determine whether this method would be suitable for ethnic motifs. These interior design ideas are a selection of work from the researcher design collection.

**Response:** New designs were created but it was felt that this direction was a ‘dead end’ for the identity of the Nubian motifs and provided little challenge. Moreover, it was feared that the essence of the ethnic motif would be lost and traditional textile methods would have to be adhered to. Even though they worked as textile designs, they lost their Nubian identity and were diffused by repetition, so the direction of work was changed towards non-repeating fabrics.

**Type 2:** Wall hangings

**Intention:** To create wall hangings for printed textile designs using copies of the motif, but not repeating them in a traditional manner.
Piece 1: CorelDraw was used with the triple-jointed palm tree and zigzags. Fill tools were used, such as fountain fill for the motif and the rectangle shape, pattern fill for the zigzag, and postscript fill for the background.

Piece 2: Photoshop was used to build this. The motif from piece 2 was repeated four times, then the distort (Polar Coordinates) filter was used. The surface of the design was divided into a rectangle and an oval and then a triangle shape was added. A scanned fabric was used as background. The distorted motif was used to fill the foreground and background. The colours were changed in some of the areas of the triangle or pyramid shape. The burn and dodge tools were used.

Reflection: Pieces 1 and 2 tended to be more open and symbolic. In piece 1, the motif was repeated irregularly to portray the palm tree under the flood. Piece 2 was more complicated than the previous one. The triangle shape was used because it is a common motif in Nubia. At the same time, the researcher attempted to emulate the traditional technique of oil painting, which gave a special dimension to the design. Using the distorted motif to fill the background as well as the foreground, movement was added to the piece and this reduced the rigidity of the triangular form.

The outcome of the practical work and conclusions
The work has shown some of the advantages of CAD. A notion has developed about how to produce new creative work without changing the essence of Nubian visual culture.

Conclusions include:

- Changing the main feature of the palm tree motif can modify and even lose the visual character of the motif.
- Exaggerated use of blending filters and layers can completely alter the ethnicity of the motif.
- Using symmetrical repeats of part of the motif can change its essential character, since it is no longer a ‘tree’.
Changing the appearance of the motif and the textures of the background can change the essential Nubian style and even make it disappear.

Traditional design methods can be used innovatively, yet they can create a ‘dead end’ in the motif’s meaning.

The key aim of future practical work is to use visual culture and new technology to create designs that maintain their ethnic identity. A test panel will be used to look at my tables and hanging designs to assess whether computer technology can create a new aesthetic without sacrificing the value and meaning of the original motif.

To answer my question: ‘Is there a creative space where ethnic identity can be preserved along with the production of new art forms?’ the researcher has decided to not rely on her responses and aesthetic judgment. So, a solo exhibition will be given and a questionnaire used. People from different ethnic backgrounds will be invited to answer as they study the work. The aims of the questionnaire are firstly, to evaluate the motif transformations using CAD and to determine whether there is a creative space where ethnic identity can be preserved along with new art forms, and secondly, to evaluate the viewers’ visual perspective by examining the different backgrounds of the respondents. Most of the questions will prompt qualitative responses rather than quantifiable answers.

Footnotes
[1] First of all, the region known as Nubia stretches from the Nile’s First Cataract at Aswan in the north to halfway between the Third and Fourth Cataracts in the south. A very large part of this area was completely submerged by the building of the Aswan High Dam and the creation of Lake Nasser. In 1963, Egyptian Nubians were forced to resettle to Kom Ombo, an area 40 kilometres north of Aswan.

[2] In the northernmost region - from Aswan to Sebua - a Kenzi-speaking group, called ‘Kenuz’ was located. The Kenuz were considered to be the result of a compound of local nations in Nubia with the Arab-Beja Beni Kenz tribe from the Middle Ages. Next to the Kenuz-area, from Wadi al-Arab to Kurusko, there was a small group of formerly nomadic, but later assimilated Arabs. The society occupying this stretch of the Nile Valley was called ‘Aleqat’. However Arab was still their mother tongue, but they were considered to be Nubians in concession of social formulation and culture. Beside the Aleqat area there was a large region in which the usage of Fadija/Mahasi clearly prevailed. The ethnic dialect in Fadja-speaking areas were- from north to south-the ‘fadija’, the ‘Sukkot’ and the ‘Mahas’. Fadija is a terminology that was used to nominate the northernmost group between Korosko and settlement of the 1960s (Poeschke, 1996:27-28).

[3] ‘Raster images are displayed on screen as a series of dots or pixels. Each pixel can be lit up independently from as few as 256 simultaneous colours to a maximum of a few million on screen at any one time, enabling complex, high quality multicoloured imagery to be achieved when displayed on higher resolution monitors’ (Aldrich, 1999:27).

[4] ‘Vector images comprise lit vectors or ‘line segment’, which when joined together from fine quality smooth lines, often displayed in one colour only. Outline shapes can be created very simply, each made up of a number of control points which can be manipulated easily and effectively to alter the image’ (Aldrich, 1999:28).
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The rhetoric of research

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Abstract

In 1993 Christopher Frayling, the Rector of the Royal College of Art in London, published an article about the nature of research in art and design. The present paper revisits his threefold distinction of "research-in art, research-through art and research-for art", and considers why Frayling found the third category to be problematic. The analytical methods used are linguistic (a constructionist approach to the rhetorical effect of construing various prepositions with "research"), and philosophical (a Wittgensteinian approach, distinguishing between socially agreed normative criteria, and non-normative indicators or symptoms).

The paper argues that the instrumentality of terms such as "research" should be contrasted by observations of how the register of artefacts is used in the advancement of the field. If one adopts a constructionist approach then one is forced to be sceptical about the reification of publicly agreed criteria. The paper uses Wittgenstein's distinction between criteria and symptoms to identify three indicators of research that may point towards a solution to Frayling's problem through the re-description of his category "research-for" art as "a work-of" art.
The rhetoric of research

This paper approaches the debate about the nature of research in art and design from a linguistic point-of-view. It suggests that the way in which we employ language in our discussions affects the connotative meanings of the words. This applies not only to the meanings of terms such as "research", "practice" and "work" but also to their grammatical construal in phrases such as "research into practice", "practice-based research" and "a work of art". To this extent we could say that language constructs the concept of research rather than describing it. This would be a constructionalist interpretation (Hall 1997: 25).

When Frayling (1993) wrote about "research-into art", "research-through art" and "research-for art", he appeared to be reporting on three different activities within research, each having a different relationship between the researching subject and his or her object. However, the constructionalist approach would say that through this normative process, the three categories were brought into existence. From this point onwards it became possible to differentiate and therefore to compare, these categories. The constructionalist approach therefore implies another, bigger problem: to what extent is our whole debate about research in art and design affected by language? In particular, to what extent do some connotations affecting our judgement about what constitutes research arise argumentum ex verbum rather than argumentum ex re.

Methodologically, Frayling does not approach the problem of "research in art and design" as a "critical rationalist". Instead he paints us a picture, deriving his imagery from popular culture, especially the cinema. This is not an inappropriate method for establishing how many of our prejudices and assumptions have their roots in our use of language. Owing to the lack of an explicit argument about what research is, we are left to sort out the possible relationships between the key verbs, e.g. thinking, doing, writing, making, experimenting, reflecting, etc., and some value-laden adverbs, e.g. emotional, cognitive, etc. The symptoms that Frayling identifies are; that the outcomes of research must be explicitly communicable to others, that practice includes writing, design, science, etc. and therefore cannot be used to differentiate these activities, and that it is the relationship of "research" to "practice" as shown in the construal of the terms "research-into [a practice]", "research-through [a practice]", and "research-for [a practice]" that can show us their instrumental relationship (Frayling 1993: 1c, 5a).

It would perhaps be appropriate here to say something about the term "instrumental". Instruments are of various kinds but in general they serve as tools with which to do something, e.g. a hammer, a barometer, etc. When we regard words as instruments we focus on their use and on what is achieved when we employ them. In this context we might regard the word "research" instrumentally if we attend to what is meant by a community of users of that word, "not with a view to discovering anything about the nature of the objects to which they seem to refer: rather, to find out whether there are such objects, and if so which objects they are" (Hunter 1990: 157). This seems to be Frayling's method: to consider the instrumental effect of cinematic representation on our perception of scientific and artistic activity. In these cases we can see that, far from the terms "research", "scientific" and "artistic" serving to focus on objective aspects of their manifestation on-screen, they become implicated in a reciprocal act of definition and interpretation. For example, we call Frankenstein a scientist, not because we see evidence of his scientific method but because his stereotypical behaviour is associated with the label "scientist". Words as instruments therefore do something: they modify our view of the world and, the constructionalist would say, construct our perceptions.

Since Frayling is concerned to ensure that our understanding of the term "research" in the field of art and design is reflected in its use by its inhabitants, it is appropriate that he should look at what
they actually do. For example, rather than accepting or rejecting Picasso's assertions about his paintings *qua* research, Frayling considers how the actions of Picasso and others, e.g. Leonardo Da Vinci, Stubbs and Constable, might be described. If we labelled their actions as research, how would this affect our interpretation of these actions, and does this label need any qualification? Frayling's conclusion is that the term "research" can be employed when qualified by a prepositional triad of "into, through, for".

Frayling's examples of "research-into" art and design include historical and theoretical perspectives (1993: 5a). His examples of "research-through" art and design include materials research and action research. But he finds "research-for" art and design problematic because its examples would have to include artefacts that embody the thinking but fail to make explicit their knowledge and understanding. The problem that arises is an instrumental one: is it the case that there is no content to the classification of "research-for art and design?" If the community values Picasso's contribution, why is it not "research-for art"?

This brings us to the concrete proposal of this paper. Instrumentally the community needs a term that describes and labels the activity that is equivalent to "research-for art and design". This is because it needs to describe how the discipline is advanced and how knowledge arises through practice, and this would seem to be unavoidably linked to the embodiment of thinking in objects. However, the implications of the models provided by the construal "research-into" and "research-through" do not transfer into a useful instrument of "research-for". That is not a problem concerning the extrinsic character of research in the field, i.e. *argumentum ex re*. It is a problem concerning the intrinsic character of how it is described, i.e. *argumentum ex verbum*. Picasso was right to say

> the spirit of research has poisoned those who have not fully understood all the positive and conclusive elements in modern art (Frayling 1993: 2a).

Picasso claims that art is advanced or changed not by research, nor by unreflective practice, but by the creation of works which come to have influence. Their influential status is demonstrated by the effect they have on the field and not by what their creators intend or say about them.

Art and design is advanced using both text and artefacts. Agrest calls these "registers" (Agrest in Allen, 2000: 164). Each has the capability to represent some aspects of a concept but not others. These concepts are critically analysed by rewriting and remaking, etc. Agrest claims that neither of these registers is comprehensive, which is why art and design uses them both. Practice-based research also adopts this assumption. It assumes that neither writing alone, nor making alone, are sufficient to represent a whole concept. It would be easy to act as though theory is synonymous with text and practice is synonymous with artefacts. Allen (2000: xvii) recognises the potential tension between theory and practice that comes from the recognition of different registers. In response he argues that each register has the capacity to support both theory and practice, i.e. that one can analyse theoretical concepts through making and practical concepts through writing. He prefers the distinction between primarily "hermeneutic practices", i.e. those concerned with "interpretation and the analysis of representations", and "material practices" that "transform reality by producing new objects or organisations of matter". Because the publicly agreed criteria of research include a need for the communication and dissemination of outcomes, research is essentially a hermeneutic practice. This will be used later to explain the AHRB distinction between practice and research.

This distinction recognises the different merits and capabilities of the register of artefacts and the register of text. Text can state aims and other intentional activity, it can describe intangibles, abstract concepts, generals and universals, conditionals, negation. This is partly because text has a
formalised syntax in a way that there is not a formalised syntax of objects (Wollheim 1980: §58). A formalised grammar allows us to understand novel ideas. On the other hand, ideas embodied in the expressive misuse of words, or the abuse of the conventional use of objects, may need an accompanying critique to contextualise what is being done, to turn disruption into understanding. Joyce's *Ulysses* was not accepted as a great work when first published. While its disruptive value may have been highly regarded from the outset, its contribution to knowledge was recognised when it was able to be placed in an historical, cultural and critical perspective. Whether one wishes to then say that the contribution to knowledge was implicit in the work, or one prefers to say the contribution was made by the critique that explicated it, is an example of different applications of the criteria of research.

**Criteria and instrumentality**

This paper has claimed that Frayling's categories of "research-into", "research-through" and "research-for" art can be conceived as instrumental rather than descriptive of the problem of research in art and design. If this is the case, how might one proceed to discuss the concept of "research-for" art and design? The problem may benefit from Wittgenstein's distinction between criteria and symptoms.

Criteria function normatively and constitute the rules for the application for a term. These rules are part of our form of representation. Confusions between criteria and symptoms arise when the form of representation is applicable and supportive of one grammatical proposition, but not supportive of another which appears to have the same structure. For example, first-person assertions of sensations such as "I am in pain" are regarded by Wittgenstein as a symptom of pain for the utterer, because of the lack of publicly available criteria. On the other hand, third-person assertions such as "she is in pain" are made on the basis of observing pain behaviour. Such behaviour is one of many possible criteria of her pain for us. Another criterion might be her avowal "I am in pain" (Biggs 1998: 9).

Thus we might distinguish between criteria for research, and symptoms of research. Criteria would be the socially agreed definitions published by universities and research councils. Even if one regards them as unsatisfactory, gaining an award requires one to conform to the publicly stated criteria. They also give a means of appeal in cases of dispute. However, if we now want to criticise the influence of these criteria from a constructionalist point-of-view, then we are forced to abandon them because of their social instrumentality and look instead for non-socially agreed symptoms.

One criterion of research is that it is particular type of process. This is the model adopted by the UK Arts and Humanities Research Board (AHRB):

*The Board's definition of research is primarily concerned with the definition of research processes, rather than outcomes. This definition is built around three key features and your application must fully address all of these in order to be considered eligible for support:*

- it must define a series of research questions that will be addressed or problems that will be explored in the course of the research. It must also define its objectives in terms of answering those questions or reporting on the results of the research project

- it must specify a research context for the questions to be addressed or problems to be explored. You must specify why it is important that these particular questions should be answered or problems explored; what other research is being or has been conducted in this area; and what particular contribution this particular project will make to the advancement of knowledge, understanding and insights in this area
- it must specify the research methods for addressing and answering the research questions. You must state how, in the course of the research project, you are going to set about answering the questions that have been set, or exploring the matters to be explored. You should also explain the rationale for your chosen research methods and why you think they provide the most appropriate means by which to answer the research questions.

The AHRB definition of research provides a distinction between research and practice per se. Creative output can be produced, or practice undertaken, as an integral part of a research process as defined above; but equally, creativity or practice may involve no such process at all, in which case they would be ineligible for funding from the Board.

The final paragraph reinforces the difference between research and some kinds of practice. It does so on the basis of whether or not the practice embodies the research process, rather than assuming that only the register of text has that capacity. This complements Allen's view that both the register of text and the register of practice have the capacity for theory and practice.

Implicit in the AHRB definition are a number of indictors or symptoms of research. For example, in order to meet the above criterion the research method must be applied systematically. Systematic, in this context, does not just mean organised and following a particular pattern or routine. Research is systematic in the sense that it is comprehensive. At the end of a period of research one is entitled to make claims because one has undertaken a rigorous enquiry that will have identified the current state of knowledge and the key players and ideas, and have provided some critical commentary or added to this. One can have confidence in the outcomes because an appropriate method will have been applied systematically resulting in an analysis from a coherent point-of-view. The enquiry is thus comprehensive from this point-of-view rather than necessarily aspiring to cover all that is known or could be said about a particular issue. It becomes a symptom of art and design research that a point-of-view or interpretational stance is made explicit, from whence the research can be judged as systematic and comprehensive. Other research on the same topic may adopt a different point-of-view. This is important for art and design because, contrary to the AHRB definition, research in this field only aspires to answer research questions that arise in a particular interpretational context. It does not aspire to provide answers on the "objective" scientific model.

A second criterion of research is an explicit and appropriate method. Within the research one might expect to find a defence of the coherence and appropriateness of the method to the issue that is to be investigated. For example, a problem of interpretation might be researched using a comparative historical method based on case studies. A recent example from the University of Hertfordshire investigated the use of allegory in sixteenth century painting and compared this with its contemporary use. Two methods were immediately apparent. The first was to undertake a linguistic analysis of the term "allegory" in these two periods and to use this knowledge as a method for structuring an iconographic comparison. The second was the reverse: to undertake an iconographic analysis and use this as a method for structuring a linguistic comparison. The outcome of the first would be insights into imagery and the outcome of the second would be insights into the use of words and concepts.

A linguistic analysis might show changes in both the meaning of allegory and its context as a mode of explanation, between one period and another. This linguistic method would be the context against which imagery could be evaluated, i.e. the relationship of the imagery to that which is to be explained. An iconographic analysis, on the other hand, would begin with the signifying elements of the imagery and conclude in observations about the use of the term. In either case, clarity about what would constitute the evidence to be analysed either linguistically or iconographically is essential for coherence. Equally authorities or counter-arguments that are relevant to each analysis.
should not be transposed. One implicit symptom of the chosen method is therefore that it must be appropriate to the kind of outcomes that are sought, and the evidence used, which in turn reflects the audience that is targeted.

An explicitly identified audience is a third symptom of research. Research must identify an issue that is consequential for an identifiable group in the field. This is why an investigation into one's own practice is not necessarily research unless it can be shown that the outcomes are transferable to other cases (the "research context" in the AHRB definition above). This need is reinforced by the requirement for all research to have some form of dissemination. This dissemination, by publication or exhibition, etc., would be irrelevant if there were not an audience for the content of the research. Of course, the target audience may not know they are the audience, or may not know that they would benefit from the outcomes of the research. One might say that the audience either would or should read or view the research because if they did then the outcomes would have an influence on their practice. This obligation should not be read as the moral benefit of being widely informed, but the practical benefit of being specifically informed about developments in one's field. The size of the group, especially if it can be explicitly identified, is an indicator of the potential impact of the research. Funding bodies seek research that will be significant both in terms of qualitative and quantitative impact. For example, the AHRB asks referees to comment on: "value for money"

The peer reviewers will assess the proposal on the basis of its academic merit, taking into account:

- the significance and importance of the project, and of the contribution it will make, if successful, to enhancing or developing creativity, insights, knowledge or understanding of the area to be studied

- the appropriateness, effectiveness and feasibility of the proposed methodology, and the likelihood that it will produce the proposed outcome in the proposed timescale

- the ability of the applicant(s) to bring the project to fruition, as evidenced not only in the application itself, but in their previous track record, taking account of their 'academic age'

- value for money, and in particular the relationship between the funds that are sought and the significance and quality of the projected outcome of the research.

With each explicit criterion there are a number of implicit symptoms. Criteria should present necessary and sufficient conditions but as a result also operate instrumentally. Symptoms are indicators that such conditions are being met. They are neither necessary nor sufficient, but because of this tend not to operate instrumentally. Returning to the problem posed above, how can this distinction be used to explain why Frayling's category "research-for" art is problematic? The problem is that examples would include artefacts that embody the thinking but fail to make explicit their knowledge and understanding. But we do have a term for such works: they are "works-of art".

A "work-of" is characterised by becoming the object of study and cited by researchers. A "work-of" systematically employs a method that results in a novel point-of-view. It deploys it rather than commenting on it. Thus it is embodied or deployed in the work rather than explicated by it. The function of research is the opposite: to explicate rather than, or in addition to, embodiment; to make explicit that which is implicit. This has the effect of demonstrating to the examiner or the consumer of the research that the researcher understands what is embodied. This crosses over into the rôle of authorial intention since a "work-of" may embody any number of potential points-of-view, any or none of which may have been the intention of the author. However the legitimacy of claiming embodiment is not a claim of intention but a claim of coherence, and whether this point-of-view can legitimately or coherently be explicated as being embodied or deployed in the "work-of". Such a claim needs to be made explicit by "research-into" the "work-of", and may be undertaken by the
author of the work. The fact that notions of habitus are said by Bourdieu to be embodied in Kant's *Critique of Judgement* does not require him to claim that this was Kant's intention.

"Works" that have a significant impact in a field may also be grounded in research, e.g. Bourdieu's *Distinction* is a "work-of" aesthetics, but it is informed by thorough "research-into" the ethnography of French-Algerian society. Wittgenstein's *Tractatus Logico-Philosophicus* is a detailed argument in favour of a particular systematisation of knowledge, but it rarely places this argument in the context of other thinkers. The lack of counter-arguments may be regarded as a symptom of a "work-of" rather than "research-into" a particular issue, e.g. the logic of our language.

The reason why Frayling's category of "research-for" is an empty set in art and design is because outcomes in this category are called "works-of". Such works advance the field and are likely to be cited as the embodiment of the field's knowledge. However, because they do not communicate this knowledge explicitly, Frayling's constructionist approach from the phrase "research-for" resulted in his conclusion that nothing met the publicly agreed criteria, rather than recognising that "works-of" exhibit appropriate symptoms instead.

**Conclusion**

A constructionist approach to language separates the material world from its symbolic representation in words. Meanings are constructed and validated at this symbolic level, with no necessary correspondence in the material world. This approach has been used to problematize the nature of research in art and design. Encouraged by the rhetorical approach adopted by Frayling, his category of "research-for" art has been reconsidered by distinguishing between the activities that are conducted in the register of text and the activities that are conducted in the register of artefacts or materials. It has been argued, from Allen, that these registers are not synonymous with theory and practice respectively. Artefacts therefore have the capacity to advance both theory and practice, but not necessarily on their own. Frayling is interested in the way in which the field of art and design is advanced, particularly through practice and the production of artefacts. Frayling constructs categories but then finds it difficult to account for the lack of content to the category "research-for" because his constructionalist approach has combined two language elements: "research" and "for".

This paper has concluded that the linguistic turn that constructed the category "research-for" was misguided. It was led by a development of publicly agreed criteria rather than by underlying indicators or symptoms of research. This paper does not reject these publicly agreed criteria, but it does propose that they constructionally imply conclusions *argumentum ex verbum* rather than *argumentum ex re*, e.g. Frayling's conclusion. By reconsidering the indicators from the world of practice, and the need to find some equivalent to the category "research-for" by which the field is advanced, this paper argues that a better starting-point would be the phrase "a work-of". This phrase has the capacity to include the symptoms of research. It corresponds to how language is used in the field and what material practices are regarded as advancing it. However, it frees the constructionalist from the linguistic arguments that led commentators such as Frayling to conclude that the advancement of the field through artefacts, the business of "research-for art", was a problem.
References


Intuitive use of products

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Abstract

The term “intuitive use” has been widely used with respect to various products and systems but has not yet been adequately defined. Through an extensive literature review, it was concluded that intuition is a cognitive process that utilises knowledge gained through prior experience. Intuitive use of products involves utilising knowledge gained through other products or experience(s). Therefore, products that people use intuitively should be those with features they have encountered before. A set of experiments with a digital camera was conducted to test the thesis. The results of these experiments support the thesis. It was found that prior knowledge of features or functions of the camera allowed participants to use those features intuitively, whereas unfamiliar features or functions had to be figured out, which was more time consuming and effortful.
**Intuitive use of products**

**Introduction**

This study aims to explore the possible meanings and applications of “intuitive use,” what it is, how and why it happens, and how design can facilitate it. Very little work has been done in this area, and there is still limited published information on cognitive aspects of product use (Stanton and Baber 1996). However, intuitive use of products has been mentioned (although not fully addressed) by a variety of authors in diverse literature.

For example, Rutter, Becka and Jenkins (1997) conducted a case study on the design of an ergonomic chair. The design team wrote into the brief that the adjustment of the settings should be “intuitive in terms of the logic of their operation” (p29), but no research into or definition of intuitive is cited. Frank and Cushcieri (1997) wrote a case study about the design of an “intuitive” mechanical surgical grasper for keyhole surgery, where movement of the fingers was replicated by the movement of the grasper jaws. No reference is made to how they knew this was intuitive. Thomas and van Leeuwen (1999) wrote a case study describing the design of two mobile phones. One objective was for it to be intuitive to make a simple phone call. Therefore the concepts developed supported conventional dialling behaviour and allowed users to apply their existing experience, although again the authors do not define what they mean by intuitive, or how they applied intuitive usability to these products. Okoye (1998) conducted a study on intuitive graphical user interfaces. She does not detail in her thesis what intuition or intuitive use is.

The Principles of Universal Design were developed at the North Carolina State University Centre for Universal Design. Principle Three is Simple and Intuitive Use. One of the authors of the Principles said that “we have not done any deep research in this area” and “the concept (of intuitive use) makes so much sense to me I never questioned it” (Story 2000, personal communication).

The concept of intuitive use is also mentioned extensively in product reviews and marketing literature, but it is not defined. While one can assume that intuitive use implies use without instruction, what is not clear from the existing literature is why and how this can occur. This paper addresses what intuitive use might entail and details an exploratory experiment conducted to investigate whether people can use products intuitively, what enables that process to take place and how designers could facilitate it.

**Background**

Products are often difficult to use correctly and are frequently misused for a variety of reasons. This situation could be alleviated by making products more intuitive to use. There are at least two aspects of this issue; overimputation and the division of control.

**Overimputation**

Difficulties can arise from the natural human habit of imputing one’s own knowledge to others (Nickerson 1999). Surprisingly, this is generally an effective way of ascertaining another person’s knowledge. However, when a person knows something very well and/or over a long period, it is difficult for them to put themselves in the position of a person who has none of that knowledge. Nickerson calls this problem overimputation. Designers can overimpute their specialist knowledge onto users (Norman 1988; Tognazzini 1989; Nickerson 1999). There could be two reasons for this:

The false consensus effect - “the tendency to see oneself as more representative of others (in various ways) than one really is” (Nickerson 1999: 749).
The illusion of simplicity, “whereby one mistakenly judges something to be simple only because it is familiar” (Nickerson 1999: 750).

Division of control
Further to the Industrial Revolution and consequent division of labour, which separated designers from users to a large extent, the technological revolution has forced a division which may be called the division of control. The user no longer has direct manipulation of or direct feedback from the controls of many everyday products. This is all done through a digital electronic interface. The terms opaque (Fischer 1991), lack of visibility (Norman 1988, 1993) and invisibility (Sade 1999) have all been used to describe a system that does not allow its function to be perceived from its structure.

In many electronic products, there is almost no physical and spatial relationship between the controls, the indicators and the state of the system. Norman (1993) divides artefacts into two broad categories according to their visibility; surface and internal artefacts. With surface artefacts, what the user sees is all there is, but with internal artefacts, information is represented internally and invisible to the user. Internal artefacts need interfaces to transform the information hidden within their internal representations into surface forms. Therefore users are dependent on the design of the device to make the information visible and usable.

Intuition research
Although “intuition … is a universal experience” (Bastick 1982), research on intuition in psychology and cognitive science is incomplete, and there is no general agreement on a definition of intuition or how the process works (Bastick 1982; Fischbein 1987; Laughlin 1997). Good overviews of the history of the concept and it’s intermittent study over the centuries are provided by Boucouvalas (1997), Bastick (1982) and Fischbein (1987). Several researchers agree that intuition is a process by which understanding or knowledge is reached without evidence of a reasoning process (Noddings and Shore 1984; Fischbein 1987; Bastick 1982). The dictionary definition also runs along these lines (Simpson and Weiner 1989).

It has been argued that the reasoning process is not in evidence when intuition is used as the cognitive processing takes place outside the conscious mind so that the steps in processing are not known (Agor 1986; Bastick 1982). Many researchers agree that the understanding or knowledge is retrieved or assimilated from memory during the non-conscious processing. This suggests that intuition relies on experiential knowledge (King and Clark 2002; Noddings and Shore 1984; Bowers et al. 1990; Dreyfus, Dreyfus, and Athanasiou 1986; Agor 1986; Bastick 1982; Fischbein 1987). The intuitive process integrates the information that one already has with what is perceived by the senses, and new associations between this information produce insights, answers, recognition or judgements (Bastick 1982).

Rasmussen (1993) developed the SRK (skill, rule, knowledge) model of task performance. According to this model, people operate on one of the levels (skill, rule or knowledge), depending on the nature of the task and their degree of experience with the situation. Extremely experienced people will process at the skill-based level. This is non-conscious, automatic processing. Those familiar with tasks but lacking extensive experience process at the rule-based level. The cues in the environment trigger rules accumulated from past experience, and previous successful solutions or decisions (Schunn, Reder, Nhounyvanisvong, Richards and Stroffolino 1997; Rasmussen 1993; Wickens, Gordon and Liu 1998). When the situation is novel, people will operate at the knowledge-based level, which is analytical processing using conceptual information. In a real world context, a person might operate at the knowledge, rule or skill-based level and will switch between them depending on task familiarity.
The SRK model was expanded into an information-processing model by Wickens et al. (1998). Here they equate rule-based with intuitive processing. During intuitive or rule-based processing a person must consider a variety of cues, which trigger retrieval of appropriate rules from memory (Wickens et al. 1998). Therefore, people can only use intuitive processing if they have had previous experience to draw on.

The dependence of intuition on previous experience is generally not recognized, and many people assume intuition is instinctive or innate. However, an individual’s experience gradually accrues over time. A baby’s intuition is composed predominantly of instinctive responses to stimuli but adults include more learned responses in their intuition as they develop (Bastick 1982).

If, as Nardi (1996) claims, “all human experience is shaped by the tools and sign systems we use” (p10), the extent to which something is intuitive to use should be shaped by products people already use. It is possible for a novel stimulus, ie one not previously experienced in a specific context, to be highly associated with a group of recognised stimuli. It might be intuitively recognized as one of the group because of its many associations with the group (Bastick 1982). Therefore, a stimulus would not need to be identical to those previously experienced, just similar enough to allow the association.

So, intuition is a type of cognitive processing that is often unconscious and utilises stored experiential knowledge.

Factors of intuitive use

Intuitive use of a product or even a product feature is multi-faceted. Through initial observation of people using electronic products, it became apparent that there would seem to be at least three factors of intuitive use for each feature on a product

- Location of the feature on the product.
- Appearance of the feature (eg structure, shape, colour, labelling).
- Function of the feature, how it works.

Therefore, each factor of each feature would need to be considered when investigating how people can use products intuitively.

Experimental approach

A set of experiments was designed to test the thesis that intuitive use of products is based on previous experience with products or systems that have similar features to those on the product. Relatively few experiments have been done specifically mentioning intuition (Bastick, 1982), so there was no established procedure for measuring it. Based on the understanding of intuition explained above, intuition was operationalised as relevant past experience. The experiment objectives were to establish if relevant past experience of product features increased the speed and/or ease with which people could use those features, and to establish if interface knowledge was transferred from known products to new ones.

Participants

Queensland University of Technology staff were asked if they could volunteer to take part in the study. Levels of expertise (the independent variable) were classified as expert, intermediate, novice and naïve with digital cameras. This is a generally accepted definition of participants commonly
used in usability research. The participants were chosen to represent the range of levels of expertise, and a realistic distribution of gender and age groups. Five people per group (a total number of twenty) were needed for this experiment. None of the participants had encountered the camera used in the tests before the experiment began, and all participants were volunteers who received no payment in return for their participation.

**Procedure**

Participants were first welcomed to the room and all the equipment to be used was explained clearly. Intuition has been shown to be vulnerable to anxiety. Thus a calm and "permissive" environment should be provided for experiments concerned with intuition (Bastick 1982). Participants were encouraged not to worry about the experiment or their performance, and were reminded that the product was being tested, not themselves.

The participants were asked to complete two operations, each of which consisted of a number of tasks, and which between them involved use of most of the functions and features of the camera:

1. Use the camera to take a photograph in autofocus mode using the zoom function.
2. Find the picture you took. Erase your picture. Search through the other images stored in the camera to find (a specified image). Zoom in on the image so that the details become larger.

Two digital video cameras were used to record the activity. As per Vermeeren (1999), one was trained on the participants’ hands as they operated the Fuji camera, and the other recorded the whole scene. However, observation alone would not provide enough data to draw meaningful conclusions. In order to get the sort of data observation cannot provide – for example, information about the cognitive processing behind participants’ actions, a verbal protocol was used. ‘Think aloud,’ or concurrent verbal protocol, being concurrent with the actions, is commonly used in usability testing and other types of research and eliminates many of the problems involved with people forgetting details when using retrospective protocol (Ericsson and Simon 1984).

The manual for the camera was only available on request and participants were asked to try to work out the operations for themselves. Referring to the manual would mask use of relevant past experience. The experimenter answered questions and reminded participants to think aloud but otherwise did not intervene during the operations.

Immediately after the completion of the operations, a technology familiarity questionnaire was completed and a structured interview conducted. As part of the interview, participants were asked if they had been anxious during the test, either because of the presence of the experimenter, the video cameras and other equipment, or for any other reasons. None of the participants reported that they were especially anxious, so it can be assumed that intuition was not inhibited by anxiety during any of the tests.

**Apparatus and measures**

The Fuji 4700 zoom digital camera (Figures 1 and 2) was chosen for use in this experiment. This particular product was chosen as it has a mix of features, some of which are unique to this model and others of which should be familiar to some users as they have been employed in other cameras, other digital cameras, and other products.
The variables measured through this experiment and the methods and tools used are shown in Table 1.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Methods and measurement tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to complete all operations, and smaller tasks or components of tasks</td>
<td>Observation using Observer Video Pro software</td>
</tr>
<tr>
<td>Correct, inappropriate and incorrect uses of camera features</td>
<td>Observation using Observer Video Pro software</td>
</tr>
<tr>
<td>Conscious reasoning apparent during each use</td>
<td>Observation using Observer Video Pro software Concurrent protocol</td>
</tr>
<tr>
<td>Percentage of first or only uses of features per participant that were intuitive</td>
<td>Observation using Observer Video Pro software Concurrent protocol</td>
</tr>
<tr>
<td>Percentage of uses of each feature that were intuitive</td>
<td>Observation using Observer Video Pro software Concurrent protocol</td>
</tr>
<tr>
<td>Participants’ level of technological familiarity</td>
<td>Technology familiarity questionnaire</td>
</tr>
<tr>
<td>Familiarity of each feature</td>
<td>Structured follow up interview</td>
</tr>
<tr>
<td>Intuitiveness of each factor of each feature, based on user expectations</td>
<td>Structured follow up interview</td>
</tr>
</tbody>
</table>

Table 1: Variables, methods and measurement tools

The technology familiarity questionnaire and the interview were designed to establish whether or not relevant past experience is transferable between contexts. The technology familiarity questionnaire was designed for this study to reveal information about the participants’ behaviour with digital products other than digital cameras. Therefore, they were asked about whether and how often they used certain products, and how much of the functionality of those products they used. The products mentioned in the technology familiarity questionnaire were chosen as they were examples of common consumer electronic products that employed similar features and devices to the camera used in the study. The technology familiarity questionnaire was used to calculate the technology familiarity score for each participant. A higher level of exposure to and depth of
knowledge of the various products in the questionnaire produced a higher technology familiarity (TF) score.

During the interview, participants were asked to rate how familiar each feature was, from other products they had used or from any other situations. Participants were also asked to assess how the location, function and appearance of each feature they used on the camera conformed to their expectations. Intuition has been equated with users’ expectations as expectations are associated with remembered situations (Dreyfus et al. 1986), and adhering to users’ expectations is acknowledged as desirable for ease of use and consistency (Nielsen 1989). This exercise was designed to reveal how each of the three factors of the features compared with each other in terms of their intuitiveness, based on users’ expectations from their past experience.

The audio-visual data obtained on the video and through the verbal protocol were coded with the Observer software according to:

- the feature used (one entry per use of any feature)
- whether each use was correct, correct for the feature but inappropriate for the task or incorrect
- how much conscious reasoning seemed to be involved in each use
- time on each task
- time consulting the manual.

Since intuitive processing does not involve conscious reasoning or analysis (Noddings and Shore 1984; Fischbein 1987; Agor 1986; Bastick 1982), the less reasoning was evident for each use, the more likely it was that intuition was being utilised. Conscious reasoning coding ranged from intuitive (fast decision with no evident reasoning), through quick comment (enough reasoning to verbalise a couple of words) and trial and error (random playing with buttons or exploratory behaviour), to with working (thorough reasoning evident) and finally using manual (relevant past experience masked). These data have been used to generate many of the results in the next section.

Intuition is defined by some writers as necessarily correct (some researchers have even operationalised intuition as a correct answer), whereas most say it is only a useful guide that rarely misleads (Bastick 1982). Bastick believes that intuition is always considered to be subjectively correct but where there is an accepted answer for comparison (as in this case), intuition may not always completely agree. Therefore, during the coding of feature uses, a few incorrect uses were coded as intuitive. For example, several people tried to use the shutter as a confirm or OK button and although this was incorrect it was affirmed during the interview that they had felt that was the right thing to do as it was a confirm button for taking an image.

When calculating the statistics relating to the percentages of intuitive uses and intuitive first uses, only correct or correct but inappropriate uses were counted, as incorrect intuitive uses do not contribute to the successful use of the product. Correct but inappropriate uses are relevant as this experiment was focussing on the features of the camera and these uses were correct uses of the features.

**Results**

The data presented here were obtained from the variables detailed in table 1. Table 2 shows the means and standard deviations for the variables time to complete operations and technology familiarity score, for each level of expertise and overall. It can be seen that there are no significant differences between the mean times and technology familiarity scores for each group.
Table 2: Means and standard deviations for time and technology familiarity score

<table>
<thead>
<tr>
<th>Variable</th>
<th>Expert</th>
<th>Intermediate</th>
<th>Novice</th>
<th>Naïve</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>TF score</td>
<td>43.4</td>
<td>7.5</td>
<td>50.2</td>
<td>6.6</td>
<td>43.2</td>
</tr>
<tr>
<td>Time (secs)</td>
<td>573</td>
<td>564.6</td>
<td>657</td>
<td>216.9</td>
<td>581</td>
</tr>
</tbody>
</table>

Figure 3 presents the relationship between time to complete the operations and the technology familiarity score, and shows the strong negative correlation between these two variables, \( r(18) = -0.69, p< 0.01 \) (NB all correlations are Pearson’s product moment correlation coefficient). The level of expertise of each participant is also shown.

Figure 4 presents a scatter plot of each participant’s time to complete the operations as a function of their level of expertise. It suggests that no strong relationship exists between time and level of expertise. No significant correlation existed between these two variables, \( r(18) = -0.1, p> 0.05 \).
Table 3 shows the percentages of correct, correct but inappropriate and incorrect uses for each level of reasoning. It can be seen that the majority of intuitive, quick comment and with working uses were correct, while the majority of trial and error uses were incorrect. It must be remembered that these numbers represent all feature uses including re-uses.

<table>
<thead>
<tr>
<th></th>
<th>Intuitive</th>
<th>Quick comment</th>
<th>Trial &amp; error</th>
<th>With working</th>
<th>Using manual</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>64.5%</td>
<td>62.5%</td>
<td>9.6%</td>
<td>79%</td>
<td>46.2%</td>
<td>46%</td>
</tr>
<tr>
<td>Inappropriate</td>
<td>31%</td>
<td>12.9%</td>
<td>7.9%</td>
<td>5.3%</td>
<td>23%</td>
<td>19.3%</td>
</tr>
<tr>
<td>Incorrect</td>
<td>4.5%</td>
<td>24.6%</td>
<td>82.5%</td>
<td>15.7%</td>
<td>30.8%</td>
<td>34.7%</td>
</tr>
</tbody>
</table>

Table 3: Level of reasoning and level of correctness for all feature uses.

The total percentage of correct and correct but inappropriate intuitive uses of the features was compared with the familiarity of the features. It was found that the mean familiarity of the features correlated strongly and positively with the mean of the percentage of intuitive uses of the features, \( r(18) = 0.523, p<0.05 \). This is shown in figure 5.

So, features that were more familiar were intuitively used more often. For example, the power button showed a high level of familiarity and a high percentage of intuitive uses. The navigate function of the menu also showed a high percentage of intuitive uses and a high level of familiarity. The DISP function, which controls the displays on the LCD screen, showed a very low level of familiarity and a correspondingly low percentage of intuitive uses. Only experts who had used similar digital cameras picked up this function easily.
There was a strong positive correlation between the percentage of first or only feature uses that were intuitive and the technology familiarity score, \( r(18) = 0.643, p<0.01 \). And a strong negative correlation between the percentage of first or only uses that were intuitive, and the time on the tasks, \( r(18) = -0.465, p<0.05 \). Therefore, participants who had a higher level of technology familiarity were able to use more of the features intuitively first time and were quicker at doing the tasks. This trend can be clearly seen in figure 6.

Figure 5: Mean familiarity of features by mean percentage of intuitive uses of features

Figure 6: Technology familiarity score by percentage of correct or correct but inappropriate first or only uses that were intuitive.
Intuitive use is based on relevant past experience, and people use their existing knowledge when they are confronted with new systems or products (Kellogg 1989). During the interview, participants were asked to indicate their level of agreement with two statements. Statement 1 was “I use my knowledge of products that I am familiar with to guide me in using a new product of the same type.” 65% agreed strongly with this statement and 35% agreed. Statement 2 was “I use my knowledge of products that I am familiar with to guide me in using a new product of a different type.” 55% agreed strongly with this statement, 35% agreed, and 10% disagreed. The level of agreement with statement two was compared with the time each participant took to complete the operations. A strong positive correlation exists, $r(18) = 0.567$, $p< 0.01$. A less strong correlation exists for the relationship of time to complete operations and level of agreement with statement one, $r(18) = 0.533$, $p<0.05$. Figure 7 shows these relationships, and demonstrates that those who agreed less strongly with the statements took more time to complete the tasks.

![Figure 7: Time plotted against responses to statements 1 and 2](image)

When asked about the intuitiveness (based on expectations) of the three factors of each feature, some participants rated one factor of a feature at one end of the scale and another factor of the same feature at the other end. Ratings ranged from 1 (low, unexpected factor) to 6 (high, very familiar and expected factor). For example, the camera icon had high means of 4.00 for function and 4.20 for appearance but a lower mean of 2.95 for location. This icon is located in an ambiguous position so it could be a label for one of two or three different buttons on the interface. The power button had a high mean of 5.15 for function, but lower means of 4.10 for appearance and 3.10 for location. The power button is located inside the mode switch, and is not colour coded or very clearly labelled, which made it difficult for many participants to find, although all knew they had to find a power button or switch of some kind as the first step.
**Discussion**

From these results, it can be suggested that prior exposure to products employing similar features helped participants to complete the operations more quickly and intuitively. The Fuji camera borrows, or transfers, features from other digital products, so even expert users of digital cameras who had limited experience with other digital products completed the tasks more slowly and effortfully than novices with digital cameras who did have experience with the features employed in the camera from using other products. This is shown in the strong negative correlation between time and TF score.

The fact that there is no correlation between time and level of expertise with digital cameras also supports this conclusion, and suggests that grouping participants into expert, intermediate, novice and naïve with the product seems to be less relevant when investigating intuitive use than some other aspects of usability, because intuitive use involves applying knowledge from other contexts and other products. A grouping based on technology familiarity score may be more relevant in this situation.

The high percentage of intuitive uses that were correct seems to confirm Bastick's (1982) statement that intuition is generally correct but not infallible.

Participants with little or no experience with digital cameras who had used other digital devices seemed to be able to use familiar features intuitively. This conclusion is supported by the correlations between familiarity of features and percentage of intuitive uses, and correct or correct but inappropriate intuitive first uses and technology familiarity score. The first uses results are particularly important as the participants had not yet had the opportunity to learn about the feature but used it either correctly or correctly but inappropriately the first time they encountered it. They could only base their actions on relevant past experience of similar features or things, so this result offers strong support for the idea that including familiar features in a product will allow users to use them intuitively first time.

The correlation between level of agreement by participants that they use knowledge gained from the use of one product to help them learn about another and their time to complete the operations also supports the hypothesis that intuitive use is governed by past experience. The more time a person took to complete the task, the less strongly they believe that they use their knowledge of familiar products when they are faced with an unfamiliar product, particularly of a different type. These people were less likely to transfer knowledge from other products and apply it to the use of the camera. Because the camera borrows so many features from other digital products, not primarily from cameras, transferring knowledge from other types of products was necessary in order to complete the tasks quickly and intuitively.

Through the interview process, it has been confirmed that location, function and appearance of features on the product are factors that need to be separated for purposes of analysis. Also, as can be seen from the analysis of the results above, this differentiation can show quite clearly which factor of a feature may be responsible for usability problems This would allow designers to correct the right problem (eg, location of the power button) not the wrong one (eg, function of the power button).
Conclusion and relevance to design

These findings suggest that relevant past experience is transferable between products, and probably also between contexts. The participants with relevant past experience with the different features show faster and more intuitive use of those features, so it should be possible to conclude that relevant past experience has contributed to that. Therefore, including familiar features and controls in a product, in a way that is easy to follow and is consistent with the user’s expectations according to her/his past experience, should increase the intuitive usability of those controls.

Intermittent users of inconsistent or counter-intuitive products, or users attempting to carry out new tasks, would have problems, although more regular users may be able to use the product well once they had learned it, suggests Kellogg (1987). Also, she found that users tend to see an inconsistent software system as undependable and unfriendly. Counter-intuitive products could well be viewed the same way.

In the current market place, there is a proliferation of electronic gadgets and a high turnover of consumer electronics products, with new models and upgrades appearing constantly. Products become more and more complex as new technology allows designers to include more functions. There are many intermittent and casual users, and many available functions within these products that are learned only when needed and not necessarily when the manual is available. Also, some products, such as office machines and equipment, are shared or passed around, and manuals become lost in the process. Therefore, designers need to make these products easier to learn and use if the current trends are to continue.

This research could contribute significantly to the design and usability of various products for all types of users. Issues that can be further explored in relation to intuitive use include how to use design to make products more intuitive, how to ascertain which sorts of features will be familiar to certain populations and applying these ideas outside the realm of products and to related fields such as software.
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An Indian who doesn’t know how to grow the maize

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Abstract

In user-centred design, a common ground that emerges is an orientation towards research into the needs and wishes of consumers. Hermeneutic phenomenology can be adopted by a designer to investigate her/his own activity and use of knowledge in designing. A reflection of this kind is presented here. It is based on design and research activities in the domain of product design, in which the realization of user-centred design was sought by means of preliminary user research, application of its results in design work, and evaluation of the outcomes through renewed user research. The outcome of the reflection is the formulation of a generative metaphor for further design and research. This generative metaphor is derived using analytic and exegetical approaches from hermeneutic phenomenology. Thinking of the designer as “an Indian who doesn’t know how to grow the maize”, it is proposed, addresses questions of an integrative view on the design task; the proximity between designers and consumers; and the use of projection to distinguish between users’ present situation and a potential future one. In exemplarily presenting this metaphor, the paper hopes to contribute to an already growing resource of knowledge in the discipline of design, and user-centred design in particular, on the possibilities, responsibilities and implications of designers’ professional activity.
An Indian who doesn’t know how to grow the maize

Introduction
In design, and user-centred design in particular, efforts have been made to develop research methods to support designers in their activity. This paper introduces a perspective to user-centred design research methodology that has not so far been applied to it: hermeneutic phenomenology. ‘User-centred design’ is not a universally endorsed term. Pheasant (1996: 13) explicitly adopted it, Dunne (1999: 30) critiques it, others use a variety of similar terms to describe their stances, e.g. inclusive design or participatory design. While these may differ in historical roots and meaning, what emerges as a common ground is an orientation towards research into the needs and wishes of consumers (f. ex. Aldersey-Williams et al. 1999).

Based on reflections on design agency in the past decades, a conceptualisation of designing as a communicative and intersubjective activity has arisen. There has been a call for metaphors that designers could use to guide their activity (Coyne and Snodgrass 1991: 130, 1993: 111-113, Schönb 1992: 137-163). Schön suggested that framing and re-framing (of a problem/phenomenon) was accomplished through ‘generative metaphor’:

“We need […] to become aware of the generative metaphors which shape our perceptions of phenomena. […]. However, this is not as easy as it sounds, for generative metaphors are ordinarily tacit. […] We may be helped […] by the presence of several different and conflicting stories about the situation […] mak[ing] it dramatically apparent that we are dealing not with “reality” but with various ways of making sense of a reality. […]

In order to bring generative metaphors to reflective and critical awareness, we must construct them, through a kind of […] analytic literary criticism, from the givens of the problem-setting stories we tell….“ (1992: 148-149)

In a reflection that is reported in this paper, Van Manen’s (1990) methodology is used in order to develop a metaphor for actions of a designer, based on knowledge about users from research, that might be seen as meaningfully related to projected outcomes for users. In the following, three sets of research activities will be sketched and then discussed reflectively.

Research

A study
The goal of an initial study on bathing for older people, was to find out about users’ wishes and needs prior to design work. Participants were residents of sheltered housing. The Wellbathing study was entirely qualitative and comprised focus group interviews, individual interviews, photographic recordings, and visual communication (Figure 1). Its methods were based on guidance from design research, as well as other fields (f. ex. Zeisel 1981, McCracken 1988; Krueger 1994). A ‘visual tool’ was developed and used, similar to tools that have recently been used elsewhere (Jordan and MacDonald 1998). With it, research participants collaged their “ideal bathroom”. The study methods and activities have been described in Lebbon and Boess (1998) and Boess (2002). Preliminary results will be discussed below.
Figure 1: a focus group session

Case studies
Later, design and teaching activities were accompanied by action research which, it has been said, is usefully reported in the form of case studies (e.g. Robson, 1993: 438-99; Schoen and Argyris 1991)

Case study assisted bathroom
The research outcomes of the Wellbathing Study were applied in the planning work of an ‘assisted bathroom’. This type of room exists in most older people’s residences. Its main purpose is for caregivers to assist people in bathing who cannot do so in their own flats.

Sample results from the Wellbathing study. The participants of the Wellbathing study had various experiences and evaluations to offer about the assisted bathrooms known to them. For example, the opportunity to bathe at all was generally valued. But the time was often too short (“ten minutes or so”), and in two of the three residences where it was present, the bathroom was rather far away from most residents’ flats, so that it was perceived that too much public space had to be traversed to get to it. In the one case where it was close, the bathroom was being enjoyably used by a couple independently of care-givers. The windowless and soberly outfitted bathroom in one of the housing complexes was dubbed “the dungeon” by residents (Figure 2).
Design. In response to the needs and wishes that had been identified, objectives were set that the design should:

- answer cultural needs ("I’m not into putting on the style, not at my age, but I would like a nice peach bathroom and peach curtains [...] and [...] a few flowers in the window…")
- realise usability: adaptability in use and low demands on the user; unobtrusive safety. ("Grab bars [are for] them, the disabled"). ("Getting in and out, it’s difficult, you know")
- provide for an overall relaxing atmosphere ("I love a good soak. Get the Radox going ...")

The first author (Boess) mainly carried out the design intervention. Its scope was limited to tiling, furniture, decoration, and placing of the sanitary objects in the room, and had to be coordinated with the general interior design concept for the building. Examples of design considerations:

A local manufacturer’s traditional tiles were named in the group discussions as synonymous with quality and style. Such tiles were then specified, alongside up-to-date equipment, informed by statements like “We like a bit of both, the old and the new.”

The assisted bathroom had already been positioned far away from individual flats, within a sports- and sauna area that was recessed off the most public area of the complex. To compensate, it was decided to make the washbasin area spacious and inviting to use, in contrast to the customary mini-
washbasin across from a toilet (f. ex. Goldsmith 1976). This should allow users to get dressed and groomed at ease before re-entering the public area (Figure 3).

Figure 3: schematic of design considerations.

The design was evaluated by Boess, visiting again after it had been in use for a year. Traces of use were noted; and short interviews with five residents, two care-givers and a longer interview with the manager of the scheme were conducted. Some outcomes of the evaluation will be discussed below.

**Case study learning module**
A ‘human factors’ learning module was planned and run at Staffordshire University. Its aims were to convey skills and appreciation of research to students, as well as to look at research methods such as the ones used during the Wellbathing study, from another perspective. A description and evaluation of the module has been reported in Boess and Lebbon (1998). During the six-week module, a group of design students and older people worked together, examining usability of and preferences for the bathroom. The students discussed their design proposals in small groups with U3A members. 3D full-size props were built by the students and appeared to be a valuable additional communication tool (Figures 4 and 5). Some problems and opportunities that were seen to arise from the module will be discussed further below.
Analysis

There is relatively little material in the domain of design on the theoretical ground of interpreting research with users, though there are many reports of studies (e.g. Scrivener et al. 2000). For example, neither the MethodsLab (Aldersey-Williams et al. 1999) nor Poulson et al. (1996) even mention data analysis, and Zeisel’s (1981) advice was rather technical and positivist in orientation.
While “natural to use research methods” have now been proposed for design (Aldersey-Williams et al. 1999: 3), uncertainties when it comes to interpretation, it appears, have hardly been problematized.

Methodological guidance for analysis of the Wellbathing study and the case studies, was initially sought in a standard work for nursing science. A Grounded Theory perspective was adopted (Polit and Hungler 1997: 377-398, Glaser and Strauss 1967). An assumption had been that knowledge of the phenomenon under study could result in indications of what should usefully be done about it. The recognition that this is not straightforward led to the evaluation that Grounded Theory has limitations in this respect. Van Manen’s methodology, which has been mentioned, was then adopted for the purpose of reflection. It will be reported in the following.

Discussion

This discussion reports on a reflection on how successful the use of knowledge generated from the various research activities, has been in realising user-centred design. It follows Van Manen’s (1990) methodological advice on structuring reflective writing. The reflection will employ two approaches: what Van Manen calls an analytical approach, “examining systematically the various themes that […] narrative[s] reveal, “in an ever-widening search for ground” (1990: 170), and through what Van Manen calls an exegetical approach, by taking recourse to previous literary and philosophical material, “in terms of a discussion of those texts and the structural themes that their authors have already identified and discussed”, and “treat[ing] the[ir] works […] as incomplete conversational scripts” (1990: 171). As an outcome, a generative metaphor is developed (see introduction) that could usefully inform user-centred designing: a metaphor for what a designer thinks she/he is doing while designing, and how she/he thinks about others involved in the process. Finally, a re-interpretation of the initial Wellbathing study results is briefly sketched, in order to project how the generative metaphor changes the authors’ perspective on possible design tasks. It does not constitute a ‘truer set of results’, but a deepening of knowledge for design. Van Manen:

“Phenomenology does not problem solve. […] Phenomenological questions […] ask for the meaning and significance of certain phenomena. […] in some sense meaning questions can never be closed down, they will always remain the subject matter of the conversational relations of lived life, and they will need to be appropriated, in a personal way, by anyone who hopes to benefit from such insight.” (1990: 23)

Themes that emerged from deploying the research results in design (analytic approach)

From the activities that have been mentioned, stories about situations have become available to the authors (see Schoen’s comment in the introduction). The stories are presented as ‘themes’. Van Manen notes:

“phenomenological themes may be understood as the structures of experience [italic in orig.], […] ultimately the concept of theme is rather irrelevant and may be considered simply as a means to get at the notion we are addressing. Theme gives control and order to our research writing.” (1990: 79)

To analytically recover themes, we might, briefly said, ask questions like, is this plausible? Is it possible? How is this experience lived? (Van Manen 1990: 91).
Theme: Integrating design issues towards user-centredness.
“We like a bit of both, the old and the new”

The design of the assisted bathroom, overall, was liked or at least praised by users. It was apparently not being perceived as overly radical or innovative: nobody said “I don’t like it”, or “I can’t live with this”. (see f. ex. Schrage 2000: 128). Shortcomings that became apparent were:

Specification problems. Grab bars had been selected because they were the standard choice for functional requirements for a room of this kind. Users of the room found that this combination of items which carried different associations for them (disability versus “nice” bathing), detracted from the quality of the experience of using the room. The problem was not a matter of disparity in the design as such: combinations of the old and the new had been expressed as desirable in the Wellbathing study.

Problems of coordination. Design decisions made, influenced decisions others subsequently made. For example, the management were so reluctant to damage the expensive tiles that a shower head was subsequently mounted higher than would be conveniently usable in the bathtub.

Diverse use patterns. The research had focused primarily on one group of users of the room: the senior residents who would bathe in it. The staff’s needs had also been researched through interviewing and interactive use of a scale model (Figure 6), but apparently not sufficiently so. For example, there was not enough provision for the storage of cleaning equipment. It ended up being left out in the open. This detracted from the aesthetic quality of the room for the bathers as well as for the staff.

A further observation was that some aspects of the design which were liked by the users, had not been closely based on the research at all. The colour scheme, for example, did not try to answer participants’ diverse expressed preferences which ranged from blue to pale pink to black and white.
Instead, a warm tone was used that would make skin look healthy. The students too encountered the problem of handling diversity. One student made it his design theme, proposing a set of washbasins in the shape of a cascade, to include diverse needs for height.

So there was, apparently, a problem of integrating a number of issues in designing. Some attempts to answer needs even ended up counterproductive. How could a designer prioritise so that the main goal of user-centredness would benefit? How could a designer account for those aspects of a design which weren’t based on expressed needs at all, but on a necessity to make a decision though faced with diversity? The problems which have been described, all seem to relate to a quality of design activity which has been termed ‘integration’ (Dorst 1998: 22). Dorst pointed to the importance of integration, an activity of making decisions which “link the elements of the problem or solution, adequate in all relevant contexts” (ibid.: 35). A generative metaphor to be developed will need to promote this. **How can a designer put her/him-self in a position/positions in which he/she can notice and integrate different relevant perspectives on one kind of use situation?**

**Theme: Getting close enough long enough to learn about daily life preferences**

“The room is lovely, but the bench isn’t very useful …”

Having elicited potential users’ needs and wishes (more than is often done for the purposes of designing), the first author worked out design solutions. The later evaluation showed that while some needs and wishes had been correctly recognised (users reaffirmed them), the actual design was not always successful. Two examples:

**Opportunities to personalise the room** had been given by providing ledges on the sides. Users kept forgetting personal things on the ledges, and an extra table near the door was eventually brought in. That turned out to be the place where personal things were usefully habitually deposited.

**A bench** had been custom-designed so that users could sit on it to undress. A custom-designed grab bar that had been planned to go next to it, had been dropped. That meant it was not easy to get up from the bench. An extra chair of a kind that had been popular with participants of the initial research (it was represented in an image as part of the visual tool), was brought in later. The relatively cheap rattan chair had integrated arm rests which were found to be conveniently usable as supports.

In the evaluation, then, it became apparent that the design interpretation of users’ needs had sometimes been too literal, and other times not literal enough. It was hampered by insufficient knowledge of users’ daily life preferences.

During the learning module, Boess noticed that the students found it difficult to ask the older participants questions relating to activities as private as using the toilet. During Wellbathing study, Boess had experienced a similar inhibition, also on the part of the research participants: for example, while a couple was being interviewed, the woman chided her husband for his half-joking descriptions of his daily rituals: “She [meaning the interviewer] doesn’t want to know that”, deselecting aspects of their life as inappropriate to the interview.

The elicitation methods had failed to reveal aspects which turned out relevant to the eventual design. But if research got even ‘closer’ to users, what would become of the problem of respectful distance which seemed to come naturally to those involved? A theme that has occupied design thinking (f. ex. Margolin 1995, Morrow 2001), is designers’ distance from consumers, thinking their own experiencing is representative enough of others’ experiencing. Perhaps as an unfortunate side effect of a respect for each other’s sphere, designs can end up inadaptable to situations deviating from those of imagined normal users. A metaphor to be developed would have to suggest
How and why closer involvement between designers and users might be successful. **How can a designer come close enough to users to find out what he/she needs to know, while maintaining a degree of proximity they and she/he feel comfortable with?**

**Theme: Distinguishing between an existing situation and a potential one.**

“I didn’t like having to design for older people …”

The students confirmed that they had found the module of great learning value. But they said they didn’t like designing for older users. They said they preferred to design for themselves or people like them. The designs they made in a follow-up module (not reported here), now free to choose the prospective user, were mostly aimed at young mobile singles, celebrating values related to hipness, technology or financial wealth. A similar phenomenon also applied to Boess’s design activities. Boess had set out with a partly ethically oriented motivation: of realizing user-centred design. Possibly being preoccupied with problems of disability and dependence she sought to address, she also ended up not making designs that would also be attractive to her.

While some participants of the Wellbathing study had said “Everything’s fine, I’m happy [with my disabled shower]”, some had also said things like “this isn’t home”, “I’m ashamed of my bathroom”, “So we’re stuck again”. Some of the very arrangements which, one must presume, had been made to support participants, were apparently perceived by them as oppressive or limiting. What remarkably emerged from the Wellbathing study as well as the learning module, was that the older participants too agreed that they didn’t want “design for old”. How could a designer distinguish between ‘being the problem’ and ‘being subjected to a problem’? How or how much do the things that surround users, determine their lives? (See also f. ex. Pantzar (1997) for a discussion from a macro-economic perspective).

Nayak’s motto is: “Design for the young and you exclude the old. Design for the old and you include the young” (f. ex. in Coleman 1997: 29). But perhaps the problem that the students had been set, and that the first author had set for herself, to design something “for the old”, hampered the inclusion of the students’ and the designer’s own interests in their design work. Design research reporting sometimes appears to treat this question in a “the consumer was happy and everything was fine” kind of way (see f. ex. the case of Ray Driscoll in Smith et al. 2000. Design is done to facilitate a consumer’s tacit intentions. Success is that the consumer liked it).

Schön (in Bennett 1996) reflected on characteristics of a designer-user relationship which would result in products that serve the user well. He suggested a professional practice oriented on outcomes that satisfied the designer and the client alike. What taste could they come to share? What could the designer project into the situation he/she has experienced? How can a designer distinguish the potential in people’s lived experience from circumstances constraining them now?

**Towards a generative metaphor (exegetical approach)**

Each of the three themes into which the reflective stories have been grouped, integration, proximity and projection, represents an aspect of the relation of a designer to a design situation which generates knowledge in user-centred designing (the phenomenon studied), and has been shown to have also been recognised in design-related literature as relevant in design practice. In order to now develop a relevant generative metaphor that could inform a design activity, an exegetical reading of two descriptions of relations is presented next.

**The first description of a relation: Van Manen.** Hermeneutic phenomenology, as Van Manen describes it, has one important sine qua non: that the inquirer be in the relation that is described. Having adopted the methodology as a research methodology, the question arose whether Van
Manen’s examples of such a relation, given throughout his work, might also be a way to look at a designer within the design process.

The second description of a relation: Deleuze. In order to focus on spatial and perceptual aspects that present themselves to a designer, another theorist’s material is also taken up: Deleuze’s (2000) small volume of essays discussing writing and art. Deleuze is not a phenomenological writer but a poststructuralist one. Deleuze draws a lot, sometimes implicitly, on texts by Nietzsche, and on Heidegger’s (later) thoughts about context- and perception-orientation. These writers also figure prominently in Van Manen’s (1990) work and have each had an impact on phenomenology (see also Spiegelberg 1994), leading the authors to cautiously assume that they can draw on Deleuze’s work for the purposes at hand.

Van Manen discusses the pedagogue in relation to the children in her/his care; Deleuze, the writer in relation to the world she/he writes about. Van Manen’s and Deleuze’s discussions have been exegetically read for the way they depict the actors in a situation and their relatedness with others, for the attention they give to perceptible elements of a situation, and for the actions they see an author (designer) as undertaking. They were not compared against each other, but read for how they can respectively deepen the reflection and shape a metaphor.

The exegetical reading can only be presented here in a summary which already constitutes the generative metaphor which has been derived from it. The metaphor that has been developed, is that of “an Indian who doesn’t know how to grow the maize”. Deleuze (2000: 12) has proposed it for the writer, based on a novel by Le Clezio. Admittedly the following might not seem quite straightforward in this necessarily brief presentation. The metaphor specifies for the design process that:

In order to put her/himself in a position in which she/he can integrate different perspectives on a use situation, a designer “becomes” (Deleuze 2000: 13) “Indian” (Deleuze 2000: 12), i.e. part of a ‘people’, though remaining aware of her/his difference (Deleuze 2000: 158). A writer (designer) lives with and among those in a “lifeworld” (Van Manen 1990: 46), or “the others that exist” (Deleuze 2000: 183) in a position of “minority” (Deleuze 2000: 15). She/he doesn’t know how to grow maize, a sustained and sustaining activity (Deleuze 2000: 12). ‘Growing the maize’ is interpreted for design to be an activity during which users ‘discover’ and change products from manufactured ‘hypotheses’ into elements in a ‘lifeworld’ or ‘world of the existing’. In order to notice the characteristics of this situation, and how people live in it, metaphoric questions a designer can ask are: in what way are they and I “minor” ones that are “becoming” “a people of” Indians? What is “growing the maize” like?

In order to seek and establish sufficient proximity for what a designer needs to know about users’ world, a designer seeks out the tone of those that ‘fit’ with her/ him and sympathetically shares with them their discovering of world. The designer needs to be close enough in order to be able to share a “seeing” and “hearing” with them (Deleuze 2000: 119). The experiential criterion of success is a feeling of sympathy [note 1] that this partial outsider shares or comes to share with those in the lifeworld (Deleuze 2000: 158 and 183, and similarly, Van Manen 1990: 46). This sympathy might enable users and designers to share more aspects of daily life. Both must also be able to ‘retreat’, of course. A designer can ask: what ‘visions’ of theirs do I see arise, and what ‘tones’ of theirs do I hear, that make us stronger?

In order to distinguish between the potential in people’s lived experience, and the situation they’re in, a designer projects images over that world of the Indians (Deleuze 2000: 169). A designer has an inner world or ‘cartography’ (Deleuze 2000: 85) that she/he brings to bear on the lifeworld studied,
which enables her/him to call up displaced linkages with it, to creatively inject ideas into it and produce ‘true visions’ (Deleuze 2000: 157). The process can also involve a ‘minorisation’ of the language of the Indians, to reveal its displacements of meaning (Deleuze 2000: 15/146). Good design then would be to successfully, poetically, transform what it is like to be “an older person bathing etc.” and to open up new ways of living it. A designer can ask: what images do I wish to inject that produce a potential transformation of their (and partially, my) world?

Outcomes arising from the designer’s activities must be referred back to that lifeworld as the ground of validity (Van Manen 1990: 46). That is why a design process should usefully be iterative for this context. Participants who are not involved in the decisions that determine situations, must have another chance to respond.

Sketch of re-interpreted data
The data from the Wellbathing study have been re-examined for knowledge that might arise from them.

On integration, the authors’ initial organizing perspective of user’s needs and wishes, the user-centred view, now comes to revolve around users’ idea of home. The home is something that

- they re-establish, re-habitualize
- embodies relatedness
- can become a ‘not quite home’, especially with the absence of relatedness.

Participants variously live (‘grow the maize’) by making technology fit with habits, by sharing privacy, by maintaining independence and their own way of life, by adapting ad-hoc to health events or by staying in accustomed roles.

On proximity, how a designer sympathizes with participants’ experience is not precisely identifiable, it is in a indiscernible ‘neighbouring zone’ (Deleuze 2000: 90). The researchers sympathized particularly, in the encounter with them, with the ‘tone’ that is audible of their resilience, and with the ‘visions’ that open up when they assert their preferences. The authors also came to feel a sympathetic sadness when visions are blocked, and the tone is numbed that could echo into the future.

On projection, the author that was here concerned with design work (Boess) can now inject images into the world she has encountered. They involve ‘fictionalized’ versions of the participants and their world, building on and extending the participants’ ‘fabling’ relationship with their environment, ‘colouring’ them in and ‘composing’ them into points of departure for design (Deleuze 2000: 156-60). The author has ‘composed’ points of departure briefly summarized as:

- **Wellness extra.** Uses users’ wishes for wellness functionality as a first guiding motive for design, rather than users’ (dis)abilities. Proposals might involve spa functions (e.g. massage jets, steam bath), potential wellness functionality of plants, or use of colour and sound.
- **- Soft tools.** Looks at the ‘handlability’ of smaller items in the bathroom. Functions are seen in terms of tools that can easily be manipulated and moved around, that are pleasing to the hand and that have an easy-access place where they ‘live’. Items might be grouped as ‘toolbox’.
- **Nature.** Refers to the bathroom’s position in relation to the house and exterior space. A connection with the time of day, with the weather, and the season of the year could be established.
• **Fold-up.** Physical objects as well as forms of organization are geared towards adaptability to use at a particular time, in a particular place, by a particular person, yet do not present an obstacle, e.g. through physical volume and weight, in the carrying out of other tasks.

• **Walk-in.** Makes available an ‘open space’ that can be furnished with appropriate functionality. Possibly also seating functionality set into a wall with water drain in the floor, to provide for walk-in semi-bathing.

In the course of the reflection, the authors have come to acknowledge the authorship of participants in the interaction stories with their own environment. Overall the elements of the generative metaphor give the results a directedness towards users and their possibilities, moving on from the situation they are in.

**Conclusion**

In employing the generative metaphor of ‘an Indian who does not know how to grow the maize’ to the process of knowledge generation about users during the design process, a designer becomes a ‘user who doesn’t know how to use’. A designer brings her/himself into an experiential situation and is perceptively directed the sharing of an experience with another.

It is hoped that it has been shown in rough outline how the metaphor applies to tasks of designing bathing environments for older people. It is a matter for further work to see what else it can do.

What has been described suggests a slightly different conceptualization to e.g. Rouse’s (1991: 34) position that designers should talk to users because designers are not (presently) users. Designers here become part-users, but not all-users. Conversely, the reflection has suggested that users might also be part-designers (compare also f. ex. Demirbilek 1999).

User-centred design might become something like ‘shared experience design’ or ‘joint exploration design’, terms that are closer to Scrivener’s et al. (2000) “Collaborative Design”, but also reflect a joint directedness towards environmental experience.

It seems that it would be fruitful to develop more methods that will make designers in general more willing and enthusiastic about getting engaged with users’ ‘lifeworld’, and vice versa. Such methods might evolve through collaborations.

**Notes**

[1] In e.g. French and German linguistic usage, “sympathique” or “sympathisch” translates into English as “sympathetic, engaging, likeable, nice, amiable” (f. ex. Langenscheidt 1977), or, as “simpatico” in U.S. English, as “agreeable […], being on the same wavelength; congenial”, rather than the common English meaning of “pitying” (Merriam Webster 2000). That’s why in this text we use ‘sympathic’ and ‘sympathical’ rather than ‘sympathetic’, to distinguish between the meanings.

**Acknowledgements**

Thanks to the DAAD (Deutscher Akademischer Austauschdienst), Germany, and to the Advanced Research Institute, Staffordshire University, UK for each funding part of the first author’s PhD study period.
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A very strange thing: commodity discourse in cultural theory and design

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Abstract

This paper attempts to bring to design dialogue an expanded meaning of the term “commodity” by revealing its presence and discussion in other disciplines via the writings of some of the predominant thinkers through history. Particularly germane to design are the notions of commodity fetishism and commodity aesthetics eloquently outlined in treatises by Karl Marx and Wolfgang Haug. Experiments in generating innovative forms largely perceived as imperative creative exercises in design are, according to Marxist thought, merely attempts to valorize capital. The redesign of product forms is labeled by Marxists as ‘aesthetic aging,’ and referred to as an activity with sole purpose of forcefully outdating existing products. Also critical is the notion discussed by Marx, and later by Walter Benjamin, that human (and maybe robotic) labor-power expended in the making of the commodity is invisible to the consumer, thereby degrading as a value. By referring to a commodity as a product (a visible, tangible termination of the process of design and manufacture), designers align themselves at the other extreme of this idea. Modernist thinking emphasized the visibility of function and means of manufacturing of products, revealing an interesting antithesis. Theodor Adorno likens the production of culture to that of mass-produced objects. He therefore portrays the commodity as a metaphor for culture by equating its means of generation, which relies on standardized industry, to that of cultural production. Not habituated to fundamental discussions of capitalism and political economy, the inclusion of such material will challenge existing definitions of objects within the debate of design history.

“A commodity appears at first sight an extremely obvious, trivial thing. But its analysis brings out that it is a very strange thing, abounding in metaphysical subtleties and theological niceties.”

- Karl Marx (1967: 163)
A very strange thing: commodity discourse in cultural theory and design

Introduction
Commodities are routinely studied, analyzed and debated by disciplines such as industrial design, anthropology, political economy as well as media studies and cultural theory. Though scholars in design, media studies and cultural theory regularly undertake examination of the commodity in generating critical discourse in their respective fields, the language used and nomenclature adopted differ and common points of convergence are rarely encountered. Terms such as form, use and utility may often be employed to mean different things. The symbolic meanings and values attached to commodities vary widely within these fields of study, and are at times in violent disagreement with each other. Design discourse largely discusses processes, systems, and methodologies of design construction and synthesis, whereas cultural theory and media studies typically deconstruct materiality, drawing upon political, economic, sociological, and anthropological approaches to analysis. Not habituated to fundamental discussions of capitalism and political economy, the inclusion of such material will challenge existing definitions of objects within the debate of design history. An understanding of the politics of power, central to cultural theory, can better inform designers just as comprehension of the design process can educate cultural and social theorists. The research project briefly outlined in this paper is a part of a larger study that aims to interrogate respective methodologies, promote dialogue, and suggest avenues for research as well as teaching across these fields. This may challenge existing definitions and parameters of our disciplines. Design may become less instrumentally pragmatic, more informed by the social, political and economic concerns central to cultural and media studies. Similarly, cultural and media studies might supplement its analysis of institutions, texts, audiences, and technologies with a deeper consideration of technological objects and the processes of their evolution.

Starting with issues related to commodity fetishism outlined by Karl Marx in Das Kapital (1887), leading up to Robert Miklitsch’s From Hegel to Madonna: A General Economy of Commodity Fetishism (1998), this paper will bring to design dialogue some of the positions of political economists and cultural critics on the commodity from a perspective largely and generally alien to design. Treatises by Theodor Adorno, Walter Benjamin, and Wolfgang Haug will also be discussed and contrasted with contemporary issues in design.

Commodity as value
One of the most exceptional early discussions of the commodity is found in Karl Marx’s Das Kapital originally published in 1867. Marx’s definition of the commodity as “an object outside us, a thing that by its properties satisfies human wants of some sort or another” (1967: 35) is expansive enough in its circumscription to be acceptable to this day to industrial design’s resolute advocacy of user satisfaction. However, further analyses reveal points of departure and contradiction that are of interest. Marx viewed objects from two distinct perspectives, which he referred to as use-value and exchange-value, the former responsible to the object’s utility and the latter to its tradability. He severed the worth of the object from its utility by postulating that when commodities are traded, their exchange-value manifests itself as entirely independent of their use-value. In fact, he assigned them antipodal forms, a physical or natural form and a value form by writing, “the value of commodities is the very opposite of the coarse materiality of their substance, not an atom of matter enters into its composition” (Marx 1967: 47). This dichotomy between materiality and value may be likened to a similar schism that existed in design dialogue between form and function, albeit with different understandings of the terms. To Marx, utility was more corporeal and inherently wedded to the materiality of the commodity, but its exchange-value was more ephemeral. In contrast,
Modernist design thinking attached utility to the concept of function, a less tangible entity than its earthly form, which was essentially the materiality of the commodity.

![Diagram showing commodity as a matrix of use-value (utility), exchange-value (tradability), form (body), function (utility), tangible, and intangible.]

**The soul of the commodity**

In his fascinating discussion of the fetishism of commodities, Marx attributes mystical character to a table that has been fashioned from a natural, ordinary material—wood. “So soon as it steps forth as a commodity, it is changed into something transcendent. It not only stands with its feet on the ground, but, in relation to all other commodities, it stands on its head, and evolves out of its wooden brain grotesque ideas, far more wonderful than ‘table-turning’ ever was” (Marx 1967: 71). This mysterious quality of the commodity, according to Marx, is not born from its utility, but is derived from the human labor expended in its creation. Marx gives the commodity a voice that speaks to the consumer. In Capital (Das Kapital), he writes, “Could commodities themselves speak, they would say: Our use-value may be a thing that interests men. It is no part of us as objects” (Marx 1967: 83), suggesting that the commodity attracts the customer on account of its utility value. This notion is at odds with the popular belief that in a market flooded with commodities that offer nearly identical functionality, the commodity body (appearance) can provide the necessary enticement to the buyer. For Wolfgang Haug, commodities are seen “casting flirtatious glances at the buyers…which they use in courting the human objects of affection” (1986: 19). In his description of the arcades in Paris (shopping malls of mid 1800s), Walter Benjamin writes about the commodities and the spell they cast on the stroller (flâneur). “The commodity itself is a speaker here… the commodity whispers to a poor wretch who passes a shop-window containing beautiful and expensive things. These objects are not interested in this person; they do not empathize with him” (Benjamin 1973: 55). However, in describing the stroller’s search for something new in the arcades, Benjamin disagrees with Marx in saying that the novelty of a commodity does not lie in its use-value. In externalizing the thoughts of the commodity, Marx, Haug, and Benjamin bestow on it an animate quality, albeit an amoral one. Industrial designers too give voice to commodities by creating a visual/tactile language that offers semantic cues to the user. This voice however, is that of reason, one that offers assistance on how to interact with the object. The commodity is at once seductive and instructive; it lures and it befriends.

**The labor process in the commodity**

According to Marx, the labor that is employed in the production of the commodity is invisible to the user. “In the finished product the labor by means of which it has acquired its useful qualities is not palpable, has apparently vanished” (Marx 1967: 183). This concealment was seen as negation of human activity and likened to degradation of labor. Not unlike Marx’s reactions to capitalist modes of production were the pleas made by proponents of the Arts and Crafts movement (who were also opposed to such dehumanization) by recalling craft ideals. Early protagonists of Modernism too, through their emphasis on the removal of ornamentation, rallied for an honesty in the use of
materials and a “proud and frank exhibition of working processes” (Pevsner 1936: 30). It has been suggested that Marxist arguments of labor were valid only within pre-industrialized methods of production and cannot be used to study current practices. In fact, replacement of human labor with the robotic arm of automated manufacturing has only added to the incognizance of commodity production, and consumers are less aware than ever of how products are made.

**Commodity aesthetics**

One of the earliest discussions of product form in post-Marxist thought is seen in the work of Wolfgang Haug in his book titled *Critique of Commodity Aesthetics: Appearance, Sexuality and Advertising in Capitalist Society*, in which he coins the term “commodity aesthetics.” In the equation of the use- and exchange-value, Haug introduces a third element, *appearance* of use-value— that which promises the buyer a certain use-value. He refers to this as an illusion and defines commodity aesthetics as “the sensual appearance and the conception of its use-value,” a device with the sole aim of accumulation of capital (Haug 1986: 17). Indeed, the practice of industrial design partially grew of this very desire to increase sales of products in a market flooded with too many goods. Meikle argues that “industrial design was born of a lucky conjunction of a saturated market, which forced manufacturers to distinguish their products from others, and a new machine aesthetic…” (1979: 39). Though referred to by responsible designers as the stigma of styling, modification of product form for increased profits and market differentiation is not necessarily viewed as a vile practice in industrial design.

Over and above the function of capital gain, Haug attributes to aesthetics the ability to control people through the device of sensuality. Cloaked in lascivious forms, these goods offer erotic promise, exploit the libido, and empty the pockets of the unsuspecting onlooker, turning her into a buyer. Ironically, this provocation by capitalists also stimulates illegal acquisition by thieves. On the other hand, it is not unusual to find in the language of design such descriptors as “sensuous” and “sexy” used in extolling the properties of a product. In fact, peddling beauty is often seen as the primary goal of industrial design. A recent essay referring to designers as “experts in the application of beauty,” emphasizes that “regardless of how important the measure of innovation and environmental impact are, beauty is the number one criteria for good design” (Viemeister 2001: 39). Paradoxically titled “Beautility,” this essay equates beauty to culture and fulfillment, and assigns it a position at the apex of a redesigned hierarchy of needs called Tucker’s Hierarchy (Viemeister 2001: 41). Though the dominant attribute assigned to aesthetics is that of control in both industrial design and political economy, in the former it is accepted as a noble and rightful goal, and in the latter as a deceptive trick. Such contrariety of opinion about the seductive nature of the commodity reveals the extreme positions taken by the two disciplines in their study of the same subject. Haug’s critique of the aesthetics of commodities should be introduced into design education to shift the locus of the curriculum from its current emphasis on consumption toward one balanced by the hypercritical stare of political economy.

**Commodity aging**

Designing obsolescence into commodities, a practice rampant in developed countries and promoted by designers, marketers, and salespeople, has been widely decried on grounds of environmental responsibility. Aesthetic innovation, a routine activity of industrial design, takes on a manipulative role when its purpose is to reduce the use-lifetime of the commodity under the guise of unsatisfied need. Haug refers to this as “product senility” (1986: 40) that leads to a reduction of its use-value in terms of quality as well as quantity. It is interesting to note that Victor Papanek (whose book *Design for the Real World* was published the same year as Haug’s first German edition of *Critique of Commodity Aesthetics*) echoed his sentiments of the diminished value of a commodity forced into senility. Papanek (1971) believed that objects designed to be discarded soon after production led to a “Kleenex culture,” which would expand the notion of disposability to human values. The
critical notion of value, economic as well as social, therefore, surfaces in the discussion of obsolescence.

Haug argues that the process of redesign subordinates the use-value of the commodity to a brand name, thereby assuring a position in the market for the next new product through the illusion of an ameliorated use-value. Designers continue to populate the world with commodities that are often mere adjustments of form that sell because of the force of a pre-established brand identity. When the image of the corporation has established itself with conviction in the buyer's mind, use-value is eclipsed entirely and, under the deception of brand loyalty, is not even missed. The promise of use-value is replaced by the promise of brand ownership, which is a paradoxical situation since it is in fact the buyer who is owned by the corporation. The process is then repeated with the next commodity in an endless cycle of acquisition and devaluation. Aaron Betsky, in a catalog of iconic products refers to them as “solid shapes we can desire, use, wear down and throw out, only to look for future targets for our object lust” (1997: 202).

The commodity as desire
Aesthetic modification is akin to molting; as the skin ages, it is exfoliated. The novelty of the commodity Benjamin talked about is referred to by Haug as its fetish character. Alluding to the deceptive illusion presented by the commodity-body, Haug believes that “appearance always promises more, much more than it can ever deliver” (1986: 50). The skin of the commodity, which is at times the realm that industrial design is limited to, becomes the receptacle for its exchange-value rather than its use-value. Creative operations are performed on the skin to stimulate desire and to valorize capital, but are often justified as attempts to satisfy a wider range of user needs. Equating the buyer’s gaze to voyeurism and the exchange-value to sexuality, Haug relegates the role of commodity aesthetics to the “sexing-up” of the object, a term that also appeared in Papanek’s writing (1971: 151). Papanek attacked design in its effort to create object lust merely by changing its skin, a process that has since been accelerated with the rapid replacement of electromechanical components with digital ones.

Commodity as need
“In the field of design, the expression of ideas is not the central issue. This lies in creating ideas in the ever-changing disguises of protean capital” (Haug 1986: 92). Under the pretense of appeasing the desires of society, corporations fill their coffers, carefully selecting only those needs that can be satisfied, making the designer a pawn in the scheme of capital valorization. Corporations are likely to take this attitude a step further by creating needs rather than satisfy existing ones, as is exemplified in Sony’s perceived design philosophy. Wolfgang Schmittel writes “Sony’s concept of creating a market instead of merely filling a demand, has become a fundamental policy, and governs the promotion and sales of all Sony products” (1975: 174). As design methodology has evolved, the role of ethnographic research and observation of users has taken center stage. Designers routinely watch and study people to identify opportunities where a new commodity can be inserted. Though not all such activity can be dismissed as capital driven, it certainly generates new needs adding to the proliferation of gadgets, meanwhile satisfying one primary need—that of the capitalist.

The commodity as a part of the culture industry
Referring to culture as an industry, Theodor Adorno, who was one of the leading members of the influential Frankfurt School of sociology, likens its production to that of commodities, making it a part of the capitalist economy. For Adorno, if the commodity combines use- and exchange-value, exchange-value deceptively takes over possession of use-value. This is distinctly visible in objects whose worth rises exponentially through design (either of the form or advertising) in spite of the lack of enhancement in its utility value. “The more inexorably the principle of exchange value
destroys use values for human beings, the more deeply does exchange value disguise itself as the object of enjoyment” (Adorno 1991: 34). This process of the destruction of use-value and its subordination by exchange-value is hastened by industrial design. “Function is out. Form is in. From radios to cars to toothbrushes, America is bowled over by style,” proclaims the sub-heading of an article titled “The Rebirth of Design” in *Time* magazine (Gibney and Luscombe, 2000). The cover features Mark Berthier’s lime-green Rubber radio, photographed in a goldfish bowl, charming and seductive, but assigned the existence of an ornamental fish trapped in the living room.

**Commodity as use, exchange, and sign**

Marx’s discussion of political economy is questioned by Jean Baudrillard through the argument that polar terms (use and exchange) are generally biased toward one extreme, in this case the exchange-value, which is the force behind the circulation of the commodity. He instead emphasizes use-value as a necessary principle that has to be established before the possibility of any economic exchange can be realized. Where Marx saw the use-value as concrete, Baudrillard explains it as an abstraction of a “system of needs” (1981: 131). He further expands the discourse by overlaying the commodity system with structural semiotics, and referring to the commodity, which, like a sign-form, is a code managing the exchange of values. Robert Miklitsch’s account of commodity fetishism attempts to include, into the use- and exchange-value equation, sign-value as well, thereby creating by extension, the “commodity-body-sign” an entity that is expressive of this triadic relationship. His economic account addresses the “specific allure, produced today via packaging and advertising, marketing and publicity, that is the hieroglyphic of the postmodern (art-) commodity” (1998: 78). He too, like Marx and Benjamin, treats the commodity as an object that is lusted after, exemplifying how design plays a significant role in every stage of its development cycle—from form generation to the creation of point-of-purchase material.

**Conclusion**

The debate presented here about the commodity is derived predominantly from its economic function, and assumes a capitalist structure, where production is fueled by a desire for capital gain. The structures of industry, labor, and economy have changed significantly since *Das Kapital*, and so have patterns of consumption. Though a dissection of the commodity that reveals merely use- and exchange-values might seem trifling, it is a model that can broaden the understanding of the object of design and present it as an object of political economy as well.

Industrial design has continued to be a slave to the manufacturing power and capital, though many changes have been observed in the profession as it has evolved. It is heartening to see that an emphasis on responsible design that goes beyond aesthetic adjustments is being practiced and seen in such areas as design for need, design for special populations, user-centered design, and sustainable design. This discourse offers a perspective largely ignored in design dialogue, and attempts to make design less design-centric.
References


Generations in design methodology

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Abstract

The relationship between design and science is examined through the lens of design methodology. The purpose is to foresee the next generation of design methodology and its attributes. Four generations in design methodology are recognized – craft, design-by-drawing, hard systems methods and soft systems methods – and each is characterized in terms of its benefits and limitations in respect of design practice. To the extent that each new generation overlays the preceding one, a system of design methodologies is created which, being more inclusive of the real world, should be increasingly useful to design practice.

The change process between generations appears to be a double exponential, suggesting that a fifth generation in design methodology is now emerging. Reasons are presented why this will likely be an evolutionary systems methodology. Such a development will position design as an evolutionary guidance system for socioculture, a much more central role in human affairs. It also has the potential, as we better understand the evolutionary nature of biological and sociocultural phenomena, to generate a profound and comprehensive relationship between design and science.
Generations in design methodology

Introduction
The relationship between design practice and science is ever-changing. Cross (2001) noted, perhaps playfully, a 40-year cycle of interest in this relationship, starting with attempts by the Modernists during the 1920s to produce works of design based on the seeming objectivity and rationality of science. A second wave of interest in the design/science relationship was embodied in the design methods movement of the 1960s. According to Cross: “We might expect to see the re-emergence of design-science concerns in the 2000s" (p. 16). A contemporary review of the relationship would seem timely indeed in view of the very substantial changes in our understanding of both design and science in the intervening 40 years.

In this account, this changing relationship is examined through the lens of design methodology. Checkland (1999: A32) described methodology as “a body of methods used in a particular activity”. It is thus a meta level with respect to method, it is about method. It is this more strategic approach that is adopted here.

The intent of this review is to determine whether changes through time in the relationship between design and science, as reflected through design methodology, exhibit patterns. If such exist, they may be helpful in discerning how design methodology could most likely develop in the near-future. Four generations of design methodology are reviewed – craft, design-by-drawing, hard systems and soft systems – primarily in terms of what they have offered design practice. These generations of design methodology are then compared to establish possible trends through time. These trends are extrapolated to define the most likely features of the next generation in design methodology.

Craft methods
The skilled craftsman was the earliest initiator of change in human-made things (Jones 1970: 15). Although crafted stone artifacts date from about 2.5 million years ago (Deacon and Deacon 1999:1), Banathy (2000:79) suggests that it was not until the Middle Stone Age, some 250,000 years ago, that “designlike thinking” emerged; this coincided with the evolution of consciousness (Laszlo 1996: 131). Such design was unconscious, in the sense that craftsmen learnt intuitively and informally - a process described well by Sturt (1923: 19): “There was nothing for it but practice and experience of every difficulty. Reasoned science for us did not exist … What we had to do was to live up to the local wisdom of our kind; to follow customs, and work to the measurements, which had been tested and corrected long before our time in every village shop all across the country”. Jones (1970: 19-20) listed the characteristics of this design methodology as follows:

- craftsmen did not, and often could not, draw their works and neither could they give adequate reasons for the decisions they took
- product information was instead stored in the form of the product itself and was transmitted through apprenticeship
- as neither the product nor the reasons for its form were recorded symbolically (e.g. by drawing), change could only occur through experimentation
- as a result, responsiveness to environmental change tended to be gradual
- thus, the form of an artefact was modified by trial-and-error over many centuries, in a slow and costly process

The incremental processes of change in products during this period have been viewed by some as possessing an evolutionary nature (e.g. Jones 1970; Norman 1988: 142). It led to high levels of product fitness for local circumstances and to considerable product diversity.
Design-by-drawing methods
Supplementation of craftsmanship with design-by-drawing occurred systematically (in architecture) from the mid-1450s (Perez-Gomez and Pelletier 1997: 17), making possible revolutionary changes in design practice (Jones 1970: 20-24):

- design became separate from production
- a division of labour within design emerged, especially for large and/or complex projects
- the ‘perceptual span’ of designers greatly increased; they could not only manipulate the design as a whole but could also easily import work from elsewhere
- for these reasons, design changes could be more substantive and accomplished in shorter time frames

The overlaying of crafting with drafting allowed design to keep pace with accelerating technological and sociocultural change. Major limitations to this development were that:

- initial development of drawings, during which critical decisions were made, was done mostly by a single designer. This was an increasing constraint as products became more complex and the needed expertise no longer resided in one person
- drawing has limited capacity to represent dynamic physical relationships (Heath 1984: 12)

Hard system methods (HSMs)

Introduction
The design methods movement, through which hard systems methods were introduced into design, came out of the work of Rittel and others at the Hochschule für Gestaltung, Ulm, West Germany in the 1950s (Moore 1973: 246). Its public emergence in Britain was through the First Conference on Design Methods, held in London in 1962 (Cross 1984a: viii). In the United States and Canada, the movement received its strongest support from Rittel, who had moved to Berkeley in 1963, and Alexander and others at Harvard/MIT (Moore 1973: 246). Cross’s compendium of twenty-one articles broadly written around design methods, with excellent overview sections for each thematic collection, provides a rich picture of hard systems methods in design. The following account draws on several works used by Cross, but adopts a different perspective.

Hard systems methods have been described as “systematically-ordered thinking concerned with means-definition in well-structured problems in which desirable ends can be stated” (Checkland 1983: 667). Their origin can be located in the emergence of operational research/management science (OR/MS) about 1935. Initially applied to military matters, OR found commercial and industrial applications, including engineering design, in the period 1945 – 1975 (Checkland 1978; Keys 1995a&b). It was during the late 1950s/early 1960s that these methods were applied in design (Rittel 1972).

Perceived benefits and limitations
Today, with the help of hindsight, we can reflect more clearly on the benefits and limitations of this period in the relationship between design and science. We can identify more readily the role which the methods of this era have come to play in design practice. It should be noted that the insights collated below were largely of their time, were drawn only from the design community, and may not fully reflect current perceptions. The key point is, though, that these insights provided an incentive for the ongoing development of design methodology to the present.

The response of the design community to hard systems methods (HSMs) was swift.
The benefits of HSMs to design practice were seen to be largely procedural (Table 1).

<table>
<thead>
<tr>
<th>Improve response to growing complexity of design task, by:</th>
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<tr>
<td>- changing design emphasis from individual products to product systems</td>
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<td>- broadening design purview from local improvements to “the total situation”</td>
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<td>- more effectively incorporating other inputs into design process, e.g. ergonomics</td>
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<td>- allowing a more structured search of rapidly growing search spaces</td>
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<td>- managing better the interdependency between system levels</td>
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<th>Help concurrent/collaborative design, by:</th>
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<tr>
<td>- making design thinking explicit</td>
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<tr>
<td>- engaging other minds at critical stages in design process</td>
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<th>Help designers to better meet shorter timelines, by:</th>
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<tr>
<td>- reducing design error</td>
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<tr>
<td>- making easier the anticipation of side effects</td>
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<tr>
<td>- lessening possibility of unintended omissions</td>
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Table 1: Hard systems methods: perceived benefits
(Sources: Archer 1965; Luckman 1967; Jones 1970; Alexander 1971; Rittel 1972)
By contrast, criticisms of hard systems methods were trenchant, centering on what were perceived as the very different roles of design and science in society (Table 2).

**Different intentions of scientific and design methodologies:**
- science seeks objective truth, design aims to satisfice
- scientists seek global solutions, designers seek local ones
- science is traditionally more concerned with theory, design with action
- hard systems methodology, which seeks to optimize, may lessen sociocultural diversity
- the reductionist nature of HSMs may stifle emergence
- scientific methodology is well suited to determine('tame') problems, whereas design methodology addresses ill-defined, unique and context-dependent ('wicked') problems

**Different approaches of science and design to problem solving:**
- scientific observers seek objective detachment from the problem, whereas designers participate in the process
- scientific method favours a linear process of inquiry, whereas the often complex, intertwined nature of design problems tends to defy such approaches
- some aspects of the design process are not ‘conscious’, and so are not amenable to systematic processes
- the conjecture-analysis approach of science is very different from the analysis-synthesis approach of design
- science uses inductive reasoning, while design prefers abductive logic
- science operates in a theoretical, systematic setting, whereas design operates in a real-world, intuitive setting
- sequential, structured analysis sits uneasily with creative thought
- science promotes an “expert-knows-best” approach, whereas design favours participatory practice
- quantitative approaches are preferred in science, while qualitative considerations are often important in design

Table 2: Hard systems methods: perceived limitations
(Sources: Esherick 1963; Reed and Evans 1967; Alexander 1971; Hillier, Musgrove and O’Sullivan 1972; Rittel 1972; Rittel and Webber 1973; Akin 1979; Broadbent 1979; Lawson 1979; Daley 1982; Buchanan 1992; Cross 2001)

Hard systems methods proved largely unable to address the “unbound complexity” of the real world (Reed and Evans 1967). Doubts about the applicability and relevance of these methods became widespread in architectural education from the mid-1960s (Fowles 1977).

**Design applications**
Despite this unfavourable response, HSMs today play a significant role in the design process, e.g. CAD, ecodesign, collaborative design, ergonomics, anthronomics (Robinson and Nims 1996), virtual design, design information systems and knowledge management, quality management, user interface design. Nonetheless, these contributions remain largely procedural and are centred very much on the progressive computerization of design process; they do not address higher order attributes of the design activity.
Conclusions
In a scathing assessment of hard systems approaches to design problem solving, Alexander (1971: 4) observed: “In short, my feeling about [hard systems] methodology is that there are certain mundane problems which it has solved – and I mean incredibly mundane … Most of the difficulties of design are not of the computable sort”. With the benefit of hindsight, such criticism seems too harsh. The First Conference on Design Methods in 1962 sought to allow, indeed encourage, “the fullest use of all the critical and creative faculties” (Slann 1963: xii). Jones (1963: 53) recognized the need for a systematic approach to design practice that was empathetic with creative practices, and was seeking “a unified system of design … that lies between the traditional methods, based on intuition and experience, on the one hand, and a rigorous mathematical or logical treatment, on the other”. While this ambitious agenda of the design methods movement was never realised, this period can be seen as the time when a new generation of design methods was defined. Even so, the idea of “a monumental edifice of knowledge” had to be surrendered and, with it, a positivist science approach to design practice (Hillier et al. 1972: 29-3-4).

Soft Systems Methods (SSMs)

Introduction
Concern with hard systems methods centred on so-called “wicked problems”, a term borrowed from Popper and re-contextualised by Rittel in the mid-1960s. Churchman (1967: B141) defined wicked problems as a “class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing”. Khisty (2000: 121) more succinctly described wicked problems as a combination of uncertain goals and objectives and uncertain technologies or strategies. Cross (1984b: 102) more pithily still observed that “stating the problem is the problem”.

According to Rittel and Webber (1973: 162-164), wicked problems were seen, inter alia:

- to be unique and context-specific
- to offer a host of courses for action
- to be without solution, only the opportunity to do better
- to rely upon political judgement for resolution

Many in the design community recognized that such problems are experienced by most people for most of the time in everyday life (e.g. Archer 1979: 17).

Simon (1973) suggested that the existence of wicked problems reflects our state of knowledge rather than something more intractable. It could, indeed, be argued that wicked problems arise only when the methods to “tame” them don’t exist. Such thinking led to proposals by Rittel (1972) for another generation of design methods. He believed that the methods of Churchman, Popper and Boulding provided a basis for this next generation. Rittel and Webber (1973: 162) elaborated this proposal by observing that the next generation of design methods “should be based on a model of planning as an argumentative process in the course of which an image of the problem and of the solution emerges gradually among the participants, as a product of incessant judgement, subjected to critical argument”. Rittel nevertheless acknowledged a considerable ‘hangover’ from the hard systems methods – in that designers (and others) were reluctant to engage with formal methods again.
The change process

Rittel’s commitment to developing a new design methodology found expression as the Issue-Based Information System (IBIS) methodology in the early 1970s (Kunz and Rittel 1970). This was intended to support “the argumentative reasoning structure of designers” (Noble 1997a: 2497). The need to develop a new methodology was also recognized by some in the operational research/management science (OR/MS) community, from whom the design community had earlier adopted hard systems methodology. This need was responded to by Checkland (1999: A4) from 1972, Ackoff from 1973, and Churchman throughout the 1970s. It was not until the 1980s that systems-based approaches really emerged (e.g. Checkland, 1981). By 1990 several hundred applications of SSM had been made by a wide range of people in many different countries (Checkland and Scholes 1990). A survey by Mingers and Taylor (1992) into the use of SSM found that, at that time, it was established as a practical methodology but was “used by particular individuals who have some previous experience of it, rather than being a standard approach to the repertoire of OR groups” (p. 331). It was only in the mid-1990s that Keys (1995c: 335) felt able to observe that “there is now a sufficiently critical mass of distinctive and mutually informative work emerging to see this as a significant development”. Even today, this change has not been reflected fundamentally in OR practice.

It had become clear through this period that problem complexity in organizational settings had again outstripped the capabilities of the available methods. Problem solving had shifted from ‘tame’ problems toward the increasingly ‘wicked’ problems of larger systems, to which SSMs were seen as an appropriate methodological response. There was also growing recognition of the breakdown of societal consensus (Toffler, 1970), which led to a desire to involve more diverse stakeholders in decision-making processes.

The holistic, systemic thinking of SSMs can be traced back to biology and medicine in the second half of the 19th century (Checkland 1983: 668). By the 1920s organismic biologists were arguing that reductionism was unsuited to understanding biological phenomena; this was a defining point in our understanding of the scientific endeavour. By the 1940s biologists like von Bertalanffy were generalizing this view to all systems (e.g. General Systems Theory). By the late 1940s systemic thinking was spreading into diverse fields, although it was not until the 1970s that it started to influence OR.

One reason why it took so long to adequately characterize and implement soft-systems methodology in OR was the transformative nature of the change. Indeed, it was not until the early 1980s that a clear distinction between “hard” and “soft” systems was made (Checkland 1999: A9). The extent of this development is evident from Table 3, in which characteristics of HSMs and SSMs are contrasted. Jackson (1982) and Checkland (1983) provide seminal accounts of the conceptualization of soft-system methodology.
<table>
<thead>
<tr>
<th>HSMs</th>
<th>SSMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounded in natural sciences</td>
<td>Grounded in social sciences(action research)</td>
</tr>
<tr>
<td>Reductionist, determinist, testable</td>
<td>Holistic, purposeful, judgemental, intuitive, descriptive, conjectural, normative, a matter of perception</td>
</tr>
<tr>
<td>“Objective”, theory-based, positivist, functionalist</td>
<td>Subjective, wisdom/values-based, experiential, empirical, pragmatic, phenomenological, hermeneutic, action-based</td>
</tr>
<tr>
<td>Inductive, logical, rational, methodical, bottom-up</td>
<td>Abductive, inferential, intuitive, top-down and bottom-up</td>
</tr>
<tr>
<td>Suitable for isolated, relatively simple systems/ highly specific problems; ‘tame’ problems</td>
<td>Suitable for highly interactive, complex systems/ problems; ‘wicked’ problems</td>
</tr>
<tr>
<td>Directly involved in real-world; ontological; views systems as real</td>
<td>Simulates real-world through models; epistemology-dependent</td>
</tr>
<tr>
<td>Stepwise, linear, sequential</td>
<td>Iterative, non-linear</td>
</tr>
<tr>
<td>Surprise-free</td>
<td>Emergent</td>
</tr>
<tr>
<td>Methodology-driven, prescriptive</td>
<td>Largely guided by informal human judgement, situation-driven</td>
</tr>
<tr>
<td>Optimizes, singular outcomes</td>
<td>Satisfies, pluralist outcomes</td>
</tr>
<tr>
<td>Static</td>
<td>Evolutionary</td>
</tr>
<tr>
<td>Address rare human situations</td>
<td>Address common human situations</td>
</tr>
<tr>
<td>Intervention-based</td>
<td>Interactive</td>
</tr>
<tr>
<td>Externally applied to system</td>
<td>Internalized by system</td>
</tr>
<tr>
<td>Systematic</td>
<td>Systematic and systemic</td>
</tr>
<tr>
<td>Explicit</td>
<td>Tacit; implicit</td>
</tr>
</tbody>
</table>

Table 3: Comparison of HSMs and SSMs
(Sources: Checkland 1983, 1999; Vicente, Burns and Pawlak 1997; Khisty 2000)

**Benefits and limitations**
In view of the limited experience to date with soft systems methodology in design practice (see below), we must instead rely on evaluations from its application most especially in organizational design, information systems design, performance evaluation and education. SSMs seem highly consonant with many core aspects of designing (Table 4). They foster participation and the inclusion of beliefs, viewpoints, values etc; they are both systematic and systemic; they promote the emergence of fresh insights so central to design. In particular, they are well-suited to fuzzy, ill-defined or ‘wicked’ problems, unlike HSMs. They also seek to satisfice rather than optimize problem situations, in the knowledge that the systems under study are typically “open”, thus interacting constantly with their environment and hence evolving over time (Jackson and Keys 1984: 475).
- **Process characteristics**
  - a systemic as well as systematic approach to problem-solving
  - oriented to learning rather than just goal-seeking
  - provides structure to fuzzy, ill-defined situations with differing perceptions and views
  - makes beliefs and viewpoints open and explicit, thus admitting a number of viewpoints into the problem space
  - tends to generate shared understandings of problems
  - identifies ‘emergent’ potential in problem situations
  - embodies Schon’s notion of reflection in action

- **Problem characteristics**
  - assumes that the world will remain problematical, but can be better understood and interacted with by using system models
  - thus talks about “issues” and “accommodations” rather than “problems” and “solutions”
  - is well-suited to the resolution of complex problems

- **Scope of method**
  - draws attention to cultural aspects of a problem
  - inclusive of all stakeholders in a problem situation
  - “keeps in touch with the human content of problem situations” (Checkland 1985: 765)
  - thus extends the problem solving capabilities of HSMs into the social and psychological domains

Table 4: Soft systems methodology: perceived benefits

(Sources: Checkland 1985, 1999; Checkland and Scholes 1990; Mingers and Taylor 1992)

SSMs markedly broaden the role of the sciences in problem-solving, by introducing the social, psychological and, to some extent, behavioural sciences. They also particularly focus on understanding the wider situation in which a problem exists (Rowley 1998: 158). In these ways, SSMs may meet Cross’s (1986: 436) requirement: “that design methods must … be based on the ways of thinking and acting that are natural in design”, a view shared by others (e.g. Sless, 2002).

SSMs are widely seen as a front-end to hard systems methodology (e.g. Platt and Warwick 1995: 21). They thus let individuals with an interest in a problem become involved before hard systems methods are applied.
• **Challenges worldviews**
  - requires participants to “see the world” through different perspectives, which can be difficult
  - can thus confront the worldviews of participants
  - can challenge the power structure and politics of a problem situation

• **Less formal**
  - is subjective; it is never independent of the user, unlike the perceived objectivity of HSMs
  - does not produce final answers; accepts that inquiry is never-ending
  - thus aims to satisfice rather than optimize
  - is interpretive rather than functionalist

• **Unfamiliar**
  - requires a way of thinking which is not always immediately evident to users
  - the methods can be time consuming and need considerable experience to apply

Table 5: Soft systems methodology: perceived limitations
(Source: Checkland 1983, 1985, 1999; Mingers and Taylor 1992)

Some would view these considerations as benefits rather than limitations!

**Design applications**
Despite its development in the early 1970s, use of the Issue-Based Information System (IBIS) method of Kunz and Rittel (1970) was, as of 1997, still “limited to academic experiments and a small persistent group of planners” (Noble 1997b: 2485). Likewise Checkland’s soft systems methods appear to have entered traditional design practice only in the late 1990s, initially in visual communication and product design (e.g. Rowley 1998; Presley, Sarkis and Liles 2000). Maybe this is the embodiment of the “design-science concerns in the 2000s” anticipated by Cross (2001: 16). SSM should find particular application in complex design projects in which diverse stakeholders are perceived to have varied but legitimate interests in the outcome.

**Conclusions**
Just as hard-systems methodology is grounded in reductionist science, soft-systems methodology has been spawned by the sciences of complexity. SSM copes better with problem-solving in the ill-defined world of ‘wicked’ problems so familiar to designers, but it does so with a worldview very different from that of hard systems methodology. The mainstream adoption of SSM in design practice seems to be a matter of time, as is a fuller appreciation of their benefits and limitations in this application. It is clear that SSM should be seen as a still-maturing methodology, certainly in respect to its use in design. It also seems clear that SSM has yet to demonstrate the fullness of its application, with recent initiatives extending beyond its accepted business/industrial applications into wider societal use (e.g Liebl, 2002).

**Evolutionary Systems Methodology: the next generation?**
Methodological advances will always be found wanting for, in further exposing the complexity of the real world, they provide the rationale for the next methodological generation. Rittel (1986: 371) put this well when he observed “… there cannot exist anything like “the” design method which smoothly and automatically resolves all … difficulties. Those people who claim the existence of
such a device postulate nothing less than the solution of all present and future problems of the world”. It seems reasonable, then, to ponder the nature of this next generation of design methodology. If we chart the emergence of the four generations in design methodology described above against time (Table 6), we find that change is occurring exponentially.

<table>
<thead>
<tr>
<th>Generation</th>
<th>Emergence in design (years before present)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crafts</td>
<td>250,000</td>
</tr>
<tr>
<td>Design-by-drawing</td>
<td>550</td>
</tr>
<tr>
<td>Hard systems</td>
<td>40</td>
</tr>
<tr>
<td>Soft systems</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 6: Generations in design methodology

Kurzweil’s (2001) observations on this phenomenon are interesting, if sobering. He believes that all dynamic systems change exponentially over time (although he is particularly interested in technology): “a serious assessment of the history of technology shows that technological change is exponential … Exponential growth is a feature of any evolutionary process, of which technology is a primary example … Indeed, we find not just simple exponential growth, but “double” exponential growth, meaning that the rate of exponential growth is itself growing exponentially”. Kurzweil continues: “[Today], paradigm shifts occur in only a few years time. The World Wide Web did not exist in anything like its present form just a few years ago, it didn’t exist at all a decade ago”. Kurzweil predicts that technological change over the 21st century will be equivalent to what would take some 200 centuries to achieve at today’s rate of change! He also makes the interesting observation that the “returns” of an evolutionary process (e.g. speed, cost-effectiveness) also increase exponentially over time.

What are the implications of such observations for design methodology, indeed for all aspects of the phenomenon of design? If Kurzweil is correct, we may conclude that:

- the next generation of design methodology should have emerged already
- subsequent generations should appear at ever shorter time intervals
- these new generations should be increasingly useful to humanity

It is suggested that the emerging generation in design methodology is most likely evolutionary systems methodology (ESMs), because:

- the notion of societal evolution is a mature one, having existed since Herbert Spencer, in 1874, “set forth the idea of evolution as a cosmic process” (Banathy 2000: 21)
- the transition from evolutionary consciousness to conscious evolution has been proposed by eminent observers for almost 4 decades. Sir Julian Huxley (1964: 37), for example, proposed that: “man’s [sic] true destiny emerges in a startling new form. It is to be the chief agent for the future of evolution on this planet. Only in and through man can any further major advance be achieved”
- observers of design have advocated a more central role for design in human affairs for some three decades. Jantsch (1975: 101), for example, noted that “Design is the core of purposeful and creative action of the active building of relations between man and his world”
such a methodology already exists (Banathy 1996, 2000), although it seems likely that this will be refined as our understanding of related phenomena improves. Conscious evolution may be conceptually the means by which we transition effectively from the uncontrolled processes of double exponential change described Kurzweil, which seem now to be approaching a critical juncture.

We can extrapolate from past generations of design methodology to predict the features of the newly-emerging generation (Table 7).

<table>
<thead>
<tr>
<th>Feature</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Craft</td>
</tr>
<tr>
<td></td>
<td>Design-by-drawing</td>
</tr>
<tr>
<td></td>
<td>Hard systems</td>
</tr>
<tr>
<td></td>
<td>Soft systems</td>
</tr>
<tr>
<td></td>
<td>Next generation</td>
</tr>
<tr>
<td>Emerging cognitive state</td>
<td>Reflective consciousness</td>
</tr>
<tr>
<td></td>
<td>Reductionist science</td>
</tr>
<tr>
<td></td>
<td>Structured systems thinking</td>
</tr>
<tr>
<td></td>
<td>Holistic systems thinking</td>
</tr>
<tr>
<td></td>
<td>Evolutionary systems thinking</td>
</tr>
<tr>
<td>Scale</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td>Usually regional/national</td>
</tr>
<tr>
<td></td>
<td>National/global</td>
</tr>
<tr>
<td></td>
<td>National/global</td>
</tr>
<tr>
<td></td>
<td>Global and local</td>
</tr>
<tr>
<td>Grounding in science</td>
<td>Mostly pre-scientific; trial-and-error</td>
</tr>
<tr>
<td></td>
<td>Mathematical Sciences</td>
</tr>
<tr>
<td></td>
<td>Mathematical and Natural Sciences</td>
</tr>
<tr>
<td></td>
<td>Mathematical, Natural and Social Sciences</td>
</tr>
<tr>
<td></td>
<td>(reductionist)</td>
</tr>
<tr>
<td></td>
<td>Holistic and reductionist sciences</td>
</tr>
<tr>
<td>Typical design cycle</td>
<td>Centuries</td>
</tr>
<tr>
<td></td>
<td>Decades/years</td>
</tr>
<tr>
<td></td>
<td>Years</td>
</tr>
<tr>
<td></td>
<td>Years/months</td>
</tr>
<tr>
<td></td>
<td>Months/weeks</td>
</tr>
<tr>
<td>Technological support</td>
<td>Simple hand tools</td>
</tr>
<tr>
<td></td>
<td>Manual/mechanical</td>
</tr>
<tr>
<td></td>
<td>Mechanical/electronic</td>
</tr>
<tr>
<td></td>
<td>Mostly electronic</td>
</tr>
<tr>
<td></td>
<td>Extensive electronic support</td>
</tr>
<tr>
<td>Knowledge base</td>
<td>Largely personal, tacit</td>
</tr>
<tr>
<td></td>
<td>Tacit and explicit; limited</td>
</tr>
<tr>
<td></td>
<td>Extensive information flows, mostly text-based</td>
</tr>
<tr>
<td></td>
<td>Huge information flows, mostly electronic</td>
</tr>
<tr>
<td></td>
<td>Knowledge management/ information visualization/</td>
</tr>
<tr>
<td></td>
<td>artificial intelligence</td>
</tr>
<tr>
<td>Interdisciplinarity</td>
<td>Mostly pre-discipline</td>
</tr>
<tr>
<td></td>
<td>Within design discipline</td>
</tr>
<tr>
<td></td>
<td>Interdisciplinary, across professions</td>
</tr>
<tr>
<td></td>
<td>Interdisciplinary, across professions and wider</td>
</tr>
<tr>
<td></td>
<td>community</td>
</tr>
<tr>
<td></td>
<td>Inclusive of all stakeholders</td>
</tr>
</tbody>
</table>

Table 7: Features of four generations in design methodology, extrapolated to define the next such generation.

These trends suggest that design may soon be realizing a fuller societal purpose, that of an evolutionary guidance system (Banathy, 1987). Buchanan (1998) recognized an historical progression in the societal role of design in his proposal for four orders of design – communication, construction, strategic planning, and systemic integration. We should be asking what fifth-order design might be. This account suggests that evolutionary systems design may be the next logical step in the broadening sociocultural role of design.

General conclusions
Cross (1972: 185) observed, in respect of design methodology: “That there should be cycles of development to come, with the death of each cycle looking like a minor catastrophe at the time, ought not to have surprised us, but of course it did, and does”. Indeed, we should not be surprised because change, indeed accelerating change, seems to characterize design methodology.

It appears, from the trends described above, that consecutive generations of design methodology have been towards more complex, higher level, and more influential roles for design in society, as might be anticipated from Laszlo’s (1996) General Evolution Theory. Further if we subscribe to
Laszlo’s (1996: 1-2) view that evolution refers to “all things that emerge, persist, and change or decay in the known universe”, we should expect that, in time, the reductionist and holistic sciences will together largely, perhaps completely, account for the design activity of humans.
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Intentionality and design

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Abstract

This paper suggests that: a model of Intentionality is required in any theory of design thinking; that “intending” is systematically informed and constrained by experience; that it is cognitively structured in terms of the source-path-goal schema; and that this schema frames, threads and manages other modes of thinking during design. The philosophical roots, cognitive structure and operational requirements of intentional thinking are indicated and a computational model of design thinking which would enable Intentionality in design to become more accessible as a subject of research is referenced.

“What use would thinking be at all, unless we could relate each thing’s details to our plans and intentions” (Minsky 1985:88)
Intentionality and design

Introduction
Designing is a purposeful act, yet philosophical issues of “Intentionality” (Searle 1983), “Intentional stance” (Dennett 1996), “intentional programming” (Simonyi 1996) and memetic entailments from prior experience (Dawkins 1976) regarding the designer’s intentions and activities have not received adequate consideration by design researchers. This is despite design research topics such as situated thinking (Gero 1998) and the application of strategic knowledge (Gero and Hori 2001), that depend on the designer’s intention for their apprehension, interpretation and implementation. Similarly, implications from cognitive science regarding purposeful thought have not been viewed through the lens of design thinking. Is intending a distinct mode of thought? If so what are its operational characteristics? What differentiates it from other modes of thought during design? How might it be apprehended in operational, computational terms?

Every designer brings to the task of design their background understandings and a desire to address the contingencies of the design task. Their intentions largely depend on how they understand what the task is “about”, and what they think or do under the conditions they encounter. What designers learn through education and experience influences what they do and helps to build the meanings their thoughts and actions have for them. Although the personal history that informs a designer’s “vision” is usually considered when they are chosen for a project, this background is usually not correlated to the activities of designing. Understandings between designer, client and others – interpretations influenced by their own intentions and backgrounds – are often poorly grounded and illusive during design. Important issues (such as creative expression) not implicit in the design problem or process but dictated by the personal and cultural histories through which the design task is interpreted remain largely inaccessible to research.

Although Schön (1987) has provided an influential treatise on reflective thinking during design, techniques of protocol analysis yielding cognitive models of prior experiences have been developed (Zachary and Ryder 1996) and research on the application of design strategies by individual designers (Cross 2001: Kruger and Cross 2001) has been undertaken, there appears to be little theory-based research concerning how purposes and goals become established and operate in the minds of designers. The shifts in intent and focus which redirect specific thoughts and actions to achieve a persistent but changing objective are not well understood. Assumptions in the designer’s approach to a design task are rarely made explicit and no computational model of intention and its interaction with other modes of design thinking has been fully implemented. (Burnette 1982, 1984, 1999, 2001c) Instead, the problem statement, design brief, strategy or procedural rationale is accepted as explication enough.

The intent in writing this paper is to illuminate the concept of Intentionality and to suggest how the representation of human intentions can be made more explicit and useful during design. The treatment proposed is part of what is, apparently, the first model of designing which attempts to represent intentional thought in operational terms suitable for implementation in a computational design support system.

Intentionality and meaning
Intentionality has been defined (Johnson 1987:177) as the capacity of a mental state or some kind of representation (concept, image, word, sentence) to be about, or directed at, some dimension or aspect of one’s experience. John Searle (1983) understood Intentionality to depend on a “network” of meanings – a “background” – that was not intentional. Johnson has argued (against Searle) that Intentionality cannot be divorced from the conditions that give it context and meaning; that this
“background” is always part of meaning and therefore of Intentionality; and that the meaning of an experience to an individual must be both intentionally established and mediated by human understanding because “otherwise there would be no relation between symbolic representations and experience. …Something becomes meaningful by pointing beyond itself to event structures representing prior experience or toward possible future structures.” (Johnson 1987:177-178)

The view presented here accepts Johnson’s argument while recognizing that Intentionality and the background knowledge that informs it are different, unique to the mind of the individual and distinct from situated experiences (such as design projects) which they respectively address and assimilate. Intentionality involves the interaction between various aspects of mental or physical experience and that part of the web of “meanings” in the individual’s mind that constitute their understandings regarding that experience. Intentional phenomena are basically semantic in that they address how processes in a brain become symbolic of something beyond themselves. (Miller 1985:10)

Although intentions are informed by and help generate “meanings” they also motivate actions to change a situation to have a desired meaning or to suit an understanding. Such imaginative projections and transformative actions necessarily rely on the understandings that constitute the individual’s “background” knowledge. Like a design project, an intention is directed, pursued and managed until the experience with which it is concerned becomes represented in the “meanings” that constitute the individual’s understanding of the experience. The new understandings that emerge in the mind as an intention is pursued are further indexed, organized and generalized in dynamic memory (Schank 1999) to constitute knowledge accessible to future intentions.

In this context, the basic questions to be addressed regarding Intentionality are: how do intentional interactions arise and how are prior understandings adjusted to circumstances (and vice-versa). The ontological and operational problems for design thinking lie in how the designer’s understanding and skill are mapped to the contingencies of the design task. These contingencies have been categorized at a high level of abstraction (Burnette 1982, 1994, 2001a) as informational, conceptual, representational, operational, and evaluative –the designer needs relevant information, ideas, representations, actions, and criteria to direct and realize his or her intentions. All such “contingent domains” constitute “aspects of a situated experience” that specify and qualify what the designer thinks about and does in the subject context. Each involves a different mode of thought requiring different cognitive skills. For example, the use of information requires lexical and linguistic skills, having ideas requires associative and analytic skills, generating and interpreting representations requires formulative and mediative skills, executing actions require procedural and operational skills, and experiential assessment requires monitoring and evaluative skills. Although these five modes of thought have different goals and address different aspects of an individual’s actual (or imagined) experience to shape his or her understanding of it, they are neither intentions nor the background knowledge that informs intention, both of which are unique to the designer’s mind, not to the circumstances of the design task.

In this theory the five objective modes of thought provide the substantive content for the Intending and Integrating modes of thinking that respectively manage the current experience and reference prior experience. Operating at a higher level of cognition, the Intending and Integrating modes are free to focus, adapt, apply and build meaning and understanding in the mind of the individual considering information from either current or prior experience. The distinction between the five domains of thought contingent on the design task and the two domains manifesting Intention and Knowledge is of both philosophical and practical consequence. Intentionality depends on background knowledge but is distinguished from it by its capacity to specify what newly generated meaning is about. It also helps to generate new understandings by relating current experience to...
prior knowledge. The five modal domains provide the objective context and aspectual structure needed to map intentions and background knowledge to each other and to experiences in the world.

Fig 1: Metacognitive and situated modes of thought in an intentional frame

As Figure 1 suggests, Intending and Integrating are understood to interact with experiential information through mediating devices such as symbolic representations, perceptual gestalts, and image schema which focus, frame and structure attention.

The Intentional Frame

Intending is the mode of thought assumed to be responsible for establishing a “mental space” (Fauconnier 1997) or “frame of mind” (Minsky 1985) capable of containing and developing a thought (expression, task, project, etc) through to its conclusion. Such framing is how the mind deals with complexity and the richness of the world and is essential to the apprehension of meaning, the direction of thought and action, and the application of language, communication, and skill. The importance of framing to thought cannot be overstated: “Our minds are always automatically applying a rich variety of frames to guide us through the world…A frame provides a “world view”: It carves the world into defined categories of entities and properties, defines how these categories are related to each other, suggests operations that might be performed, defines what goal is to be achieved, provides methods for interpreting observations in terms of the problem space and other knowledge, provides criteria to discriminate success from failure, suggests what information is lacking and how to get it, and so on….Because the world cannot supply to the system what the system needs first in order to learn about the world, the essential kernels of content specific framing must be supplied initially by the architecture.” (Barkow, Cosmides and Tooby, 1992:107) I have suggested elsewhere an architecture of frames (Burnette 2001b) based on cognitive schema (Burnette 2001a) implementing “modes of design thinking” (Burnette 1982) that reflects these considerations.

Because framing is essential to the apprehension of thought and meaning, a fundamental role of Intending is to create, focus and configure the intentional frame. Some capability is also required within the frame to support the process of resolving meaning or outcome and to resolve and/or terminate a frame. The philosophical, and cognitive rationale outlining a structure for Intentionality that supports these capabilities follows.

The Structure of Intentions
If Intentionality is understood to be “about” something and about doing something in an experiential context based on understandings gained from prior experience, then how are intentions generated and how can they be apprehended, represented and managed to fulfillment? Dennett (1996) has argued that designing can be understood as the act of applying an intention to quickly arrive at an acceptable solution from many possible ones. He has defined “Intentional stance” as “the strategy of interpreting the behavior of an entity (person, animal, artifact, whatever) by treating it as if it were a rational agent who governed its “choice” of “action” by a “consideration” of its “beliefs” and “desires”. (Dennett 1996:27) The implication is that intentions are grounded in beliefs and desires which are mental constructs based on prior experiences. We “read” the “Intentional stance” of other people and understand their behavior using inferences from such constructs. Within this context, he has defined “Design stance” as behavior in which one predicts that an entity is designed as they suppose it to be and will operate according to that design. Similarly, Dennett defines “Physical stance” as behavior in which one predicts based on the laws of physics and the physical constitution of things. Thus, an “Intentional stance” is one in which the thinker makes assumptions based on past experience in the world. A “Design stance” is one in which the thinker predicts events based on perceived patterns or cues relating form to behaviors known to be associated with such forms, while a “Physical stance” is one in which the thinker predicts outcomes based on the experienced properties of things. Although for Dennett all three stances are directed at entities to help explain them, one might characterize the designer’s frame of mind (desires, meanings, assumptions, perceptions, capacities, goals, and relevant knowledge) regarding the design task as their “Intentional stance”, their mind set regarding what to do and expect as their “Design stance” and their appreciation of properties of the problem as their “Physical stance”. The “Intentional stance” is thus declarative and directive, the “Design stance” prescriptive and procedural, and the “Physical stance” experiential and descriptive regarding states of mind and the world they represent. Although thought may proceed from “Intentional stance” (desire) to “Design stance” (proposal) to “Physical stance” (execution and testing), it may fail to progress from one stance to another. (As, for example, when a desire or belief is overridden by a predicted outcome, or expectation failure.) All three stances within an intentional frame may remain purposefully focused and persistent over many disjunctive events until the conditions of satisfaction for the intention are met, changed or dismissed.

Minsky (1985) has noted that it is useful to distinguish interactive levels of thinking in order to reduce complexity. It is suggested that intentional thought has three levels: the highest level
associated with “Intentional stance” and concerned with establishing the scope and direction of a thought; the intermediate level, associated with “Design stance” and concerned with managing pursuit of the intention through pattern finding and knowledge based propositions and the lowest level associated with “Physical stance” and concerned with empirical assessment of status and confirmation of fulfillment. This hierarchy implies that an interim direction or goal must be declared before a “Design stance” is taken and a “Design stance” must be taken before a goal can be satisfied. This serial processing implication is overcome by assuming default values (expectations) for each stance based on a prior experience. In this way an initial approach and goal is always available even if it does not fit the situation being addressed (i.e prejudice, bias, false assumptions, etc.) and processing can be initiated from any stance.

This model recalls Kant’s three part categorization of mental faculties, as “willing”, “feeling” and “knowing” (conative, affective and cognitive). However, here the model is conceived as a three level structure of intentional cognition in which affective faculties are distributed across all stances and levels: “willing” (feeling about) is associated with bringing an intention into being, “feeling” (feeling engaged) with the process of pursuing the intention, and “knowing” (feeling informed) with its experienced fulfillment. This is consistent with the understanding that “Emotions are, in essence, impulses to act.” (Goleman 1996:6) and thus inherent to Intentionality in all its aspects. In this regard, Pinker (1997:373) has noted that “Once triggered by a propitious moment, an emotion triggers the cascade of goals and sub goals that we call thinking and acting. Because the goals and means are woven into a multiply nested control structure of sub goals within sub goals within sub goals, no sharp line divides thinking from feeling...."

**Cognitive structure**

The cognitive structure of Intentionality is best represented by the source-path-goal image schema (Lakoff 1987, Johnson 1987). (Image schema are generalized cognitive structures that organize information obtained from the body, through the senses or from other mental constructs. They operate at a level of generality and abstraction above mental images and constitute cognitive structures for organizing experience and comprehension.) The source-path-goal image schema is basic to understanding all processes that go from an initial state to a desired state as well as for the metaphorical translation of meaning from an understood source to a less understood target. In this proposal, the “Intentional stance” is identified as the “source” agency, addressing stimuli, background, and direction; the “Design stance” as the “path” agency addressing issues of process, persistence and prediction while the “Physical stance” functions as the “goal” agency registering outcome, difference and value. Although collaborating in the agency of Intentionality, each sub agency has certain responsibilities.

**The “Source” agent**

How might an intentional source agent in a hierarchically structured source-path-goal schema operate? Intentionality is a natural consequence of being in the world. The brain automatically compares new information flowing into it to what it knows and makes predictions about what to expect based on that knowledge. Errors and conflicts are detected during this process and cause the brain to search for resolution. Background knowledge and incoming information regarding a situation never match exactly. However, if the match is sufficient, resolution is automatic, the expected actions and outcomes occur and there is no expectation failure and no problem to solve. If a mismatch can’t be automatically interpreted or transformed using the referenced information the process of intentional (often conscious) goal attainment is initiated. This switch in mental focus establishes the intentional frame in which the problem between incoming and background information is ultimately resolved (displaced either by passing it to episodic memory when resolution is achieved or by subordinating, deferring or dismissing resolution (through reprioritization, etc). Thus, the source agent must be able to index knowledge from prior experience
in dynamic response to new information coming into an intentional frame from the world of concern. To do this efficiently the source agent must generate an intentional frame that shares a common aspectual structure with incoming information and memory (Burnette 2001a, 2001b).

A metaphor occurs when the designer attempts to understand a focal situation in terms of what they already understand. The mapping of the “source” situation to whatever “target” information is recognized as relevant (semantically, structurally, figurally, operationally, or evaluatively) gives structured content to the intentional frame. For example, a semantic apprehension of the focal situation as “fragmented”, directs one to consider the structure of fragmentation, suggests many prototypes of fragmented things, processes for how things fragment and come together and asserts a value of wholeness against which fragmentation can be judged. Thus, the metaphor both “frames” the intention and “generates” the instruments for interactive transformation of the information it references. In this regard, Schön’s (1979) concept of “generative metaphor” has all the elements required of the source agent in an intentional frame: it semantically expresses the problem of an unfamiliar situation, sets the direction in which to seek resolution, establishing structures and strategies for selective attention, references normative models or prototypes as mediating representations, invokes actionable questions and processes and establishes appreciative values.

Thus the “source” of an intention (what it is about) lies in the interaction between prior knowledge and incoming information. Directedness (what to do, what “path” to follow, what approach to take, what “Design stance” to assume) and what outcome to anticipate (what comparisons to make, what criteria to employ, what goals to attain) are determined through metaphorical projection within an intentional frame. At minimum this implies indexing, threading and prioritizing functions in the source agency, subjects extensively studied in the field of artificial intelligence and case based reasoning (Schank 1999, Kolodner 1987).

The “Path” agent
Basic to understanding how information in an intentional frame is resolved at the “Path” level of cognitive processing is the notion that designing is purposeful, persistent and directed – a goal driven activity with conditions of satisfaction. Designers know from experience that a design is not usually immediately apparent, especially if the contingencies involved in the project are complex, ill determined, and emergent, or if the designer is inexperienced or lacking relevant information or expertise. The process of solving a problem or creating a design is highly interactive and dynamic, constantly referencing and adapting the thinker’s knowledge in a process Schön (1987) has called “reflection in action.” It is suggested that this persistent, goal directed interactivity is conducted through the “path” agent operating in the “Design stance”. Processing at this level of agency is invoked when the “source” agent establishes a project or task by framing a metaphor between some understood source and the focal information.

As Minsky (1985:78-79) noted “A “goal-driven” system does not seem to react directly to the stimuli or situation it encounters. Instead it treats the things it finds as objects to exploit, avoid, or ignore, as though it were concerned with something else that doesn’t yet exist. When any disturbance or obstacle diverts a goal-directed system from its course, that system seems to try to remove the interference, go around it, or turn it to some advantage…What kind of process inside a machine could give the impression of having a goal – of purpose, persistence and directedness….The difference engine scheme remains the most useful conception of goal, purpose, or intention yet discovered. … The idea of a difference-engine embodies a representation of some outcome and a mechanism to make it persist until the outcome is achieved…. (it) must contain a description of a desired situation. It must have subagents that are aroused by various differences between the desired situation and the actual situation. Each subagent must act in a way that tends to diminish the difference that aroused it.” It is this last requirement that necessitates ways to shift
attention to different aspects of an experience, different understandings or memories until reframing or reinterpretation of the intention results in an acceptable resolution. This is the strength of the “Design stance” in which something which behaves in the manner required is proposed through conjecture, hypothesis, or similar means. While a mismatch, choice, or goal is instrumental in launching an intentional frame and proposition and prediction in processing it, measurement and prioritization are necessarily involved in managing the goal attainment process. These depend on the assessment of predictions and outcomes.

The “Goal” agent
Although the pursuit of an intention is goal directed, and a goal is always available in an intentional frame by default or as a result of metaphorical projection and development, a supporting agency is required to monitor status relative to the goal, and confirm that the goal has been attained, changed or dismissed. A comparative assessment is involved in which there is a reference entity or criteria (the goal) and an expectation or predicted outcome resulting from the resolution process. The resolution must also involve assimilation into the network of meaning that represents the design objective for the individual, supports their memories regarding it, and facilitates the abstraction, generalization and indexing of knowledge for future use as preferences, expectations, rules of thumb, etc. Intentionality, it will be recalled, always interprets and assimilates outcomes in terms of the background experience of the individual thinker.

Although not fully defined, these component agents, structures, forms, processes and criteria are posited as the roots of Intentionality - aboutness, directed action and assessment. Together they permit focusing on what to attend, ignore, act on, learn, and remember.

A Computational Proposal
An operational definition of Intentionality requires a computational model that can represent the richness of referencing, processing, and management that has been indicated. As an illocutionary act, intending commands, asserts, questions, expresses, activates, prioritizes, and commits. If such operations are understood as computational in nature then a programming architecture suited to the task is needed. Charles Simonyi (1996), principle software architect at Microsoft, has articulated the concept of “intentional programming” in which intentions are expressed as a powerful ecology of abstractions which can be extended to support many outcomes. In such a view the abstractions and their relationships specify an ontology of potential experiences distinct from their application. Entailments extending from the abstractions act to structure thought as do constraints in the situation being addressed. The user’s intentions become expressed through the content, structure and interactions afforded through the component abstractions of the computational system.

It has been suggested that Intending (the initiation, processing and management of goal directed thought and action) and Integrating (accessing, adapting and applying knowledge derived from situated experiences) are modal components of higher level thinking. These two components manage and resolve purposeful thinking in terms of five subordinate modes that address different aspects of a situated experience. All seven modes of thinking are treated as components in a collaborative enterprise framework that implements a distributed computing system (Kobryn 2000). Each component is thought of as an enabling abstraction – an “intentional object model” – representing an aspect of experience that can be instantiated in a great many ways. The instantiation and processing of these components is managed through the “Intending” Component, the collaborative outcome (the “design”) is presented through the “Mediating” component, and knowledge of the experience is maintained in the “Integrating” component (adaptive memory). Although a computational specification of these components is beyond the scope of this paper, Figure 3 provides a diagram using the conventions of the Universal Modeling Language for software development (UML) to characterize a distributed component enterprise framework and the
computational interactions between all seven modal components. It will be seen that each mode of thinking, including Intending and Integrating, is to be implemented as a distinct computational agency in a collaborative framework. A more extensive treatment of this internet oriented distributed processing model is presented elsewhere (Burnette 2001c).

Fig. 3: Component Enterprise Framework for distributed design computing

In summary, the “Intending” component in a computational model of design thinking should provide a three level, hierarchically structured interactive process to 1) initiate an intentional frame 2) index situated information to the frame 3) index relevant and well configured knowledge in episodic memory to the situated information 4) compare the situated and recalled information 5) resolve mismatches to approximate goal criteria 6) accept, replace, reprioritize, defer or dismiss the outcome 7) and transfer frame control to an Integrating adaptive memory as appropriate. While the issues involved have been explored in the field of artificial intelligence, they have not been formulated or implemented as indicated in Figure 3.

Discussion
This paper has focused on Intentionality and its interactive relationship with background knowledge. Some philosophical points and theoretical suggestions regarding the structural representation and operational modeling of these agencies have been made and relevant literature has been cited. It is hoped that the presentation has made the point that Intentionality serves as the headwater for the flow of design thinking and that no theory or model of design thinking can afford to ignore it. The implication for design research and practice is that more attention should be paid to the dynamic matching of prior knowledge to the focus of current concern. While this does happen
to some degree, for example, when an architect asks a client for magazine clippings to learn what they like, or when an ethnographic researcher attempts to understand user behavior in the context of need, or when a designer uses hypothetical scenarios to better anticipate user behavior, such techniques are not fully integrated into design thinking, or computational support systems. Until they are we will be unable to study and improve the process as a whole.
References


The study of the UK SMEs employing external organisations to support innovative products

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Abstract

Product innovation is a vital strategy for organisations to grow and survive (e.g. Coyne, 1996; Trott, 1998). The recent study of 100 CEO’s found that ‘companies that did not keep creating novel products and depended on extensional products showed poor growth rates’ (PA consulting quoted by Perry, 2001). Unquestionably, product innovation is an activity which contains high risk and uncertainty. Either is it hard to define the final result or the achievement of the result is in market.

The research aims to investigate general viewpoints of ‘how’, ‘why’, ‘with whom’ and ‘which way’ the UK SMEs link with other organisations in supporting new products. One hundred and thirty eight innovative product case studies, the winners of Millennium Products Awards during 1997-2000 were selected from the results of the first study by the Design Council regarding the 26 innovation issues/processes. The case studies employed the issue of Links with other organisations in the contribution to their design and innovation successes. The postal questionnaires were directed to Company Directors or Managers who were involved with the winning product. 55.8 percent is the response rate.

The paper presents the result of the external sources that the organisations linked with, and at which stage of innovation process the organisations linked with other organisations. In general, the research result presents 88 percent of innovative products which show a degree of radical changes in design. Research institutions (47%) –universities and laboratories and production suppliers (42%) –new technologies of components and systems are the most frequently chosen of external resources in comparison with governmental specialist organisations (18%) and design consultants (16%). The average number of links of external sources is one or two. Four stages during the innovation process: research and development, concept testing, idea and concept generation and manufacture show the important value of employing external organisations.
The study of the UK SMEs employing external organisations to support innovative products

Importance of innovative products
This paper defines innovative products as “new changes of industrial products”. However, new changes of industrial products could be interpreted in many degrees of innovativeness. According to Booz Alan & Hamilton, innovative products are defined into six categories: new to the world products, new product lines, improvement of existing products, additions to existing product lines, cost reductions, and repositioning. Following six categories, innovative products which are mentioned in this paper do not include the categories of; additions to existing product lines, cost reductions, and product repositioning. In addition, innovative products need to emphasise either solving problem of existing products or applying new knowledge to create new product concepts.

It has been shown that the activities involving innovative products encounter high risk and uncertainty during the product innovation process and the result of end products within market. Nonetheless, the importance of innovative products has been also proved by many successful industrial enterprises that it is central to sustained wealth creation and maintaining competitive advantage. For example, Akio Morita (1992), chairman of the Board of the Sony Corporation, is a successful industrial innovator in the area of many electronic developments, especially for the domestic audio-visual market and the miniaturisation of radio-receivers. Dr. William E. Coyne (1996), Senior Vice President Research and Development of 3M is with the concept of providing products which give customers startling, new and valuable innovations. He mentioned the reason behind the success of 3M is that innovative products provide delight to customers and ‘that delight is the basis for long lasting customer loyalty’. Moreover, the recent study of 100 CEO’s found that ‘companies that did not keep creating novel products and depended on extensional products showed poor growth rates’ (PA consulting quoted by Perry, 2001). In short, innovative products play a significant part for industrial enterprises in sustaining their competitive advantage, wealth, and long-term survival and growth.

Problems of UK SMEs
The critical problems of UK SMEs in creating innovative products are their internal constraints, such as financial insufficiency, labour skills, and lack of management, marketing and sales skills (Cosh and Hughes, 2000, cited by Hughes 2001) in comparison with larger enterprises. Following the qualitative data from DTI (2001), ‘large firms tend to employ more workers, have higher skill levels, pay higher wages and offer more stable prospects to their workforce which means that they have the power and the capability to innovate consistently’ (Technology, Productivity, and Job Creation, OECD, 1966 cited by DTI, 2001). On the contrary, ‘small firms tend to have more limited financial and human resources, less ready information and shorter time horizons. In addition, they are generally more risk averse and reluctant to engage outside help expect for the very specific short-term.’ (Managing National Innovation Systems, OCED, 1999 cited by DTI, 2001; ENSR, 2000). Moreover, these constraints effect SMEs performance in producing innovative products. The UK innovation survey of 2,344 enterprises, conducted by the Office for National Statistics on behalf of the DTI during 1994-1996, revealed that ‘larger enterprises were more likely to innovate than SMEs. Particularly, in the manufacturing sector where 83 percent of large enterprises, but only 48 percent of SMEs were innovators - an enterprise that introduced any technologically new or improved products, processes, or services (DTI, 1999). Moreover, large firms were approximately three times more likely to be novel innovators than SMEs. Inevitably, these lead thus to the low rate of growth and survival of SMEs due to their internal constraints which are related to poor performance of introducing innovative products.
As mentioned in the previous section, the importance of innovative products sustains industrial enterprises to grow and survive. Unfortunately, the critical constraints of SMEs are mainly from their internal sources. Certainly, these affect the result of rapid birth and dead rate of SMEs. Generally, statistical data over recent years in the West Country indicated that ‘less than 50 percent of SMEs survive for five years. Only 5 percent of SMEs are high-growth firms in terms of general business expansion’ (Burton-Jones, 1999). Moreover, in Europe-19, referring to the latest data available in 1995, showed that almost 2 million new enterprises arose, while over one and a half million enterprises ceased to exist (ENSR, 2000). In short, from the low rate of growth and survival of SMEs it might be assumed that they lack many skills and resources in developing their new products.

**External resources and innovative products**

It has been widely claimed that links with external resources are so crucial in sustaining innovative products for industrial enterprises in many ways, such as spreading high costs and risks, access to market strengths, accruing technological capabilities and know-how knowledge, and being able to generate product differentiation (Håkansson, 1989; Grabher, 1993; Johnston and Lawrence, 1991; Nooteboom, 1999; Pilkington, 1999). Moreover, the research, conducted by UMIST on the topic of “Risks and Rewards of Collaboration” (Littler, 1993 cited by Tidd et al 1997), revealed reasons for collaboration of the UK SMEs with other external resources that they wanted to respond to key customer needs, a market need, technology changes, competitors, and a management initiative. In addition, the research pointed out that collaboration assisted SMEs to reduce risks and costs of R&D, to broaden product range, and to improve time to market. In short, industrial enterprises which know how to gain benefits from external resources indicate the benefits of reducing risk and uncertainty, responding to key demands and fulfilling their internal incapability. From this viewpoint, these reinforce the idea of encouraging SMEs to employ external resources in order to expand their opportunities in creating and developing their innovative products.

The recent studies reveal that most industrial enterprises which attain the achievement of creating innovative products in response to market needs are employing external linkages with other organisations. Three well-known forms of business networks are: supplier-buyer relations in automotive industry, regional networks in fashion and textile industry and global strategic alliances in high technology industry. For example, in automotive industry, supplier-buyer relations have been used as a way to share resources and capabilities in manufacturing process and design & development of new products (Pilkington, 1999). In computer industry, there is collaboration between various technological organisations to bring in a wide range of technologies to develop new products (Nordwall, 1991). In textile industry in the northern part of Italy, social network and linkages of family businesses play a significant part in creating new products (Perry, 1999). In short, the paper assumes that these ways of business networks will play a crucial part as new models for industrial enterprises to initiate innovative products in the beginning of 21" century.

**Aims**

According to the importance of innovative products, the problems of the UK SMEs, and the relationship between external resources and innovative products, these are driving forces which push an idea on this research. In order to broaden the idea of external resources and the achievement of innovative products, the research aims to explore further general viewpoints of ‘how’, ‘why’, ‘with whom’ and ‘which way’ the UK SMEs link with other organisations with regard to innovative products.

**Case studies**

The Design Council awarded the Millennium Product Awards, during 1997-2000, for the UK enterprises which had the achievement of most innovative, well-designed products and services.
There are 1012 innovations which won the Awards. One hundred and thirty eight industrial products were selected from the initial research by the Design Council, namely Innovation Stories. The Innovation Stories, an analysis of 1012 innovations, revealed 26 innovation issues/processes. The innovation issue/process, links with other organisations, was selected.

**Research methodology**

The study chose a postal questionnaire as means of this investigation. The survey was done during March-August 2001. The questionnaires were sent out to Managing Directors, Project Managers, Technical/Engineering Managers, Product/Design Managers, or managers who were involved with the award winning innovations.

**Questionnaire design**

A postal questionnaire was designed, entitled ‘links with other organisations sustaining innovative design’. It was divided into two main sections: (1) Design/Company Information and (2) Design/Company Visions. In the former section, the study wanted to gather SMEs’ real experience in links with other organisations in supporting innovative products. The latter section was to ask about SMEs’ visions and beliefs about the main idea of links with other organisations which will contribute new changes in design and will change the way SMEs do their business in the future.

**Results**

One hundred and thirty eight postal questionnaires were sent out. Seventy-seven questionnaires were returned. The response rate was 55.8 percent. The results, which are revealed in this paper, are an extraction from a whole outcome. The paper reveals the results from the questions one, four, and seven. Questions one and four were designed by providing a list of constructed responses. Question seven was designed providing a Likert-style rating scale on a four-point scale. Therefore, the paper presents two ways of analysis: (1) mode, on questions one and four and (2) mean, on question seven.

**Question one**

Question one was aimed to investigate characteristics of innovative products that the UK SMEs created by employing links with other organisations. The study designed a list of five responded answers. There were three choices which are defined as innovative products: (1) offering completely new, unique and different design, (2) offering highly innovative design for specific users, and (3) combining user needs and technology availability to offer new improved products. The result reveals that 88 percent of SMEs can achieve innovative products in a level of radical changes in design. The rest, twelve percent presents benefits of design improvement and an updated version of the previous product. The entire result is shown in Table 1.

<table>
<thead>
<tr>
<th>A list of responses</th>
<th>Score (N)</th>
<th>Percentage</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Offering completely new, unique and different design</td>
<td>20</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>2. Offering highly innovative design for specific users</td>
<td>22</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>3. Combining user needs and technology availability to offer new improved design</td>
<td>25</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>4. Highly improving functions, appearance and quality in your design</td>
<td>6</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>5. Offering an updated version of the previous product</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. Others: new concept</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

Remark: N (A total number of the responded answers) = 77

Table 1: shows different types of industrial products that UK SMEs exploited from strategic linkages.
**Question four**

Question four was aimed to investigate which external sources were linked by the UK SMEs in supporting the achievement of innovative products. It was designed by providing a list of fifteen external resources. In general, an average number of external resources with which SMEs connected are one or two as shown in Table 2.

<table>
<thead>
<tr>
<th>A number of external sources</th>
<th>A total number of organisations (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
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<td>2</td>
<td>22</td>
</tr>
<tr>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Remark: N (A total number of the responded answers) = 74

Table 2: shows an average number of the external resources with which SMEs connected

Research institutions, including universities and laboratories are the main external resources with which 47 percent of SMEs connected. Production suppliers, providing new technology components and systems, are in the second place with 42 percent. Legal advisors, competitors, marketing research organisations, and financial institutions show less benefit in supporting innovative products. The entire results are shown in Table 3.

<table>
<thead>
<tr>
<th>External sources</th>
<th>Score (N)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research institutions (Universities and Laboratories)</td>
<td>35</td>
<td>47</td>
</tr>
<tr>
<td>Production suppliers (New technologies of components and systems)</td>
<td>31</td>
<td>42</td>
</tr>
<tr>
<td>Distributors</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>User groups</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Government specialist organisations</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Knowledgeable organisations as co-suppliers</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Design consultants</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Professional designers</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Retailers</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Innovation Centres</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Legal advisors</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Competitors</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Market research organisations</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Financial institutions</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>*Customers</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Remark: N (A total number of the responded answers) = 74

* (Asterisk) means the study separates ‘customers’ from ‘user groups’. This is because user groups are defined as a group of users who use products and customers are defined as a group of customers who exploit from selling or buying products

Table 3: shows the percentage of external resources with which the UK SMEs linked in the achievement of innovative products.
Question seven
Question seven was aimed to investigate during which phase of the product innovation process the UK SMEs employed links with other organisations. The result reveals four main stages that most SMEs connected with external organisations. Four stages have connection with initial stages of product innovation process: (1) research and development, (2) concept testing, (3) idea and concept generation, and (4) manufacture. The entire result is shown in Table 4.

<table>
<thead>
<tr>
<th>Each Phase of the Product Innovation Process</th>
<th>Score</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Research and development</td>
<td>230</td>
<td>2.99</td>
</tr>
<tr>
<td>2. Idea and concept generations</td>
<td>184</td>
<td>2.39</td>
</tr>
<tr>
<td>3. Concept research</td>
<td>143</td>
<td>1.86</td>
</tr>
<tr>
<td>4. Concept testing</td>
<td>187</td>
<td>2.43</td>
</tr>
<tr>
<td>5. Market research</td>
<td>162</td>
<td>2.10</td>
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<td>11. Others: Product testing</td>
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Remark: N (A total number of the responded answers) = 77

Table 4: shows an average value of each phase with which the UK SMEs linked during the product innovation process

Result discussions
From the result of question one, it is clear that the UK SMEs employing strategic linkages with other organisations obtain high value in attaining radical changes of industrial products. Combining user needs and technology availability is the most popular way in introducing innovative products. User needs play a significant role as new driving force for innovative products instead of concerning two economical factors: high technology implications and market mechanism. In short, it is becoming clear that external resources become part of promoting radical changes of industrial products.

Further to the result of question four, it indicates that the UK SMEs make connection with research institutions and production suppliers to gain new technologies, knowledge and/or information. This means the SMEs need special support in terms of new technologies and/or knowledge which consume time and money to embed them in-house. Moreover, the supports from distributors, user groups, governmental organisations, manufacturers, and design specialists are complementary in promoting the achievement of innovative products. If we look back to such internal constraints of SMEs in creating innovative products, there are problems such as lack of various knowledge, financial and capital constraints which are the main barriers. The result indicates a contrary view in terms of finance because the UK SMEs demonstrated low value of financial institutions. This may assume that they believe in the returned benefits of innovative products. In short, the result indicates six significant external organisations supporting the achievement of innovative products for the UK SMEs are: new knowledge organisations (technology and knowledge), distributors, user groups, governmental organisations, manufacturers, and design specialists.

According to the result from question seven, it has been shown that SMEs mainly employed external resources with regard to four main phases during the product innovation process: research and development, concept testing, idea and concept generations, and manufacture. These phases
reveal that the UK SMEs put their concerns on three stages: incubation stage, product planning stage, and production stage. The connection with services, distributions and disposal phases indicates less concern. In short, it is clear that the UK SMEs focus on innovative products just as their production processes.

**Conclusion**

The research reaffirms that links with organisations can sustain the UK SMEs in order to produce their innovative products. All results reveal that links with other organisations can mainly provide radical change for SMEs’ products. As shown on a list of external organisations in question four, there are a lot of possibilities where the UK SMEs experienced different benefits from different organisations. The research suggests six external organisations with which innovative SMEs should link: new knowledge organisations, distributors, user groups, governmental organisations, manufacturers, and design specialists. Moreover, links with other organisations gain advantages in supporting some highly investment phases during the product innovation process, such as research and development and manufacturing processes which SMEs cannot afford to build up in-house easily. In addition, they support SMEs on creative phases, idea and concept generation. According to a focus group in this research, nonetheless, there is a small number of the UK SMEs that know how to employ external resources as a way in supporting innovative products. The study hopes that these results will help the rest of the UK SMEs to see an alternative way to sustain their innovative products.
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Well-defined versus ill-defined design problem solving: the use of visual analogy

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Abstract
Analogical reasoning is considered to be an efficient heuristic for solving non-routine problems, and particularly helpful in design. It is during the design process, where a large collection of visual displays aid designers, in which the use of visual analogy is of specific importance. Few works have studied the effect of the use of visual analogy in design problem solving, and there is no research which has studied whether it plays a more significant role in the context of ill-defined problems or in well-defined problems. The objective of this study is to empirically compare and investigate the use of visual analogy in well-defined design problems (routine) and ill-defined design problems (non-routine). Results showed that students benefited from the use of visual analogy, which significantly helped them to improve design solutions in both design contexts. Additional results showed that architects also benefited from the use of visual analogy in ill-defined design problem solving. In contrast, visual analogy did not aid them to improve their performance in solving well-defined design problems.
Well-defined versus ill-defined design problem solving: the use of visual analogy

Well-defined and ill-defined problems
A main distinction has been established, between well-defined problems and ill-defined problems (e.g. Gero and Maher, 1993; Goel, 1995; Medin and Ross, 1990; Mitchell, 1993; Reitman, 1964; Rittel and Melving, 1984; Simon, 1984). Well-defined problems are defined by: completely specified initial conditions, clear goals, a defined set of operators for transforming conditions, and a limited number of solutions. A classical example of a well-defined problem is a sum problem, because it meets all the necessary requirements. Well-defined problems are called routine when they allow the use of efficient algorithms to generate solutions that may fully satisfy the initial requirements (e.g., Cross, 2000; Visser, 1996). Ill-defined problems, on the other hand, can be defined by: no clear initial conditions, no completely specified goals, a large number of unpredictable solutions, and no defined set of operators or algorithms. Since solutions to ill-defined problems may be ambiguous, it is not possible to forecast whether an algorithm may fit the initial requirements. For this reason, ill-defined problems cannot be solved in a routine way. These types of problems are associated with the generation of different novel solutions to a similar problem situation. A main feature associated with non-routine problems is the generation of unexpected solutions that are significantly different from prior problem situations (e.g. Suwa et al, 1999). Since this is often the case, design problems are generally considered as prime examples of ill-defined and non-routine problems.

Design problems as main examples of ill-defined problems
Design problems are usually considered as fundamental examples of ill-defined problems (e.g., Gero and Maher, 1993; Goel, 1995). Design methodologists who studied problem solving directed their attention to well-defined problems (e.g., Jones, 1970; Lawson, 1980), and routine processes. They did not understand the ill-structured nature of design problems, and thought that design could be studied as well-structured problem-solving. By considering the design process as a series of connected and sequential well-defined steps, the methodologists proposed that rational prescriptive models of design problem-solving, might aid in finding optimal solutions. However, instead of helping to gain a deep insight into the design process, these models over-simplified rich and complex aspects of design.

Recent research has shown an increasing interest in studying ill-defined design problems. A main feature of these design problems is, the generation of solutions that have no obvious relation with, or that are considerably different from prior existing design solutions (e.g., Goldschmidt, 1994; Suwa et al, 1999). This suggests that in ill-defined problem solving, the range of possible solutions can be extended to unknown and unexplored possibilities.

Analog as a problem solving strategy
Analogical reasoning is considered to be an effective heuristic in dealing with problem solving, particularly with ill-defined problems where as noted above, the production of novel solutions is possible. An analogy is defined as a resemblance of structural relations, as in A:B :: C:D, or A is related to B like C is related to D, where D is the unknown term that has to be established. The use of analogy implies the transfer of related abstract information from a known domain (source), to a situation that should be explained (target), (e.g., Gentner, 1983; Novick, 1988; Vosniadou, 1989). Reasoning by analogy depends on the application of a system of structural relations to the problem at hand. The use of analogy is a cognitive mechanism that enables one to retrieve old information that can support the acquisition of new knowledge. The identification of a similarity between known relations in the source situation and potential relations in the target situation, allows for the
creation of an analogy (Pierce and Gholson, 1994). A system of relations of relevant knowledge (common higher abstraction) is transferred from base to target by analogical mapping (Dejong, 1989).

**Visual analogy in design problem solving**

Research in *visual analogy* was almost absent from cognitive science. Exceptions are the recent studies achieved in visual analogy in problem solving (e.g., Antonietti, 1991; Bean et al, 1990; Beveridge and Parkins, 1987; Gick and Holyoak, 1983; Verstijnen et al, 2000). However visual analogy, as compared to analogy, was never considered an independent category. Therefore, its contribution to problem solving in general and to design problem solving in particular, was not completely appreciated. During the design process, designers constantly refer to and frequently use visual displays. These references and uses, are by themselves important reasons why visual analogy can be considered to be a helpful cognitive strategy for improving the quality of the design outputs. Goldschmidt (1994a; 1994b; 1995; 1999) who studied the use of visual analogy in design, proposed that while looking for a suitable solution the designer tries to identify clues from relevant visual displays in order to establish mappings with the design task. There are a number of anecdotal cases of well-known architects illustrating the successful use of visual analogy. For example, Le Corbusier has implemented a number of analogs into the designs of different buildings, such as ships and wine bottle-racks. The shell of a snail also served Le Corbusier as a main analogical base to design the “endless” plan of the Museum of Tokyo. Similar examples of analogical transfer from a natural phenomenon to a design instance are reported in the works of Calatrava. His ingenious structural inventions are the consequence of using animal skeletons and tree branches in his design process.

Most of the early studies in the fields of cognitive science and design directed their attention to well-defined problem solving, while only recent works have studied ill-defined problem solving. Recently, a few empirical studies have been carried out, on the use of visual analogy in ill-defined problem solving (e.g., Casakin & Goldschmidt, 1999; Casakin & Goldschmidt, 2000; Verstijnen et al, 2000). However no empirical work has focused on a comparative analysis between ill-defined and well-defined design problems.

**Empirical research**

**Objectives and hypotheses**

The objective of this empirical study is to verify possible differences in the role played by visual analogy in ill-defined and well-defined design problems. We would like to test, to what extent students and architects are able to use visual analogy, and how this contributes to enhancing the quality of their design solutions in well-defined and ill-defined problem solving. The major hypothesis is that, the use of visual analogy will help student and professional designers to improve their performance in ill-defined design problem-solving, but will not aid them so much in well-defined problem-solving. To validate this hypothesis, a comparison is made between results obtained in solving both types of design problems in each group of subjects.

**Subjects**

63 architectural designers belonging to three groups with different levels of expertise participated in this experiment while solving ill-defined problems. They were divided into 17 architects, 22 advanced students, and 24 beginning students. In the well-defined context, a total of 54 architectural designers divided into 17 architects, 17 advanced students, and 20 beginning students participated in the experiment.
Experimental conditions
In order to achieve the objectives of this study, two experimental conditions in which subjects were required to solve the design problems, were implemented as follows.

**Test condition**: Solving design problems with visual displays, and with an explicit requirement to use analogy:

Subjects were provided with general instructions and a description of the design problem. Together with these they were given a board with an assortment of visual displays including, images from the architectural domain as well as from remote domains. They were informed that some of the images might serve as potential analogs for the design problems. The subjects were required to identify relevant sources, and to use analogy while generating solutions to the design problems they were given.

**Control condition**: Solving design problems with the aid of visual displays but devoid of any explicit requirement to use analogy:

A similar task was given to subjects with the same degree of design expertise, as in the previous experimental condition, consisting of the same instructions, design requirements, and visual information. However, they were not explicitly required to use analogy.

The three design problems solved in the ill-defined context were: a) the prison b) the dwellings and c) the viewing-terrace. The two design problems solved in the well-defined context were: a) the staircases and b) the parking-garage.

**Procedure**
The experiments were carried out in individual design sessions (one participant at a time). Subjects were provided with general instructions, and a description of the problem’s requirements. They were then given approximately 20 minutes to solve the design task. At the beginning of the session the experimenter answered subjects’ questions, but did not intervene throughout the duration of the experiment. It should be noted, that various subjects solved more than one design problem under the test or control condition, so therefore the number of statistical ‘entries’ as described below exceeds the number of subjects. However, in these cases, design tasks in the control condition were always given before design tasks were provided in the test condition.

**Equipment and materials**
The Research Laboratory room used for the experiments was small and soundproof. The subject was shown a 1m x 0.7m board containing a vast assortment of visual displays, which varied according to the problem at hand. The boards included an average of twenty-four images classified according to: a) pictures from the architectural design domain, to which the problems belong (within-domain sources) b) pictures from other remote domains (between-domain sources) like science, art, or engineering. Some of these images could be related to the design problem, while others could not.

**Scale of assessment**
An ordinal scale from 1 to 5 points was established, in order to evaluate the design solutions for ill-defined design problems. A range from 1 to 2 points was assigned, to cases where the design solution did not satisfy the design requirements, and a range from 3 to 5 points was assigned to cases where the design solution, did satisfy design requirements. A different scale, of 0 or 1 point, was established to assess solutions for well-defined design problems. Zero was assigned where the solution did not satisfy design requirements, and 1 point when the solution was seen as satisfactory.
Judges
Three naive judges unaware of the test conditions, scored the design solutions produced in the different experiments, independently. All of them were architects with at least seven years of professional experience, who volunteered their time. A reliability analysis showed a low disagreement rate among the judges for all the design solutions (average of 3%).

Statistical analysis methods
The scores assigned by the judges in the context of the well-defined design problems, were tested using Fischer Exact’s Tests. The scores assigned in the context of the ill-defined design problems, were submitted to T-Tests. Differences between subject groups, were considered significant at a level of 90% (p<0.1). For statistical analysis considerations, the three ill-defined design problems (‘the dwellings’, ‘the prison’, and ‘the viewing terrace’) were grouped together. Similarly, the two well-defined design problems (‘the staircases’ and ‘the parking-garage’) were grouped together.

Well-defined and ill-defined design problems: Qualitative results
In this section we describe two individual sessions, carried out by two novice designers, while solving well-defined and ill-defined problems. The purpose is to illustrate two different cases, in which student designers successfully used visual analogy to solve the assigned design problems. In the well-defined problem session, the student dealt with the ‘parking-garage’ problem. The subject was required to arrange, the internal subdivision of a 15m high parking-garage building, in order to accommodate 120 cars. A 6m wide two-way passage was required for the internal circulation of cars. Two external lifts were required, to elevate cars through the different floors (See figure 1). The building was divided in two split-level wings, with one-meter difference in their respective lengths. While 60 cars could be easily allocated in the longer wing, the main design problem was to find a solution to arrange the rest of the cars in the shorter wing.

In the ill-defined problem, the student dealt with the ‘viewing terrace’ problem which was comprised of the schematic design of a 30m² viewing terrace which had to be located at the highest

Figure 1: Plan and section drawings for the 'Parking Garage' problem.

In the ill-defined problem, the student dealt with the ‘viewing terrace’ problem which was comprised of the schematic design of a 30m² viewing terrace which had to be located at the highest
point of a 16m high precipice. A main constraint was to divide the terrace into two different sectors. While one sector was required to have maximal contact with the ground, the other was required to have minimal contact with the ground. The descriptions below are based on protocols obtained from recordings of the two different design sessions.

**Successful well-defined problem solving aided by visual analogy**

The design session begins with the student analyzing the design problem. While focusing on the design constraints the subject says:

“The height of the building is 15m, [and it is] divided in two wings. One [wing has] about 15x16 m and the other [has] 15x15. There is a 1.20m height difference between both wings of the building. I have to arrange 120 cars… The minimum height [per floor] within the building has to be 2.60m.”

In order to illustrate an understanding regarding the provided information about car arrangement within the parking-garage, the student decides to produce a first sketch and says:

“First of all I am trying to see how can I organize the interior of the building. I am going to check the way that cars relate to the corridor…[figure 2]. 5,6,5…This will be the car/corridor relationship… So let’s see if there is any problem…”

![Figure 2: Sketch I (well-defined problem). Distribution of cars along corridor.](image)

In a second step, the designer starts thinking about the possibility of representing the organization of cars in three dimensions. In order to do so, the subject manipulates the spatial arrangement of cars by referring to plan and section drawings. These lead to a realization that in order to be able to find a suitable design solution, space shortage constraints need to be included.

“Considering that each floor should have 2.80m at least … I can divide the building height [15m] into six floors…[figure 3]. Sixty cars can be easily located in one of the wings… I am going to check what can be done in the second wing. Oh… now I can see the problem… The second wing is [one meter] shorter in plan so that I do not have enough space to organize the 60 remaining cars like in the other wing.”
Only after understanding the scope of the design problem, the novice student begins to examine the assigned board containing the set of visual displays. While trying to identify similarities that can potentially serve to establish an analogy with the problem, attention is focused on a ‘within-domain’ visual display, and a ‘between-domain’ visual display. In so doing, relevant analogical principles such as ‘partial superposition’ and ‘split-level’ are discovered.

"I am now looking at the board, trying to see what can I get from the visual displays. There is a general principle dealing with organization between things… I can see that in the dwelling [figure 4a] there is something like a split-level situation [principle] between the different floors. This can match the problem of height differences [between both wings]. Probably the figure of the zigzag [figure 4b] may be of help to arrange objects, but I think that [the image of] the dwelling is clearer to me. That is the way forms [floors] superpose one with the other. I can now figure out how to deal with the problem of the split levels, and on the other hand the possibility of partial superposition [between levels to deal with space shortage]..."
In the last stage of the design process, the subject manages to successfully transfer and apply the analogical principle of superposition, from the visual sources to the design problem. Two additional sketches are produced in section (Figures 5a and 5b), illustrating that the design solution is based on the idea of overlapping split-levels between both wings. While sketching the subject comments:

“The problem that I am facing is how to arrange 120 cars in such a way that I could overcome lack of space. I will check if there is a better way to arrange the cars…Yes there is a possibility to do so by overlapping floors between both wings…”

Figure 5: Sketch III (well-defined problem). (a) Relationship between two overlapping cars in section drawing. (b) Relationship between overlapping cars along the different split-levels in section drawing.

Analogical reasoning is successfully applied. The designer is able to identify, retrieve, and transfer the structural principle from a ‘within domain’ display, which is crucial for finding the single appropriate solution to the well-defined problem.

**Successful ill-defined problem solving aided by visual analogy**

In contrast to the previous design session, the student started from a general perusing over the available visual sources. Before focusing on any specific image the subject says:

“I am now looking at the visual displays… perhaps they will help me to focus on the program requirements… and [will also aid] in finding a possible solution for the viewing-terrace [design problem].”

With the purpose of identifying structural relationships that may help to establish an analogy, the student decides to explore some of the visual displays. Suddenly, the subject focuses on a particular ‘between-domain’ image that seemed to deal with the principle of “digging into the ground”, and comments:

“Now looking at the graphic information displayed here I see that the spiral [figure 6]…helps me to think about [the principle of] digging into the ground…”
Figure 6: Displays for the 'Viewing Terrace' problem. (a) downwards spiral object. (b) Pompidou Cultural Center by Renzo Piano. (c) fire brigade connection point. (d) respiratory and perspiration systems. (e) water spreading from a canilla.

The novice designer continues working, and establishes a mapping of ‘deep’ (structural) relationships between the visual source and part of the design requirements. In the next stage of the design process, the subject succeeds in transferring them to the problem. A sketch is made illustrating the relationship between the precipice and a sector of the viewing terrace that have a strong contact with the ground (section, figure 7).

“If I want to design a part of the viewing terrace with maximum contact with the ground… I need to work in drawing section. The question is how to design the viewing-terrace to answer to the design requirements. Well… there might be many possibilities…In order to reach a maximum contact I can dig into the ground through a tunnel, or through a canal… This is a part [of the viewing-terrace] going deep into the ground…It is clear that this part is surrounded all over by ground so that [the terrace] is in maximum contact with it [the ground].”

Figure 7: Sketch I (ill-defined problem). Section drawing of the viewing terrace -maximum contact with the ground.
The subject continues working, and in an attempt to identify an analogical principle that might help to deal with the second programmatic requirement of “minimum contact with the ground”, the board is surveyed once again. While exploring the functions of ‘within domain’ and ‘between domain’ images, principles such as ‘climbing up’, ‘exit out’, and ‘detachment’ are noticed, and then used to establish an additional analogy with the design problem:

“I can see the facade of the Pompidou [Cultural Center] [figure 6b] which makes me feel a sort of climbing up. Oh but image 17 [figure 6c], image 9[figure 6d], and the water spreading out [figure 6e] help me to understand the idea of exit out or detachment from the ground.”

The designer continues developing the initial sketch, and manages to transfer the above-mentioned analogical principles to the design problem. The underground sector of the viewing terrace is successfully connected with a new sector largely detached from the ground (see section and plan, figure 8).

“Now I will try to deal with the second design constraint concerned with the design of the remaining part of the viewing-terrace with a minimum contact [with the ground]. It is impossible to totally detach the viewing terrace from the ground, at least with the available technology of today…Therefore I would think in some kind of technology that might allow me to suspend part of the viewing terrace on the air. I will add a couple of columns so that the suspended plate will hang on them, while it is connected to the underground passage through this connecting point [staircases].”

Figure 8: Sketch I (ill-defined problem). (a) Plan and (b) Section drawings of the viewing terrace – maximum and minimum contact with the ground.

In the final stage of the design process, the novice student was able to map and transfer ‘deep’ relationships between the ‘viewing-terrace’ problem, and ‘suspension’ and ‘underground’ principles from different analogical sources. Although a number of different designs were possible, we maintain that the availability of visual displays, and instructions to use analogy aided the subject in finding a successful solution. As a result the programmatic design requirements, of keeping each sector of the ‘viewing terrace’ with maximum and minimum contact with the ground were fully met.
By comparing the two design sessions, we found a number of differences in the way subjects approach the problem in each design context. When an ill-defined problem is assigned, the designer starts the session by familiarizing himself with the assortment of visual displays. The student is confident that these will help to clarify the design goals. Although both a ‘within domain’ visual display and ‘between domain’ visual displays are identified as potential analogs, the latter seemed to be more helpful in finding a successful design solution. In ill-defined problem solving, where a large number of unpredictable solutions is possible to be found, ‘between domain’ (remote) visual displays proved to have better chances to contribute in finding novel design solutions. The production of sketches were helpful to represent the way that the analogical principle is applied to the design solution.

Contrary to this, when a well-defined problem is assigned, the other student begins the session with an attempt to clarify what the main goals of the problem are. Although well-defined problems are characterized by completely specified initial conditions, as well as clear goals, the lack of experience does not allow the novice designer, in the first stage of the design process, to understand what the problem constraints are. The design session turned out to be a ‘puzzle-like’ solving problem, which called for the use of an efficient algorithm to generate a satisfactory solution. But the inexperienced student, who has not yet developed knowledge structures, was unable to apply any algorithm or some kind of routine procedure. The first sketches aided to visualize and understand the major constraints, and only afterwards to start looking at the visual displays as potential analogs. Although the student was also able to identify a ‘between domain’ display and a ‘within domain’ display both as potential analogs, the latter (a display that belongs to a domain close to the problem at hand) helped to establish a ‘deep’ analogy that lead to the unique design solution.

**Well-defined and ill-defined design problems: quantitative results**

In this section we show statistical results regarding the use of visual analogy obtained in the different groups of subjects that participated in the empirical tasks. In order to test the hypothesis of this work, we carried out the experiment described above. The individual performance of students and professional designers in the test and control conditions, were compared in both design problems. In the ill-defined problems/ test condition, 68 solutions were obtained (21 by architects, 25 by advanced designers, and 22 by beginning designers). In the ill-defined problems/ control condition, 62 solutions were obtained (19 by architects, 22 by advanced designers, and 21 by beginning designers). In the well-defined problems/ test condition, 38 solutions were obtained (11 by architects, 13 by advanced designers, and 14 by beginning designers). In the well-defined problems/ control condition, 35 solutions were obtained (11 by architects, 12 by advanced designers, and 12 by beginning designers).

The hypothesis, that the use of visual analogy plays a more important role in ill-defined design problem-solving than in well-defined problem-solving, was partially confirmed. Contrary to what was predicted with the provision of visual displays and explicit instructions to use analogy, students who solved ill-defined design problems performed as good as those who solved well-defined design problems. However, architects who solved ill-defined design problems achieved significantly better results, than those architects who solved well-defined design problems. Tables 1 and 2 present results of a comparison between test and control conditions in both design contexts.

A discussion and main conclusions about these findings are offered in the next section.
Experimental Condition | Displays Provided | Displays Provided
| Instructions to use Analogy | No instructions to use Analogy
| (Control Condition) | (Test Condition)

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Table 1: Well-defined design problems: quality of designs as a result of the use of visual analogy.

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Table 2: Ill-defined design problems: quality of designs as a result of the use of visual analogy.

Conclusions and discussion

A comparative analysis of results, obtained in the experiment where visual displays and explicit instructions to use analogy were given, partially validates the working hypothesis, which states that: the use of analogy plays a more important role in ill-defined design problem solving than in well-defined problem solving.

From results of this experiment we see that inexperienced students, who have not yet developed knowledge structures, have the cognitive ability to use analogy as a problem-solving strategy. The use of analogy for them, has a similar importance in ill-defined problem-solving (when trying to find unexpected relations between certain sources and the problem), as in well-defined problem-solving (when looking for a unique specific analogical relation). This contradicts the expectation that students who solved ill-defined problems will perform better than those who solved well-defined ones. We suggest that instructions to use analogy contributed to an increase in capturing their attention to previously overlooked structural relationships between, some of the visual sources and the design problem components. It also helped them to enhance the exploration of several unexpected possible solutions. Although we thought that students are able to successfully use visual analogy in ill-defined problem solving, we also thought that inexperienced students, who generally lack problem-solving algorithms, are not able to spontaneously apply routine processes to successfully solve well-defined problems. One of the reasons for thinking in this way is that searching for a finite number of possible solutions, which are supposed to be reached through the
use of an appropriate algorithm, is an unfamiliar and non-routine process for novices. Moreover, the use of analogy is limited to establishing high-level relations between visual sources and the target problem. Therefore, students who generally do not have a large knowledge base relevant to the problem, usually have difficulty to identify a single solution principle. However, it is seen that the implementation of analogy might have been especially useful in providing a new understanding of an unknown domain in terms of a known domain, and thus assisted them in well-defined problem solving as well.

Results from the group of architects validated the research hypothesis. It is observed that these subjects benefited from the use of analogy, which helped to enhance the quality of their design solutions in ill-defined problem-solving, but did not benefit from the use of analogy in solving well-defined problems. It can be said, that instructions to use visual analogy encouraged architects to expand the boundaries of known and even conventional ill-defined designs, while searching for a number of unpredictable solutions. Reasoning by analogy probably helped them to increase their awareness regarding unexpected ‘deep’ relations between certain clue-harboring displays and the design target. This might lead them to new reformulations of ill-defined problems in non-conventional ways. However, in a comparative analysis of well-defined problems, it was seen that instructions to use visual analogy did not lead to different results in the test condition when compared to the control condition. An interpretation of these findings is that architects have enough expertise to successfully identify, and use, potential analogical sources, and thus do not need additional instructions to reason by analogy. Another explanation is that experienced architects have such developed knowledge structures, that the use of analogy in well-defined problems cannot assist them further. Therefore, it is possible, that at least for conceptual design problem-solving, instead of using analogy, architects preferred to retrieve familiar algorithms, routine processes, or adapt existing solutions, which led them to successful well-defined problem solutions. If this argument is valid, it can be concluded that mastering problem-solving algorithms and adapting existing solutions to similar problems, might be a better strategy for well-defined design problem-solving.

Acknowledgments
The author wishes to thank Prof. Gabriela Goldschmidt, who supervised Hernan Casakin’s Doctoral dissertation The role of analogy and visual displays in architectural design, on which this paper is based.
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Design rationale and information management in the construction domain: the outcome of the ADS project and suggestions for future research

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Abstract

In this paper the development and the outcome of the completed EPSRC funded ADS (Project Advanced Design Support for the Construction Design Process) will be presented. The focus of the project was mainly on managing design information without intruding too much on the design process. The ADS prototype can facilitate a change towards a more collaborative process in construction design by improving the effectiveness of decision-making throughout the project and to provide clients with the facility to relate design outcomes to design briefs across the whole building life cycle.

Finally some of the emerging research strands generated by this piece of work will be introduced.
Design rationale and information management in the construction domain: the outcome of the ADS project and suggestions for future research

Introduction
In this paper we will present the development and the outcome of the completed EPSRC funded Advanced Design Support (ADS) for the Construction Design Process Project as well as introducing some of the emerging lines of investigation generated by this piece of research.

The ADS Project built upon the technical results of an earlier project (COMMIT) to exploit and demonstrate the benefits of a CAD based Design Decision Support System. The COMMIT prototype system could store knowledge about knowledge within a design process. ADS, aiming to apply the generic COMMIT system to construction domain specific processes, linked COMMIT to an existing object-oriented CAD system, MicroStation/J from Bentley Systems. The combined system is able to record design decisions, the actors who take them and the roles they played. It also enables members of the project team, including clients and constructors, to browse and search the recorded project history of decision making both during and after design development.

The ADS project facilitates change towards a more collaborative process in construction design, to improve the effectiveness of decision-making throughout the project and to provide clients with the facility to relate design outcomes to design briefs across the whole building life cycle. The project focused on the thorny problem of managing design information without intruding too much on the design process. After the ADS prototype was tested with historical data of a real project, described elsewhere (Peng, Cerulli et al. 2000), the testing and evaluation was extended to a real ongoing project to gather valuable knowledge about how a Decision Support System like ADS can be used in practice. The objective of these trials was to assess the extent to which the underlying ADS approach enhances the design process, and to gather and document the views and experiences of practitioners. A full account of the field trials, carried out over a three-month period at the Building Design Partnership (BDP) Manchester office, is also published elsewhere (Cerulli, Peng et al. 2001; Cooper, Rezgui et al. 2001).

In this paper we summarise the outcome of the ADS research project with a particular focus on user feedback, stressing how this fed into further research currently being developed. Some suggestions were made by the users for strategies to increase the likelihood of an ADS type tool being successfully used in practice. This included pairing up ADS with other commonly used software in practice, thus reducing the real or perceived workload of having to use an extra application.

Finally we present two stems of the original ADS system that are currently being explored: one is the use of ADS functionalities in conjunction with Internet based Project Extranets and the other is the use of process models as contextual frameworks for Design Rationale information. Both these strands of research have in common the fact that they pair up the ADS Design Rationale (DR) capturing functionalities with some other software application already in use by the target users. We hypothesise that by attaching DR info to another set of design information [another subset of the WHOLE project design info], being it the process model or the project extranet, it will reduce the amount of contextual information needed to be input to describe design decisions, making the DR gathering process substantially leaner and, hopefully, more effective.
The ADS Project

The ADS Project (Advanced Design Support for the Construction Design Process) was funded under the Innovative Manufacturing Initiative by the EPSRC and aimed to exploit and demonstrate the benefits of a CAD-based Design Decision Support System. The project built upon earlier work on the theoretical information management concepts developed in the COMMIT project (Construction Modelling and Methodologies for Intelligent Information Integration), an earlier EPSRC funded project. ADS developed from COMMIT by incorporating its advanced information management and decision support techniques into an existing object-oriented CAD system (MicroStation/J from Bentley Systems), and applying this tool to the management of design information and decision making in a real life project provided by the Manchester Office of Building Design Partnership (BDP), a large multidisciplinary design practice.

Both the COMMIT and ADS projects were concerned with defining mechanisms to handle the proactive management of information to support decision-making in collaborative projects. In implementing the COMMIT approach in a real design situation, though, the emphasis shifted towards learning and understanding more about the decision-making process within design activities. ADS focused on how to provide designers with tools for recording and managing the group dynamics of design decision-making in a project's lifetime, with the explicit intention to minimise any intrusion on the design process itself.

The deliverable of the ADS Project was an advanced CAD tool that facilitates capturing designers' rationales underlying their decision-making throughout the design and construction development. The system also enables members of the project team (extendable to all the actors involved in the process, including clients), to search and browse the recorded project history of decision-making, during and after design development.

Commit and beyond

As mentioned above, the ADS project was set up to bring forward the developments from the COMMIT project, which was concerned with the management of information to support decision making in multi-actor environments. It addressed six primary issues that are central to information management:

1. The handling of ownership, rights and responsibilities;
2. Versioning of information;
3. Schema evolution;
4. Recording of intent behind decisions leading to information;
5. Tracking of dependencies between pieces of information;

Many of these are distinct issues, but they have been found to be closely inter-related, making it difficult to address them individually. During the COMMIT project, the Institute of Information Systems (ISI) at the University of Salford has employed object-oriented technologies (first in C++ then in JAVA) to implement an information management framework that addressed the above problems (Brown, Rezgui et al. 1996).

COMMIT and ADS do not impose a decision making sequence, leaving it to the design team, but provide an infrastructure through which all members of the team have the opportunity to be aware of what decisions were made, who made them and when as well as why. The way in which this is achieved is described elsewhere (Rezgui, Cooper et al. 1998).
**ADS: aims and objectives**

The key aim of the ADS project was to develop a system adequate to demonstrate an object-oriented approach to managing design decision-making across the whole building life cycle. The ADS research project was also seen as an opportunity to investigate a number of issues concerning computer-mediated collaborative design processes such as the integration of recording/capturing design intents/rationales into a general CAD platform.

ADS provides designers with the tools to record any information related to a particular design decision-making process. That information can then be recalled and accessed by other actors involved in the process such as clients, other designers, contractors etc. At any point in time the actors involved in the process are enabled to make informed design decisions in the light of the information about other design decisions that are being or have been made by other project actors and that relate to the current one. The system supports and facilitates the collaborative asynchronous decision-making process.

**Feedback supported continuous development**

Throughout the project feedback from users and members of the construction Industry were used as a tool for refining the system, generating several development cycles. A detailed description of the ADS system and its continuous development is available elsewhere (Cooper, Rezgui et al. 2000; Peng, Cerulli et al. 2000; Cerulli, Peng et al. 2001; Cooper, Rezgui et al. 2001).

Several were the mechanisms used at different stages to collect feedback about the system, its usability and its appropriateness for construction design practice: a) **Retrospective case studies:** two case studies were carried out using project historical data to populate the ADS system; b) **Workshops:** three workshops were conducted inviting practitioners, academics and various construction industry professionals; c) **Field Study:** one live case study was carried out testing the ADS prototype on a real ongoing project. Feedback from the users was recorded throughout the experiment; c) **Interviews with practitioners:** a series of interviews were conducted with members of leading practices to disseminate objectives and results of the ADS Project as well as collecting system feedback and broadening the scope of user requirements gathering.

**Retrospective case studies**

Case Studies were used as strategy for collecting a significant amount of real practice data regarding the design decision process, project information management and flow, documentation and communication.

To maximise the amount of data gathered within a limited time frame and, therefore, to allow more development iterations, it was initially chosen to use historical data. A large amount of project information was made available by the industrial partners and the histories of segments of design development were reconstructed for some projects from drawings, correspondence and interviews. Using historical data does have some limitations deriving from the post rationalization of design information. Within the broader ADS strategy for information gathering, though, these limitations were compensated by real-time project data collected during the live case study.

The retrospective case studies were carried out one at the beginning of the ADS project as a starting point for user requirement definition, and one towards the end of the project to gather requirements for future research.
Field Trials
Following the pilot Case Study in which ADS was populated with historical data, the ADS prototype was tested on live projects with the collaboration of BDP. An account of the completed ADS Live Case Study and a critical evaluation of the system is published in (Cerulli, Peng et al. 2001; Cooper, Rezgui et al. 2001).

ADS was used to record design decisions as they are made over a 4-month segment of the overall design processes. The projects used for the trials are: the Round Foundry Residential and Retail Development in Leeds, the Deansgate Hotel and M&S New Store Refurbishment in Central Manchester (M&S Ref hereafter). Mainly, two of the designers involved in these projects were using ADS.

During the field trials particular care was taken to avoid any interference with the design development as well as any imposition regarding the frequency at which to insert data in the system. Designers regularly e-mailed the updated ADS project database and the model files (in dgn format, the proprietary format for MicroStation by Bentley Systems. At the time of the field trials BDP Manchester Office was using MicroStation). Short meetings were held periodically to gather feedback about system and interface usability and for post hoc interviews about the data analysis.

One of the main objectives of the ADS field trials was data gathering: populating the system with real data gathered in real time, in anger, without any artificial simplification of the design process. Associated with this objective was the intention to explore the potential of ADS as a tool for carrying out research on design processes as an unobtrusive way to monitor real design processes, without significantly interfering with the observed process. ADS could support new methods of investigation by complementing existing ones where they have flaws. Lawson identifies five methods of investigating design processes: 1) speculating about design, 2) laboratory observation of designers under rigorous empirical conditions, 3) observing designers at work in the studio, 4) listening to designers telling about the work they do, either by interviewing them or reading what they have written about their process and 5) simulating the design process (Lawson 1997). All these ways of researching design processes have been tried and each appears to have some flaws. Either the events studied do not reflect real events or the analysis is bound to be biased by the investigator’s personal perceptions or the experiments deal with artificially limited phases of design or the fact that knowledge about the process often remains implicit in the designer’s head. Despite the ADS system being originally developed as an innovative tool for supporting decision making in design (Cooper, Rezgui et al. 2000; Peng, Cerulli et al. 2000) the research group realized that it could also offer a fundamentally new methodology for studying the design processes by capturing design development events in a relatively unobtrusive way. Effectively this offers Lawson’s third technique to cut any on-line intrusion. The ADS database can later serve to provide stimulus for interviews (Lawson’s 4 method) but without distortion of memory.

Another key objective of the ADS field trials is the evaluation of both the ADS System and the User Interface. It has to be pointed out that these field trials are regarded as a tool to support the system development: user feedback and evaluation, as well as results of the project data analysis fed back directly into the development that runs in parallel to the experiment. Incremental changes to the system were continuously implemented and released for testing and evaluation and a few development cycles were iterated throughout the duration of the case study.

Data gathered
A number of design decisions were recorded into the system. A detailed description of the ADS Decision Record is available in (Cerulli, Peng et al. 2001).
To illustrate the type of data gathered let us consider one of the decisions recorded during Field Trials - Phase I (Figure 1) committed by the actor Garrett, S. in her role of Architect, to which the rights of creating/deleting/modifying the model had been assigned. The user was left totally free to determine at what point to commit a decision, the amount of information to insert and the number of design changes to be included in a single decision or transaction. The rationale for that decision was input in an unstructured form in a free-text box, and, for the decision in examination, reads as follows: “Building B: revised stair to allow access from bin store at ground level. Revised floor levels in sections to correspond with stair layout”. The system also stored information about the CAD elements (dgn objects) involved in that decision. They belonged to two different dgn files: ap0120_02.dgn; a plan, and ascc20_02.dgn; a section (the relevant portion of those files is shown in Figure 1). The Select Objects button allows highlighting the CAD object involved in the decisions when one of the files containing them is open (MicroStation does not allow having more than one dgn file open at one time).

Figure 1: Illustration of a design decision

Lessons learnt
At the time of the field studies the ADS system as a recording tool was still under testing and under development. The data structure proved to be versatile, easily accommodating changes and developments in the software architecture. Minimum intrusiveness is crucial to the success of any decision support and design rationale-gathering tool. With ADS the granularity of decisions is determined entirely by the designer using the system.

Obviously the benefits deriving from recording design rationale are proportional to the quantity of data gathered and, possibly, inversely proportional to the granularity of events/decisions/transactions. A potential impediment or deterrent to the data gathering is the fact
that it is likely that the main beneficiary of such activity is not going to be the very person that is requested to input the data into the system. But there is also a cultural dimension of the construction design process that determines the success of design rationale and project information capturing. It is possible to envision a gradual increase in the amount of information recorded into the system as the designers become more aware of the real potential benefits of recording design rationale.

The user response was very sympathetic towards the overall objectives of the system. Frustration was occasionally expressed towards the limitations of specific implementations. In particular limitations in processing speed were pointed out as disruptive and intrusive.

During the field trials, the need for fine-tuning the system data recording functionalities to the user needs necessarily shifted the focus on the ADS system as a data gathering tool rather than a design aid tool. Future developments of the ADS system will need to place more emphasis on improving the retrieval of information and to implement extra functionalities like the notification of changes to potentially affected objects, mechanisms for mapping relationships between decision (affected and pending decisions) and the nesting of design decisions.

Potential applications of ADS

During the feedback gathering exercise a few suggestions were made by users and members of the industry for strategies to increase the chances of a tool like ADS to be used successfully in practice. They mainly advocated pairing up ADS with other software that is already being used in practice, integrating them in a seamless way. This would reduce the extra workload, either real or perceived, of having to use an extra application and users would access the ADS tool through a software environment or framework they are already familiar with. It was suggested that by adding ADS functionalities onto a software tool that is already accepted by the users community, the change towards the adoption of a design rationale-gathering system will be incremental and we can hypothesise that this would increase the software usage rate and therefore the design rationale data gathered.

The software environments indicated by the users as candidate media into which plug-in the ADS functionalities, are companies’ Intranets, Information Management Systems [e.g. Columbus by Arup] and software dealing with the ISSUING of drawing for periodical publication. When issuing a drawing, e.g., it is necessary to attach SOME information about what is contained in that drawing and how it is different from previous versions of the same drawing. It was suggested that such environments could be very favourable for the gathering of design rationale data because the users would only be asked to complement and complete information that they had to spend time providing anyway with the issuing or the exchanging of drawing [for legal reasons].

Other suggestions were made for potential fields of application of ADS as a tool for various sub-processes of the whole construction design process: Briefing, Client Changes, Quality Procedures, Personnel Management; Value Management. For instance let us illustrate how ADS could become a tool to support the ongoing briefing process. In one of the retrospective case studies a scenario was described in which the exchange of various pieces of information amongst various stakeholders in the project was supported by ADS. A step forward in this direction would be to have the brief requirements to become objects of the project database and allow for them to be linked by various types of relationships to the other object like, e.g. decisions. “Meeting minutes and workshops reports should be transformed into a series of object of the ADS db”. In this scenario ADS would become a briefing support tool: it could allow, e.g., to relate design decisions to requirements, to identify client requests that have not been addressed by the design team or simply to learn from previous projects.
Future research
In this final section we will introduce two lines of investigation stemming from ADS that are currently being explored: one is concerning the use of ADS Design Rationale (DR) capturing functionalities in conjunction with Internet based Project Extranets and the other is mainly dealing with the use of process models as contextual frameworks for DR information.

Within the ADS Project the need for and the feasibility of collecting construction design project data were demonstrated and the information management model that supports doing it was developed. In addition, an advanced decision support tool was implemented and tested on construction projects while ongoing. Ads developed and implemented a method to track all design decisions, their owners, their timing and consequences. ADS was linked directly to a CAD system (Bentley MicroStation) and a decision record was triggered by a change to the CAD model. One of the main lessons learnt within ADS was that, to strategically gather meaningful project information, the design rationale recording tools need to be stand-alone applications, independent from the CAD environment and accessible to all the project stakeholders. Although the idea of linking changes to the CAD model seemed sensible and to be minimising intrusion, it has turned out to be both technically complex and restrictive. A further lesson was that capturing the rationale behind decisions is essential to make the tool fully usable. The level of detail at which rationale needs to be captured became clearer as a result of ADS but it needs further investigation, supported by an extensive set of data.

The two strands of research described below have combined the ADS DR capturing functionalities with some other software application already in use by the intended users. The pairing up of ADS with other software was suggested by users in the ADS feedback-gathering exercises and the rationale behind it is the hypothesis that attaching DR information to another set of design information [another subset of the WHOLE project design information], it being the process model or the project extranet, will make the DR gathering process substantially leaner and more effective by reducing the amount of contextual information that the user is required to input to describe design decisions. Despite the sharing with ADS of most of the underlying ideas, future research will promote a substantially different strategy for design rationale capturing in construction processes. While ADS, by being integrated with a CAD tool, had the limitation of supporting the generation of design rationale information at drawing level, future research seeks to develop a suite of tools that are active at a higher level, where key decisions are more likely to be made. The systems developed will aim to capture design decisions (in a robust yet non-invasive manner), store them, and enable rapid retrieval (again, without impeding the design process) to assist the design team in both rationalising their design outputs and making more considered decisions during the design process on future projects.

ADS functionalities and project extranets
One of the research strands stemming from ADS that is currently being pursued is concerned with identifying, recognising, facilitating and supporting good practice in Internet based project information management tools for construction design projects. The focus is on the support, observation, knowledge-capturing and process analysis of a number of design projects, selected amongst ones using Project Extranet solutions. Functionalities of the ADS software, will be built into existing commercial Project Extranet software to complement them not only as tools to support and facilitate the collaborative design process, but also as tools for design rationale capturing and retrieving and for briefing support.

A recent survey by Construction Plus (2001) highlighted how an increasing number of UK construction projects are now using a range of web based collaboration and information
management tools. At the date of publication of the survey “over 1,500 British construction projects with a total capital value of over £20bn” were using project extranet tools. Project Extranets clients, as buyers of project collaboration and information management solutions, are aware of the potential benefits of new IT enabled processes and, therefore, appear as suitable partners for conducting research on design decision support systems.

The proposed research will be carried out on real life projects, as they are developing, without altering their course. The main aim will be to record and capture design rationales against various types of information exchanges recorded and tracked by the Project Extranet software. By complementing technology that is already in place and being used successfully in practice this research will constitute an invaluable opportunity to both study these processes enabled by cutting edge technology and to investigate the potential of ADS design rationale gathering and retrieving functionalities in the framework of Project Extranet.

This research will also allow investigating the potential of ADS as a Briefing support tool throughout the duration of a project.

**Process models as frameworks for DR data gathering and retrieving**

Another line of investigation stemming from the ADS project is the one that sees its DR capturing functionalities integrated with process tools to record and capture design rationales against a user-specified process model. This research will allow investigating the terminology, process, and structure of a detailed design programme, providing the industrial partners with a tool for validating and appraising their process models as well as recording DR for design decisions.

To achieve this the ADS prototype will be further extended to develop new functionality that will allow members of a design team to program their own process model as the reference framework for capturing design rationales during the project’s lifetime. No pre-determined process models will be imposed by the ADS system: ADS will provide generic constructs and functionality that can be specified and instantiated by the design teams to form their own design process model. The process model attributes will be generic and optional.

The industrial partners will test the software developing bespoke project programmes for the trial project using their existing internal design models and design planning techniques. The design team, including designers, suppliers, and so on, will be asked to utilise the ADS system as they progress through the detailed design stage. The decisions that are captured will be related to the design programme, which will act as the *datum* against which we record the decisions and agreements that are made.
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Using visual communication resource shifts to inform CMC design

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Abstract

Talking about and with things is characteristic of design communication. In this paper we are concerned with how to design computer-mediated communication (CMC) systems that support such talk between designers separated by distance. We describe a design method based on Scrivener’s (2002) postulate that users in a communication environment satisfy communication purpose by selecting, from the resources available to them, that most appropriate for communication purpose. A method for enhancing the overall utility of a given CMC environment is described where analysis of the shifts between resources reveals insight into their relative strengths and weaknesses which is then used to synthesise design improvements. It is claimed that because the method focuses on user behaviour in a particular communication environment it facilitates the discovery of the latent communication possibilities offered by that environment. Nevertheless, because the method yields statements that describe visual communication needs independently of the particular communication environment studied, the needs uncovered by using it should prove characteristic of a broad range of visual communication contexts.
Using visual communication resource shifts to inform CMC design

Introduction
Designers routinely talk about things. Increasingly, this talk about things is between designers who are separated by distance. In design the visual sense predominates; multifarious artefacts populate the designer’s world. Office furniture, videos, magazines, books, products, drawings, computer displays and design models, inter alia, are all grist to the designer’s mill; they are the maidservants of creativity and communication. The visual is so important to designers that they prefer to show rather than to tell: often, when thinking and talking, designers will requisition a napkin, the back of an envelope, virtually anything at hand, as a display for showing. We are interested in how designers separated by distance talk about things when talking, showing and seeing is mediated by a computer in real-time, because we wish to develop ways of designing efficient and effective computer-mediated communication (CMC) systems.

Scrivener (2002) has argued that that current approaches toward understanding mediated communication environments have provided neither reliable design requirements for CMC systems, nor methods for enhancing the performance of such systems. Instead, he (ibid.) argues we should be exploring how users communicate in a given CMC environment with a view to understanding how the performance of that system might be improved. He (idid.) postulates that in a multimedia communication environment:

1. A user will only select resources that are sufficient for the communication purpose at that moment. A resource that is insufficient for a particular communication purpose will never be used for that purpose.

2. A user will only employ those resources that are needed for the communication purpose at that moment. A resource that is not needed for a particular communication purpose will not be used for that purpose.

3. Given a set of redundant resources, each of which is sufficient and needed for the communication purpose at a given moment, a user will select that which is most appropriate for the communication purpose at that moment.

This being the case, the selection of one communication resource from among others implies that the selected resource offers some benefit over those not selected. Scrivener (2002) has argued that by analysing the selection of communication resources, we can uncover these benefits and thereby offer insights into how a system might be modified both to reduce the weaknesses and enhance the strengths of the available resources.

Acknowledging this approach, we will describe a design method based on communication resource selection that comprises five-stages: assessing resource strengths and weaknesses, formulating redesign recommendations, resolving inconsistent recommendations, redesigning the system, and, finally, testing the performance of the refined system. Although the method can be applied to any computer-mediated visual design communication system, the weaknesses, strengths and improvements of each system will be particular to that system and therefore unlikely to be generalised. Nevertheless, we will show that analysis of resource strengths and weaknesses leads to statements of communicational need that are independent of the particular resources employed in a given system.
Visible representations and objects in design

Broadly speaking, the outcome of designing is the specification of an object that, when made, people will see, touch and interact with. Given the primacy of the visual sense in the apprehension of objects, the corresponding dominance of drawings and three-dimensional models in design specification is not too surprising. However, these visual representations are not merely tools for conveying the results of designing. They are produced, used, and re-used in various forms throughout the design process, functioning both to support design cognition and design communication. Recently, both of these functions have been the subject of much research, and in each case computer-mediated design can be seen as a motivating factor.

Computer-aided design has been a reality for more than thirty years and yet designers still prefer to use the humble sketch in the early stages of design. It is now becoming increasingly difficult to argue that this is due to resistance to change or lack of training. Generally speaking, CAD is now fully embraced by the design community, being widely used in industry and a key component of design education. This has led to the suggestion that sketching and sketches must support design cognition in ways that computers currently do not (cf., Fish and Scrivener 1990), and to sustained effort on unraveling the complex relationship between sketching and cognition (cf., Purcell 1998, Goldschmidt and Porter 2000).

Computer-aided design is also behind recent research exploring the role of visible representations in design communication. Here, it is the computer’s possibilities rather than its limitations that are stimulating activity. In many domains, design is becoming increasingly team-based. At the same time, the globalisation of design, both in production and markets, means that design teams are often composed of members separated by distance and time. For example, in “24hr Follow the Sun Design” a developing design is passed from one design team member to another as the one’s working day ends and the other’s begins (Lindemann, Anderl, Gierhardt and Fadell 2000). Likewise, the Taiwanese government is helping indigenous manufacturers to expand their markets by funding projects where designers from these markets work with them (Woodcock, Lee and Scrivener 2000). This trend toward team and distributed design suggests that while design communication is likely to increase, the opportunity for face-to-face working is likely to decrease. This raises the spectre of more but less efficient and effective design communication, stimulating the investigation of how designers communicate with and about the visible representations and artefacts populating their working environment.

Determining design communication requirements

Many researchers have taken face-to-face working as the starting point for determining the requirements of computer-mediated design communication systems. Tang (1989) and Bly (1988) studied designers working in face-to-face settings, describing the role of gaze, gesture and drawing in design communication. Later studies addressed other design communicative materials. Harrison and Minneman (1996) have shown how objects at hand are used pervasively in design communication as self referents, as stand-ins for other objects, and in combination with utterances or representations of the objects being designed. Similarly, Logan and Radcliffe (2000) explored the role of artefacts in a longitudinal study of a Rehabilitation Engineering Centre where rehabilitation engineers, technicians and occupational therapists collaborate as a team to match assistive technologies with individuals’ requirements, to increase their independence by reducing handicap.

Lindemann, Assmann and Stetter (1999) have argued that the persuasiveness and motivational impact of design communication can be enhanced by the selective use of virtual (i.e., CAD), graphical and physical design models. In a similar vein, Wagner examined the role of what she calls ‘persuasive artefacts’, both digital and tangible, in architectural design cooperation (2000: 380). Minneman and Harrison (1997) have observed that as a design project progresses, the objects that
are actively employed by designers during the process change and accumulate in the studio on all available surfaces. They call these artefacts ‘process ephemera’ (ibid., :18) and argue that their ephemerality resides in the fact that they are useful in the moment, the cocktail-napkin sketch being a typical example. They are also ephemeral in relation to a project and other project representations. Minneman and Harrison (ibid.) argue that a rich assemblage of ephemera is a means through which collective understanding is expressed and discussed.

These studies reveal something of perceived importance of visible representations, artefacts, and objects are employed during design communication. It has been assumed by many that the communicative media and behaviour of face-to-face working are necessary for effective design communication, leading to often highly novel CMC environments designed to replicate face-to-face working. For example, Ishii and Kobayashi’s ClearBoard system (1992) allows collaborators to assess each other’s line of gaze, whether directed at a person or the workspace. Nevertheless, such studies do not in themselves allow us to conclude that the behaviour observed in face-to-face working is necessary for successful computer-mediated design communication. Consequently, the question of which media are needed to support which behaviour in computer-mediated communication has been explored by comparing different CMC environments to each other and to face-to-face working. However, Scrivener (2002) argues against this approach, concluding that it is not a question of what media is best for what groups doing what tasks in what contexts, it’s a question of how do we get the best out of the communication media available in a particular context.

In this paper we take forward this idea, focusing on visually-supported communication. Specifically, we explore the following:

1. How do we identify events in a communication environment where verbal design communication is supported by visualisation?
2. What does the analysis of these events tell us about communication needs?
3. How does this analysis lead to recommendations for improving the particular communication environment studied for visually-supported communication?

We will conclude by proposing a design method based around the steps undertaken when exploring the above questions.

Identifying events where verbalisation is coupled with visualisation

According to Scrivener (2002) we must begin by observing design communication in a particular mediated-communication environment. Hence, we conducted a study that allowed such observation. Given our interest in the visual in design communication, our focus was on events where verbalisation is coupled with visualisation.

The participants and the task

Three design dyads participated in the study. One participant, an industrial design tutor at the University of Derby with more than 25 years experience as a practicing designer, was common to each team. The other three participants were BSc Industrial Design students in their final year of study at Loughborough University. The task was based on the Delft Protocol workshop (Cross, Christiaans and Dorst 1996) in which designers were asked to design a fastening device for attaching a backpack to a mountain bike.

The communication and technological environment

The study involved synchronous CMC between two parties separated by a distance of around twenty miles. At each location, a workspace was arranged resembling a typical studio environment.
that included a desktop PC equipped with colour monitor and an A3 size digital tablet. A proprietary system, PictureTel Live100, Version 1.6, was used for synchronous CMC between the two sites via a basic rate ISDN line. The PictureTel system was equipped with full duplex audio and a camera with manually adjustable zoom, brightness, and focus control. This stand-mounted camera could be adjusted to capture the desired scene, such as documents on the desk. It could also be detached from its stand to capture objects in the workspace, e.g., a bike leaning against a wall. LiveShare Plus (Version 3.00), an integrated collaboration application, was installed on each desktop PC. The main tool for on-line work was a whiteboard - a shared drawing tool enabling participants to simultaneously see and edit a drawing. The basic whiteboard drawing tools included a pen whose colour and size could be modified, text entry, and an eraser. Participants could also paste camera-captured images into the whiteboard. Thus LiveShare Plus supported communication over three media: video, whiteboard, and audio. A colour ink-jet printer (HP Deskjet 660C) was also available at Loughborough to allow the junior designers to print off whiteboard pages, as they were expected to work on the designs between sessions. At each site, the design materials included marker pens and paper. Design information included the design brief, design assignment, schedule, and design data, such as market research, backpack usage and user evaluation reports. Three reference products relevant to the task were also located at Loughborough: a mountain bike, a rear carrier, and a backpack.

Each of the three dyads undertook the task over a four-week period during which weekly, one-hour synchronous CMC sessions took place. Each session, was video recorded for later analysis. Two dyads participated in all four teleconferencing sessions, while one dyad failed to undertake the fourth session, resulting in recordings of eleven CMC sessions.

**The data**

The primary data for analysis comprised the video and audio recordings of the on-line CMC sessions. The discourse captured on these tapes was transcribed to text, organised and labelled in terms of turns by individual speakers. These were sub-divided into those utterances that included reference to a real or imagined object and those that did not (Scrivener, Chen and Woodcock 2000) provide a detailed account of the process of determining that visualisation is coupled with visualisation). The former group provided the ‘talking about things’ data. Having identified all such artefact-related turns, every word was categorised in terms of whether or not it was accompanied by visualisation. It’s important here to understand that this is not simple a matter of noting co-occurrence (i.e., talking and drawing at the same time). To be regarded as visually coupled, there has to be evidence that the words and visualisation are about the same thing.

The system enabled visual communication via the medium of whiteboard or video (see Figure 1). The whiteboard supported two mechanisms of communication, drawing and gesture, while video supported three, namely drawing, gesture and object reference. This yields five media-mechanism combinations, i.e., whiteboard-drawing and -gesture, video-drawing, -gesture and -object manipulation.
The purposes served by visual coupling

The purpose of an utterance is different to the purpose served by visual coupling. The former is what motivates the communication while the latter concerns the way that specific visual information contributes to the communication. As we shall see later, the assignment of a purpose to an instance of visual coupling assists the interpretation of resource selection. Tang (1993) observed how designers used gesture to facilitate communication. He concluded that gesture has three functions: to store information, to express an idea, and to mediate interaction. As noted earlier, Harrison and Minneman (1996) studied the role of objects in design discourse, analysing relationships among designers, designers’ gestures, and the object referenced in a design environment. They observed that gesture was used to clarify or specify something. Based on the above, five purposes of visual coupling in design discourse were identified as follows:

1. Clarify: dictionary sources define this term as meaning to, ‘make more comprehensible’, and, ‘to clarify something means to make it easier to understand, usually by explaining it in more detail’. Using this definition, visualisation coupled with a term was identified as clarification if the designer used a medium-mechanism combination to communicate an attribute of a thing, such as its shape, or a relation between two things.

2. Specify: is defined as to ‘identify clearly and definitely’ and to ‘give information about what is required or should happen in a certain situation’. In visual coupling, ‘to specify’, means to identify clearly and definitely what is being discussed, thus isolating it from the other drawings or objects present. What distinguishes it from clarification is that no new information is introduced.
3. Emphasise: means to, ‘give emphasis to’, emphasis being defined as the, ‘special importance, value, or prominence given to something’. It is also given the meaning, ‘to indicate that it is particularly important or true, or to draw special attention to it’. Again what distinguishes emphasis from clarification is that no new information is introduced. Nor is emphasis simply specification as it draws special attention to what is being discussed.

4. Annotate: is defined as to, ‘add notes to (a text or diagram) giving explanation or comment’, and to, ‘annotate written work or a diagram means to add notes to it’. Generally, annotation adds nothing to what is being said and merely echoes verbalisation, serving primarily to store information for later reference.

5. Identify: means, ‘to associate someone or something closely with’, and, ‘if you identify someone or something, you name them or say who or what they are’. In visual coupling, the distinction between identification and clarification or specification is subtle. Like specification it does not involve the introduction of new information, but unlike specification it relates one visualisation to another.

Having identified the purposes served by visualisation in supporting verbalisation, each instance where a word was coupled with visualisation was assigned to a purpose (c.f., Scrivener, Chen and Woodcock 2000) for a fuller account of this process).

Visual coupling in medium-mechanism

Table 1 shows the distribution of visual coupling purposes to medium-mechanism combinations. First, whiteboard-drawing would appear to be the most used resource, followed by video-gesture, video-drawing, video-object and finally, whiteboard-gesture. Clearly, the latter medium-mechanism combination is virtually useless. Second, across medium-mechanism combinations the distribution of visual coupling to purpose is not uniform, with some combinations showing strong dominance for particular purposes, e.g., video-gesture for amplification and whiteboard-drawing for clarification. Harrison and Minneman (1996) pondered over whether the use of objects at hand as embodied representations was comparable to drawing. ‘Is this’, they asked, ‘the same kind of externalisation’ (ibid., p435). From Table 1 we can see that video-object is used for externalisation purposes and the distribution of purposes to video-object is very similar to that of video-drawing. Finally, we can see that visualisation serves primarily to clarify and to specify what is talked about in design communication.

<table>
<thead>
<tr>
<th>Video (VD)</th>
<th>Whiteboard (WB)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>VD-D</td>
<td>VD-G</td>
<td>VD-O</td>
</tr>
<tr>
<td>Emphasise</td>
<td>4</td>
<td>353</td>
</tr>
<tr>
<td>Annotate</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clarify</td>
<td>243</td>
<td>386</td>
</tr>
<tr>
<td>Identify</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Specify</td>
<td>159</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>414</td>
<td>777</td>
</tr>
</tbody>
</table>

Table 1: Visual coupling frequency against purpose in medium-mechanism

Using medium-mechanism shifts

According to Scrivener (2002) the identification of visual coupling purpose and explanation of why, in each case, the selected medium-mechanism was chosen for this purpose (see later for an
illustration of this process) can contribute to design, revealing the relative strengths and weaknesses of medium-mechanism combinations. The design goal should be to remove these differences and to build on strengths. Let’s say, for example, that we found that at a particular moment, whiteboard-drawing was used rather than the other combinations because paper drawings had been produced between sessions. While highly efficient in this instance, video-drawing might be less effective than whiteboard-drawing, say, because of the camera’s lower resolution than that of the display. Whiteboard-drawing could be improved by making it easier for designers to capture and transfer paper drawings, and video-drawing could be improved by using a higher resolution camera, thus enhancing the quality of each medium-mechanism combination.

However, the analysis of all visual couplings (i.e., 4220 in this study) is very time consuming and is unlikely to be of practical value in CMC system design. However, in synchronous communication where transactions are frequent a method based on the detection and analysis of shifts between medium-mechanism offers a more viable alternative (i.e., in this study shifts between medium-mechanism occur in 13% of visually-coupled words), Table 2.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Shifts to Video</th>
<th></th>
<th>Shifts to Whiteboard</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VD-D</td>
<td>VD-G</td>
<td>VD-O</td>
<td>WB-D</td>
<td>WB-G</td>
</tr>
<tr>
<td>Emphasise</td>
<td>3</td>
<td>130</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Annotate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Clarify</td>
<td>50</td>
<td>76</td>
<td>56</td>
<td>81</td>
<td>6</td>
</tr>
<tr>
<td>Identify</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Specify</td>
<td>30</td>
<td>9</td>
<td>33</td>
<td>34</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>218</td>
<td>96</td>
<td>121</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 2: Frequency of shifts to medium-mechanism combination against purpose

**Formulating redesign recommendations**

Assigning visually coupled words to purposes is, in effect, the first step in the first stage of a five-stage design method. Having identified shifts between medium-mechanism combinations and their communication purpose, the second step is to assess each shift for gains in efficiency and/or effectiveness. Scrivener, Chen and Woodcock (2000) have described this second step and have explained the rationale for focussing on efficiency and effectiveness. What we will do here is to show how this information we can be used in the second stage of our design process to consider, for each shift, how both the shifted-to and shifted-from medium-mechanism combinations might be enhanced through redesign. We will illustrate this process using a shift where the analysis at Stage 1 indicated benefits in both efficiency and effectiveness.

A shift from whiteboard-drawing to video-object for the purpose of identification occurred at the term ‘here’ (underlined in Turn 155) in Dyad R’s third session, when Designer R affirmed his understanding of his remote partner’s thinking by pointing to the relevant physical object, Figure 2.

154 D at the bottom of your leg (WD-D) there's some sort of circle (WD-D) that sits over (WD-D) the pole (WD-D), sits over the pole (WD-D), right, ...and has a strap (WD-D) that goes around there (WD-D), right, ... and onto a spike (WD-D) which is actually part of the, you know ...the member (WD-D)

155 R oh, right, I'm with you. So on the bike...it goes on this part here (VD-O)
In this instance, video-object is likely to have been more effective than whiteboard-drawing for identification of the relevant parts because of it being visible in the context of other associated parts which would have helped to disambiguate the part referenced by the term ‘here’. It was also more efficient than whiteboard-drawing as only small camera adjustments were required to achieve a satisfactory view of the object. In contrast, the continued use of whiteboard-drawing would have required the designer to draw these components. Here then is a case where selection of a new medium-mechanism combination is both more efficient and effective than continuing with the current mode of visual communication.

Given this interpretation, we could look to enhance the efficiency of whiteboard-drawing. One approach, for example, would be to enable drawings to be produced more fluently. We could consider improving the effectiveness of whiteboard-drawing by enabling more accurate drawings to be produced. Finally, the effectiveness and efficiency of the video-object medium-mechanism could be improved by the use of higher quality video and more sophisticated camera control.

**Resolving inconsistent recommendations**

Above we have described two stages that provide insights into how to enhance the visual design communication capability of a given CMC system (e.g., PictureTel in this study). However, examination of the recommendations for improvement associated with each shift reveals inconsistencies.

To illustrate this situation, let’s consider the following example. Having applied Stages 1 and 2 to the shift data from our study, in some instances it was recommended that whiteboard-drawing could be improved by making the image fuzzier. For example, at Turn 322 of one dyad’s first session, Designer D shifted from whiteboard-drawing to video-gesture at the term ‘piece’ for the purpose of ‘clarification’.

322   D    …I’m just moving back, so you can see me on, right, on the front of this thing, we’ve got a piece (VD-G) of stiff plastic, right

Here the shift-to combination, i.e., video-gesture, was judged to be more effective and efficient as it allowed a conceptually ill-defined shape to be conveyed in a non-specific way. Consequently, the recommendation made in this instance was that whiteboard-drawing could be enhanced to support this need by equipping the whiteboard with, say, a drawing layer or tool where the specificity of strokes would be automatically dampened down.

In other instances the opposite was recommended. In another dyad’s session, a shift was made from whiteboard-drawing to video-object at the term ‘here’, in Turn 170, for the purpose of ‘clarification’.

168   R   that could link up onto the frame here (WD-D), so the frame of the erm...

169   D   yeah

170   R   so that perhaps they could link up here on (VD-O) the back of (VD-O) the rack (VD-O)

Analysis of the data suggested that video-object was more effective than whiteboard drawing as its spatial and structural reality communicated the designer’s intended meaning more clearly than whiteboard drawing would have done, and more efficient because showing the visual information was quicker than drawing it. Here, it was recommended that whiteboard-drawing could be made more efficient and effective for this purpose and need by enabling high-resolution images of objects to be readily transferred onto the drawing surface. Clearly, there is potential inconsistency here as whiteboard images are required to be both vague and resolved in detail. Thus further consideration,
and possibly re-analysis of the shift, is necessary to consolidate the recommendations in such a way that conflicts are resolved. A potential solution in this case might be a mechanism that allows designers to choose either fuzzy or detailed images according to the requirements of a given moment.

**Summarising the medium-mechanism shift method**

We have seen that the analysis of shifts between medium-mechanism combinations can uncover the relative strengths and weaknesses of medium-mechanism combinations. Analysis of shifts offers insight into how to design more effective and efficient communication environments. The identification of the purpose served by the coupling of talk and visual representation at a shift, and the determination of why the medium-mechanism was selected for this purpose can contribute to redesign. As noted above, the analysis of each medium-mechanism combination shift reveals the relative strengths and weaknesses of each combination for a given purpose at that time. The design goal is to ameliorate the weaknesses in the shifted-from, medium-mechanism combination and to build on strengths of the shifted-to combination.

We have proposed a design method that can be applied to assess and enhance given CMC environments without limiting the potential for exploiting the latent opportunities of new telecommunication technology. Indeed, we believe that the method may stimulate recognition of these possibilities. The method may be summarised as follows:

1. Assessing medium-mechanism combination strengths and weaknesses
   Taking a computer-mediated design communication system, the system designer must first define the medium-mechanism combination resources and record the systems use over a period of time. Having then identified shifts between medium-mechanism combinations, as illustrated in Section 6.2, the gains in efficiency and/or effectiveness of the combination shifted-to over that shifted-from should be assessed and described.

2. Formulating redesign recommendations
   For each shift, redesign recommendations for enhancing both the shifted-from and shifted-to medium-mechanism combinations are formulated. Here, other evidence from, say, subjective usability assessments, should be sought to support the proposals.

3. Resolving inconsistent recommendation
   Any inconsistencies in the set of recommendations associated with each medium-mechanism combination are then considered and resolved.

4. Redesigning the system
   As far is possible, the system should be redesigned to satisfy the recommendations made in Stage 3.

5. Testing the performance of the refined system
   Finally, the expected improvement in system performance should be verified by comparing the performance of the new system to the old system.

**Conclusions**

We have described a CMC design method based that uses the interpretation of shifts between communication resources as a foundation for design improvements. Because the method focuses on user behaviour in a particular communication environment it is open to the discovery of the latent communication possibilities offered by that environment. Thus, for example, the application of the method to both face-to-face and mediated environments will enable us to uncover the affordances...
and limitations of both. On the other hand, the method yields statements that describe communication needs independently of the particular environment studied. For example, above we identified the need to communicate ill-defined shapes in a non-specific way. If Hollen and Stornetta (1992) are correct that communication needs are independent of communication media and mechanisms, then we should find that the communication needs uncovered by using the method are characteristic of visual design communication contexts.
References


Human factors considerations in human-webpad interaction – a discussion on color application

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Abstract

The purpose of this study is to explore the role of color in human-Webpad interaction based on a model of human factors. Color is a prominent and prevailing visual stimulus encountered by humans daily. It affects how humans process information perceptually and cognitively. Four important design issues pertaining to the model of human factors, i.e., issues concerning humans, Webpad technology, user interface, and environment, are discussed in this paper. The authors hope that this discussion can be utilized to improve the applications of color in Webpad user interface design and, at the same time, point us towards the right direction for future color research on various types of interaction applications. In this paper, the authors also emphasize the concept of human factors to be used to facilitate the internationalization and localization of a Webpad user interface design. A table illustrating how human factors considerations can facilitate Webpad internationalization and localization in terms of physical, perceptual (physiological), and cognitive (psychological) aspects is provided.
Human factors considerations in Human-Webpad interaction – a discussion on color application

Introduction
Color has been used as a visual tool in organizing (e.g., grouping icons with relevant functions) and signifying (e.g., presenting a warning message) information on a computer display in order to draw the user’s attention. Research has demonstrated that the appropriate use of color in computer display may enhance users’ overall task performances (Sidorsky, 1982), improve user performance on visual search tasks (Kinney & Huey, 1990), assist the organization of screen information (Galitz, 1989), and help yield positive feedback from users (Tullis, 1981). However, if color is used improperly, under certain circumstances, it may decrease users’ task productivity and impair their performances as well (van Nes, Juola, & Moonen, 1987). For example, Miller (1956) proposes that using various sensory modalities, humans can recognize approximately 7±2 items (or chunks) of information at one time. Jones (1962) also contends that a human can recognize about 9 distinct colors on an absolute basis. Based on their theories, an interaction designer can apply up to 9 different colors on the same screen. Other relevant research studies reveal that the maximum number of colors used on a screen is from 4 to 10 with an emphasis on the lower numbers (Luria, Neri, & Jacobson, 1986). In addition, Luria, et al. (1986) and van Nes, et al. (1987) also demonstrate that as the number of colors on a computer screen increases, not only the users’ response time to a single color will increase, but the probability of their color confusion may increase as well. Since the application of color to a Webpad display is such a vital task, it is necessary for an interaction designer to apply color efficiently to facilitate the human-Webpad interaction by satisfying users’ color preferences while improving their computer performance.

An effective Webpad user interface should be self-explanatory, and easy to learn and operate by all of its potential users. Figure 1 shows a sample Webpad design. It should also make it possible for users with various levels of computer expertise to achieve their intended task easily. This paper is intended to introduce interaction design concepts pertinent to the application of human factors to facilitate the design of human-Webpad interaction regarding color application.

Figure 1: A Webpad design (courtesy of Tatung Company)
Model of human factors
The term, human factors, indicates that the research issue is centered on human beings. Human factors is the discipline which emphasizes designing useful man-made objects or equipment so that users can operate them effectively and safely (Huchingson, 1981). In the context of a Webpad design, the model of human factors can include two subsystems, the human subsystem and the Webpad (technology) subsystem, interfacing within the physical, social, cultural, legal, and virtual environments (see Figure 2). The primary information-processing stages are embedded within two subsystems: human subsystems and Webpad subsystems.

In human subsystem, the way that a human processes information is based primarily on the following stages: a) When information comes from the external environment (e.g., physical, social, cultural, legal, virtual), a human encodes this information by means of his/her sensors (e.g., eyes, ears, nose, skin, etc.). This stage is called sensation. b) Once a human has encoded the information, s/he starts to organize the information with his/her internal processes. This stage is called perception. c) When a human has organized the information, s/he understands the meaning of the information; in other words, s/he transforms the information into knowledge. This knowledge is a form of intelligence that can help the human conduct problem-solving, decision-making, or reasoning tasks. This stage is labeled as information processing or cognition. d) After the information has been processed, the movement control system will instruct the body responders (e.g., hands, legs, eyes, and mouth) to carry out possible actions.

![Figure 2: Model of human factors pertinent to Webpad design](Derived from Branham & McCleary, 1990)

In the Webpad (technology) subsystem, it processes information in the following stages: a) When the Webpad’s input device receives the stimulus from the human responders, it will send electronic signals to its internal processor. b) Once the Webpad’s internal processor receives the electronic signals from the input device, it begins to function by actually using instructions embedded in the system to process the information and send the results to the display device. c) After the display device receives the result signals from the internal processor, it will start to present the output on the touch screen. The displayed information can then be perceived by the human sensors.
DESIGN ISSUES CONCERNING HUMANS

Humans are intelligent information-processing agents. However, humans still have perceptual and cognitive limitations when processing information. Therefore, when assigning colors to a Webpad screen, the interaction designer needs to take the user’s perceptual capability and cognitive capacity into account. Otherwise, the users may be overloaded with superabundant information that they cannot process efficiently. For example, Miller (1956) proposes that using various sensory modalities, humans can recognize approximately 7 plus or minus 2 items (or chunks) of information at one time. Since the application of color in Webpad screen design is such a vital and unavoidable task, it is necessary for an interaction designer to apply color efficiently to facilitate the human-Webpad interaction by satisfying users’ color preferences while improving their computer performance.

Perceptual and cognitive processing of color

Color is the result of visual interaction of light that is further processed by the optic nervous system. Two types of human visual processing of color are identified in this study: perceptual processing and cognitive processing. Though both types of visual processing of color are unconscious processes, a human must perform perceptual processing of color before conducting cognitive processing of color. Perceptual processing of color is related to the physiological functions of the human eye. Though the human eye is a fascinating optical instrument, like all optical instruments, it has certain physiological functions and limitations. For example, the Bezold-Brücke effect, luminance contrast effect, simultaneous color contrast effect, color assimilation effect, movement and depth illusion effects, after-image effect, human color vision deficiency, and blue discrimination deficiency are all caused by the physiological functions and limitations of the human eye. These visual phenomena occur across all human cultures. The human cognitive processing of color is pertinent to the connotations of color preferences that may vary from one culture to another (Hall, 1959). Different cultures may assign diverse meanings to different colors according to their traditions. That is, various color preferences exist among different individuals, corporate companies, societies, nations, and cultures because of their unique identities.

The human eye is not physiologically equipped to detect blue

The human eye is a fascinating optical instrument. However, like all other optical instruments, the eye has certain physiological functions and limitations of which an interaction designer needs to be aware. For instance, the human eye is not physiologically equipped to detect blue. This is because blue has a low contrast as well as inherent problems in visual focusing among older people. Brown (1988) argues that blue is suitable for background, graphics, and less important items, but not for primary data presentation. Important information should not be displayed in blue. However, for shading some graphic areas and for de-emphasizing some screen information, blue’s low brightness may be beneficial. Based on Murch (1984), the reason why the human eye is not able to detect blue well is because:

• The lens itself does not transmit all wavelengths equally. It absorbs almost twice as much in the blue region of the color spectrum as in the yellow and red sections.

• The yellowing of the lens, which causes it to filter out short wavelengths, also increases with age. Thus, older people cannot perceive blue very well.

• A pigmentation in the central part of the retina transmits yellow while absorbing blue. The net result is a relative insensitivity to shorter wavelengths. This is because there exist fewer blue-region photoreceptors than those responsible for detecting red and green regions of the visual spectrum. More specifically, in the central retina area, 64 percent of the cones contain red...
pigment, 32 percent carry green pigment, and only 2 percent possess blue pigment. Because of this, a blue area on a screen needs to be either larger or brighter in order to be as visible as other colors.

• There exists a bias against blue photopigments in the perception of brightness. Thus, colors differing only in terms of the amount of blue will not produce sharp edges. When saturated blue is used for fine detail or at the edges, the image will appear blurred. In addition, there is a difference in perceived color between a large blue area and a smaller one even though the color is physically the same. Because a small blue area does not activate many blue photoreceptors, it will appear to be more desaturated or washed out than the large blue area. Thus, when applying blue to a Webpad screen design, the interaction designer needs to avoid employing blue for small text or intricate graphics.

DESIGN ISSUES CONCERNING WEBPAD TECHNOLOGY
Color images on a Webpad screen are mainly generated in two ways. One is by the light emission from the Webpad itself; the other is by hardcopy devices (e.g., scanners, camcorders, or digital cameras) that can capture images from outside media and transport the images to the screen. It is important for an interaction designer to know that color should always be used with other, redundant, visual cues. That is, on a Webpad’s screen, texts, patterns, sizes, shapes, graphics, or other visual cues should always be used together with color to enhance the interface visibility. As the screen technique becomes more advanced with higher resolution, it has become possible to create more realistic images of both natural and artificial scenes. However, there are still some limitations of Webpad screen technology of which an interaction designer needs to be aware before employing color to facilitate human-Webpad interaction:

• Certain colors in the natural environment cannot be reproduced by Webpad screen, such as the color of gold and silver. This is because the limits of the physical properties of the light emitted by the LCD technology.

• A Webpad’s screen cannot produce a true black. If we look at a Webpad’s screen when the power is off, it will appear to be a dark gray color under normal indoor lighting. The dark gray color is produced by the reflection of ambient light outside the screen rather than by the LCD itself. It is the darkest color that can be reproduced on the screen. When a Webpad is turned on, its screen may produce blacker colors than that of the switched-off screen because of the user’s expectations and color contrast effects.

• The maximum brightness on a Webpad screen is limited. In fact, the luminance produced on a Webpad screen is relatively low when compared to that produced by natural light. Therefore, the range of possible colors that can be reproduced on a Webpad screen is significantly limited when compared to those in the natural environment.

• Screen resolution and image sharpness on a Webpad is limited. The resolution of a Webpad screen is pertinent to the number of addressable pixels on a screen. The higher the resolution of a Webpad screen is, the sharper the image that can be illustrated on the screen.

DESIGN ISSUES CONCERNING USER INTERFACE
The term “interface” can be defined as a concrete or an abstract medium which facilitates the communication between a user and an artifact, such as a Webpad. A concrete interface promotes tangible interaction by focusing on the design of physical interfaces (e.g., a power button, a scroll button, or any other type of input and output device) with ergonomic considerations. An abstract interface assists intangible interaction by incorporating users’ psychological considerations (e.g.,
users’ mental models) in the design process to emphasize the design of user-friendly interfaces. Color which is an abstract property of a user interface can be used to facilitate the intangible interaction perceptually and cognitively between a human and a Webpad.

**Mental models and interface metaphor**

Users’ mental models are culturally dependent models. That is, users from different cultures may possess different mental models towards the same Webpad user interface. Although changes in users’ mental models often occur through unconscious processes, there is no doubt that users are upgrading their internal representations persistently through different Webpad interaction strategies. To an interaction designer, the purpose of conducting research on users’ mental models is to investigate how a user communicates with a Webpad based on his/her existing mental models, and the research findings, in turn, will be analyzed and utilized to help design a better Webpad user interface.

In addition, a metaphor means the application of existing well-known concepts as an analogy to a new design concept. An interface metaphor can be viewed as a representational model used to help define an interaction task. Research has demonstrated that the selection of appropriate metaphors is crucial to help users develop adequate mental models (Carroll & Thomas, 1982). That is, by using these mental models, users can interact with the interface efficiently and effectively. Generally speaking, an interface metaphor can be viewed as a medium that facilitates users in establishing an initial mental model pertaining to a particular computer system. The proposed Webpad system is implemented by CE.NET platform that incorporates similar strategies regarding office organization and work procedures as metaphors in the graphical desktop operating system design to make the human-Webpad interaction easier as well. Johnson (1992) also suggests that the design of a user interface has to be considered from a number of different perspectives, each of which affects the quality of the overall interface design. These perspectives are listed as follows:

- The functional perspective which is concerned with whether or not the interface design is serviceable for its intended purpose.

- The aesthetic perspective which is concerned with whether or not the interface design is pleasing in its appearance and conforms to any accepted notions of artistic design.

- The structural perspective which is concerned with whether or not the interface design has been built in a manner that will make it reliable and efficient to use and can be maintained and extended easily.

Based on the three perspectives above, it is important for an interaction designer to realize that designing an effective interface requires the incorporation of the user’s mental models in the design process. By so doing, this interface will be easy to use because it can “match” the user’s mental models, and “guide” the user through various types of interactions.

**Using mental models to facilitate Webpad interaction design**

The design of a user-friendly interface is by far one of the most challenging design tasks that an interaction designer can encounter. Theoretically, this user-friendly interface should satisfy the majority of users’ needs and preferences even though they possess different mental models. Nonetheless, there exist neither concrete nor implementable formal methods to guarantee the creation of a universal interface for this ultimate interaction. It may even be impossible to generate a set of detailed guidelines to cover every relevant design issue in creating a universal interface. However, based on the existing design knowledge, an interaction designer may be able to apply important interaction principles to facilitate the design of a useful Webpad interface. If the Webpad
interface is equipped with some degree of adaptability and flexibility, the user will be able to dedicate more effort to carrying out the interaction task without spending too much time learning to use the Webpad.

**DESIGN ISSUES CONCERNING ENVIRONMENT**

An environment is what surrounds us, containing both tangible objects and intangible concepts with which we can perceive and interact. Human color sensitivity can be changed under different lighting environments because the same color will look different under strong, normal or dim light environments. That is, the same color shown under different environmental settings may be perceived differently because artificial lights may cause human eyes to adapt to perceived colors, distort color appearance, or reduce color discrimination. Therefore, the environment in which an interface is used may have a great impact on a user’s task performance. Most human-Webpad interaction takes place in a man-made environment. Though an interaction designer may have no control over the user’s working environment, s/he should understand thoroughly the possible environmental factors pertinent to the application of color to facilitate the human-Webpad interaction, and try to design a useful and effective interface to accommodate as many environmental factors as possible.

**Physical environment**

The physical environment is a concrete space surrounding us. Research reveals that color has been proven to be very useful to facilitate wayfinding in an unfamiliar physical environment (De Jonge, 1962), because color can enhance a person’s spatial perception which helps him/her understand more of this environment. The physical environment can be discussed on two different levels: micro-environment and macro-environment. The micro-environment in the context of human-Webpad interaction is closely related to a user’s ergonomic requirements regarding his/her viewing distance and field of view. In this micro-environment (e.g., a work space), one of the most significant influences on the human perception of color is the lighting provided inside that space. For example, the user’s normal viewing distance from the Webpad screen to the eyes is recommended to be between 60 to 90 cm. If the proper viewing distance is maintained, the user will not need to change his/her eye focus so frequently to prevent eye fatigue. The major concern in the macro-environment in regards to human color perception is also the lighting design in that environment because color and light can either enhance or degrade a user’s Webpad performance. When interacting with a Webpad, it is necessary to provide the user with enough light to illuminate peripheral printed or written materials without directly illuminating the screen itself and reducing screen contrast. If both of the ambient lighting and screen contrast are very low, the eye’s speed and precision of accommodation and convergence will be reduced and the legibility of text on the screen will be poor.

**Social environment**

The social environment provides a social space in which a human interacts with a Webpad under various social influences (e.g., attitudes, preferences, motivations, habits, expectations, and computer expertise). With the progress of advanced computer technology, humans are able to communicate with each other more easily and effectively by means of Webpads. Because of this, the computerization of modern communication technology will also promote human socialization. Research has also demonstrated that in classrooms where students have access to computers, more social communication and cooperative problem-solving activities occur than in other types of classrooms (Office of Technology Assessment, 1988). Moreover, due to the rapid development of Internet technology, people from every corner of the world can meet and talk to each other on the Internet by using Webpads. Since Webpads play such an important role in facilitating the social interaction among users, it is necessary for an interaction designer to take social factors into account...
when applying color to facilitate human-Webpad interaction. This is because color has social meanings as well.

**Virtual environment**
A virtual environment is an interactive computer-generated environment (Stuart, 1996). The virtual environment provides a cyberspace within which various types of interactions may occur, such as distant training or education, on-/off-line prototyping, digital communication, and entertainment. In fact, a virtual environment provides “artificial reality” to facilitate users’ interaction tasks. This is because modern state-of-the-art computer technology has enabled users to perform three-dimensional interactions (e.g., 3-D simulation and animation) together with sound and lighting effects which make the virtual environment more like a physical environment. Similar to the effects in a physical environment, color can also facilitate a user (i.e., a virtual actor) in navigating through a virtual environment (e.g., the Internet or a corporate Intranet) by means of a Webpad.

**Cultural environment**
Culture has been defined as “shared patterns of behavior” (Mead, 1953). A cultural environment can provide an emotional space in which a set of beliefs, values, and behaviors can be commonly shared by members of a society or population (Ember & Ember, 1977). Cultural patterns must be generally agreed upon by the majority of the members of the culture, not just by an individual alone. Therefore, within one culture, the majority of the members will share the same color meanings and associations.

**Cross-cultural studies on color**
Color preferences vary from one culture to another (Hall, 1959) because different cultures assign diverse meanings and associations to different colors according to their cultural traditions and aesthetic values. For example, Stockton (1984) points out that, among various nations in Africa, the most preferred colors are green, red, and yellow. This is because green represents fertile lands, red implies blood lost in revolution, and yellow is associated with the sun and other natural resources. Allen (1986) also maintains that, in Latin America, the preferred colors for the festive design are rainbow colors. In addition, even climate plays a crucial role in the color of clothing for people in various regions. For instance, light-colored clothing is preferred in hot climates, and dark-colored clothing in cold climates (Sharpe, 1974).

In recent years, the progress of global communication has effectively encouraged researchers to focus more on cross-cultural studies, especially the interpretation of colors among different cultures. Moreover, the growing competition among international markets is another reason why interaction designers must consider cultural distinctions in their interface design process. It is important for an interaction designer to realize that the purpose of conducting cross-cultural studies on color is not only to explore the nature and meaning of color, but also to employ color for practical applications to benefit every culture around the world. In fact, designing a useful and effective Webpad user interface can be viewed as a cultural activity, and color is one of the cultural factors to facilitate the user’s visual interaction with that interface.

**Designing international user interfaces**
To an interaction designer, the purpose of conducting international user interface design is to create useful and effective interfaces that can be utilized by all the potential users with various cultural backgrounds around the world. In fact, international user interface design should be considered as a cross-cultural collaborative work between interaction designers and users from different cultures (Ito & Nakakoji, 1996). Designing international user interfaces requires taking the concept of both internationalization and localization of user interfaces into account. Internationalization is the
process of designing a base interface that can be further integrated with various cultural factors to meet different cultural needs (Fernandes, 1995). Localization is the process of adapting an internationalized user interface based on the features of a particular culture. In fact, the process of interface internationalization will facilitate the process of interface localization as well. The process of interface internationalization can provide a dynamic framework (or structure) in which interface localization can be implemented by adding cultural factors into the design.

Because the internationalization of user interfaces requires intensive cultural considerations, an interaction designer needs to identify and separate basic principles regarding interface design into culturally independent and culturally dependent variables. The culturally independent variables are the variables used to help interface internationalization, and the culturally dependent variables are used to facilitate interface localization. For example, color which is an important visual interaction language can be used to facilitate both internationalization and localization of user interfaces. That is, color used for interface internationalization should be considered as a culturally independent variable. Research from the human eye’s physiological functions and limitations of color processing can be incorporated into the process of interface internationalization. This is because all humans, regardless of their cultural backgrounds, possess similar physiological functions and limitations in color processing. On the other hand, color used for interface localization should be considered as a culturally dependent variable. Research pertinent to color preferences among various cultures can be used in the process of interface localization. This is because different cultures assign widely different meanings and associations to various colors based on their cultural preferences. Table 1 illustrates how human factors considerations can facilitate the Webpad’s internationalization and localization in terms of physical, perceptual (physiological) and cognitive (psychological) aspects.
Table 1: Human factors considerations for Webpad internationalization and localization

<table>
<thead>
<tr>
<th>Design Aspects</th>
<th>Design Considerations</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internationalization (Focusing on similarities)</td>
<td></td>
</tr>
<tr>
<td>Physical aspect</td>
<td>The consideration of the sizes of small-scaled products or components that can be</td>
<td>E.g., the sizes of surface buttons and on-screen soft keyboards designed</td>
</tr>
<tr>
<td></td>
<td>operated by the majority of international users.</td>
<td>for Webpads or their possible accessories.</td>
</tr>
<tr>
<td>Perceptual (Physiological) aspect</td>
<td>The consideration of common users’ physiological functions and limitations.</td>
<td>E.g., limitations of human visual perceptual processing of color.</td>
</tr>
<tr>
<td>Cognitive (Psychological) aspect</td>
<td>Common behavior patterns followed by international users, such as the design</td>
<td>E.g., press to increase a Webpad’s volume will increase its loudness.</td>
</tr>
<tr>
<td></td>
<td>consideration of display and control compatibility on a product or a system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Localization (Focusing on differences)</td>
<td></td>
</tr>
<tr>
<td>Physical aspect</td>
<td>The consideration of the sizes of large-scaled products or components to be used by</td>
<td>E.g., the requirement differences pertinent to the sizes of Webpad’s</td>
</tr>
<tr>
<td></td>
<td>various human races and special user groups.</td>
<td>handgrip areas between Asia and North American users.</td>
</tr>
<tr>
<td>Perceptual (Physiological) aspect</td>
<td>The consideration of physiological functions and limitations of certain cultural members or special user groups.</td>
<td>E.g., blind users’ tactile and auditory senses are more sensitive than those possessed by users without tactile and auditory impairments.</td>
</tr>
<tr>
<td>Cognitive (Psychological) aspect</td>
<td>The consideration of cultural factors towards users’ information processing process; i.e., the research on users’ mental models.</td>
<td>E.g., users’ cognition towards icons, texts, sizes, screen colors, and symbols used on a Webpad’s user interface.</td>
</tr>
</tbody>
</table>

Conclusion
The study explores the role of color in human-Webpad interaction based on a model of human factors. Various important Webpad interaction design issues were discussed in detailed. The authors hope that the discussions can be used to improve the design of human-Webpad interaction pertinent to color applications. At the end of this paper, the authors also emphasize the concept of human factors to be used to facilitate the internationalization and localization of a Webpad user interface design. This is because the internationalization of Webpad user interfaces requires intensive cultural considerations. It is also hoped that by means of carefully designed Webpad user interface, users can communicate with each other in a more efficient and effective way.
Acknowledgements

Financial support of this research by National Science Council under the grant NSC 90-2218-E-011-017 is gratefully acknowledged.
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Barrier free bus stop design for Taipei senior citizens and weaker passengers

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Abstract

The purpose of this project was to provide barrier free bus stops for Taipei senior citizens and passengers with traffic difficulties e.g. blind, deaf and people with moving problems. The improved solution of a barrier-free environment consists of three aspects, which are a waiting zone, an on-coming bus information and assistive devices for weaker passengers.

This study began with the investigation of the present contextual situation of Taipei City bus transportation systems, by using methodologies of observation, interviews, and documentation of literature. In order to select the most effective solution, a well-defined Ranking and Weighting method was then developed to access the factors of comparative importance. During this project, the Transportation Agency of Taipei City Council (TATCC, 1998) provided their existing bus transportation system for better insight assessments and also the Cultural and Educational Foundation for the Blind, Taiwan, offered the researchers a better understanding of blind people’s needs.

This research finally provided an ideal barrier free bus stop design solution for Taipei senior citizens and weaker passengers. Through this solution, all passengers can not only wait for a bus in a safe and comfortable environment, but also be provided with a precise bus on-coming time schedule and useful information about alternative routes. Furthermore, the landscape of Taipei City can be improved considerably.
Barrier free bus stop design for Taipei senior citizens and weaker passengers

Introduction
The existing bus stop in Taipei City is very unfashionable and ugly. It is a design for basic needs, which provides only the basic sheltering from sunshine and rainfall. In an international city like Taipei, these bus stops are the weakest link in the modernized city landscape. They were in strong need of improvement (TATCC, 1998). In addition, their usability is not able to reflect the total citizen requirements. Recently, more and more importance on special needs issue indicates that to provide a special needs’ solution, a barrier free bus stop in Taipei City is a major priority (Siedie, 1996).

Aims and objectives
The purpose of this project was to provide a better design solution for barrier free bus stops with a dynamic on-coming bus information and assistive devices for Taipei City commuters especially for senior citizens and weaker passengers. There are four objectives (4E) in this project, i.e. Easy, Enjoyable, Effective and Empowering.

- Easy: The information system should be easy to use and the symbols and signs communications system should be easy to identify.
- Enjoyable: Waiting for a bus should become enjoyable.
- Effective: The information system should be able to provide commuters with alternative bus routes information during travelling. At the same time, it should also be able to inform the bus control center and the bus driver in advance to pay attention to the senior citizens and weaker passengers waiting and to provide assistance if necessary.
- Empowering: This new barrier free bus stop should be one of the highlights attractions in the city landscape in Taipei City.

Research methodology and process
Three research methodologies were used during this project, observation skills, interviews and Ranking and Weighting analysis. Observation skills and expert interviews were two main methods of this project. This journey was focused on the following five points of view, i.e.

- Existing problems in bus service system;
- Drivers’ behaviour analysis while parking at the bus stop;
- Design criteria and specification for the shelter;
- Special needs of weaker passengers in accessing bus stop;
- Photos taking of the existing environment (e.g. traffic island, parking bay, passenger-waiting and information service zones).

For better understanding of dynamic on-coming bus information service system and the special needs from Taipei senior citizens and weaker passengers in accessing a bus stop, the experts at Transportation Agency of Taipei City Council recommended that Jen-ai Road in Taipei City would be a suitable location for this study. There were six processes in this observational study:
(a) To access the recommended bus stop at Jen-ai Road;
(b) To observe the context of commuters/passengers in waiting for a bus and take photos;
(c) To observe the context of commuters/passengers in accessing and reading the bus service information system and then take photos;
(d) To observe the city bus accessing bus stop and take photos;

(e) To interview some passengers and record their opinion and recommendations;
(f) To draw relationship between aspects of the existing environment (e.g. traffic island, parking bay, passenger-waiting and information service zones).

**Observed reviews and results**

From the viewpoints of this observation, there were many long term existing problems with Taipei City bus services.

First of all, there were serious delays and/or damage at the installed boards/screens of on-coming bus information, bus route indicators, bus stop symbols, signs and location equipments and ticket identification machines, which have to be repaired and re-installed regularly all year round.

Secondly, unqualified bus drivers’ behaviour and service attitudes were also main service problems observed from the journey. In the quality concerns of passenger services, sometimes, for bus drivers’ own convenience, they always parked at the improper boarding entrance.

In this project, a proper path of drive way was recommended and re-organised to enable the bus driver to stop at the reserved parking bay and provide a safe and comfortable travel environment for Taipei senior citizens and weaker passengers.

During interviews, the experts in the Transportation Agency of Taipei City Council indicated their existing problems of design criteria and specification for bus stop shelters. The dimensions of bus lane and traffic island were related to total traffic capacity. The more traffic jam happened, the more bus lanes needed, therefore, the bus lane will become narrower and narrower. Many public facilities and spaces constructed in Taipei City were planned by copying from overseas and sometimes forgetting or ignoring the manner of Taipei City. So when you travel in Taipei City, you may lose your Taipei feelings.

After the observation and expert interview studies, a well-defined ranking and weighting method was developed and followed to analyse the importance of factors for bus stop environment. Figure 1 presents the important factors for the bus stop environment, which need to be first solved and re-design. Dynamic bus information services system (i.e. on-coming bus information, bus route indicator, and bus stop sign and location) shows its most importance with 45% among all factors. Lighting follows the importance of 19% as second priority. The passengers waiting space of 16% and railing of 12% also present their importance.
According to the results of the ranking and weighting analysis, the design specification and criteria of this project were drawn by the researchers as follows.

For the normal passengers:
- Dynamic bus information services system (i.e. on-coming bus information, bus route indicator, and bus stop sign and location):
  - To re-organise the bus service route monitors/screens, loud-hailers, video camera (CCTV) and aerials.
  - To adopt new durable materials to avoid rust and collision damage to the outer covering.
- Symbols and signs communication system:
  - No matter when day-time or night-time and no matter where on the pavement or bus, the symbols and signs communication system should be easy to identify.
- Lighting:
  - It should have sufficient lighting and enhance the landscape at night.
- Passengers waiting space and railing:
  - To re-arrange the proper waiting space and using path for Taipei senior citizens and weaker passengers.

For people with special needs (senior citizens and weaker passengers):
- Speech sounds systems:
  - During interview, the experts and practitioners at Cultural and Educational Foundation for the Blind suggested that the most difficult problem for the blind to take bus is on-coming bus identification, which means that they did not know the route (or number) of the on-coming bus while waiting for it. From this point of view, to design a dynamic bus information services system with sound or speech announcement system is very important. These interviewees also indicated that this facility can provide the blind with a total barrier free and highly secure travelling environment.

**Design protocol**

According to the recommended bus service route by the Transportation Agency of Taipei City Council (1998), Jen-ai Road was selected as the basic design platform for this project (as shown in figure 2). There are three phases of design processes in this study, which are concept design, detail...
design and prototype phases.

Figure 2: The basic design platform for this project (Jen-ai Road, Taipei)

**Concept design phase:**

**Concept 1:** (as illustrated in figure 3)
- Non specific waiting zone and boarding zone for Taipei senior citizens and weaker passengers.
- The traffic island is divided into three boarding (on/off) zones.

**Concept 2:** (as illustrated in figure 4)
- Non specific waiting zone but do provide a specific boarding zone for Taipei senior citizens and weaker passengers.
- The traffic island is divided into three boarding (on/off) zones.
- Providing a specific waiting zone only when senior citizens and weaker passengers are waiting.

**Concept 3:** (as illustrated in figure 5)
- Providing a specific waiting zone for senior citizens and weaker passengers.
- Improving the height of the assistive railing to prevent the senior citizens and weaker passengers from falling down from the traffic island.
- The traffic island has one boarding (on) zone, and one boarding (off) zones in front of the specified waiting zone.
Detailed design phase: (as illustrated in figure 6)

- The detailed design is developed from main concept 3, which is a specified waiting zone with one separated boarding on and off zones in front of the specific waiting zone.
- This provides a safe and comfortable waiting space for senior citizens and weaker passengers. Furthermore, it can also prevent the bus driver from hurrying his parking at the improper place.
- For safety concerns, an assistive railing can be provided (designed) to prevent the senior citizens and weaker passengers from falling down from traffic island at the front area of the specific zone.
Prototype phase:
In this stage, the specified waiting zone is re-considered for special needs. It provides Taipei senior citizens and weaker passengers with barrier free boarding on/off spaces with assistive devices. These are the key points of the design solution, as illustrated in figure 7.

Discussions

Design characteristics:
• Barrier free waiting zone: The traffic island is divided into two zones i.e. yellow and blue zones, the yellow zone is a public access area for all passengers (normal passengers) and the blue zone is the place specially for those senior citizens and weaker passengers. There is only one boarding on/off area in front of the blue zone to provide a better service without chaos.
• Furthermore, there is also a special guidance paving constructed on the ground surface to assist the blind passengers during boarding on/off the bus safely.
• There are double layers designed at the roof of the bus stop shelter. The upper layer of the roof is designed by using a special opaque aluminum material with net construction to enhance the strength of the roof. The second (lower) layer is designed by using a transparent Polypropylene (PP) material for lighting consideration.
• To adopt the height of the railing at 130cm (International Labour Office, 1996 and Leibrock, 1993) for senior citizens and weaker passengers to prevent them from falling down.
Dynamic bus service information system:
- “You Are Here” board and bus service route monitors/screens are designed at the yellow zone for passengers. Also design a dynamic bus information services system with sound or speech announcement system for special needs at the blue zone.

Special needs facilities:
- As mentioned, a special guidance paving constructed on the ground surface only at the blue zones to assist the blind passengers during boarding on/off the bus safely and settle themselves at the specified zone of blue while travelling.
- As illustrated in figure 8, 9 and 10, the assistive devices were introduced to two systems, one is the “GOTO Input System” (i.e. on-going bus number input device), and the other is “GOTO Display System” (i.e. on-going bus number display input device). Senior citizens and weaker passengers can easily access these systems to indicate their direction.
- And this message will also be passed to both the bus service control centre and on-coming bus driver to understand that there are weaker passengers waiting at the blue zone of next bus stop.
- While the bus arrive the bus stop, both of speech/sounds and screen announced for special needs.

Figure 8: The GOTO Input/Display System
Figure 9: The GOTO Input System

Figure 10: The GOTO Display System

Conclusion and recommendation
This research finally provides an ideal barrier free bus stop design solution for Taipei senior citizens and weaker passengers. Through this solution, all passengers can not only wait for a bus in a safe and comfortable environment, but can also be provided with a precise bus on-coming time schedule and useful information about alternative routes. Furthermore, the landscape of Taipei City can be improved considerably.

Acknowledgement
Thanks to the Transportation Agency of Taipei City Council for their permission to use their published materials Better insights on transportation regulations and the existing bus service information system. Thanks also to the Cultural and Educational Foundation for the Blind, Taiwan for providing the researchers with a better understanding of the demands for blind people.
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TAACC (Transportation Agency of Taipei City Council), 1998, Better insights on transportation regulations and the existing bus service information system. Taipei, Taiwan, R.O.C.
Design behaviours: the innovation advantage-
the multi-faceted role of design in innovation

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Abstract

Design is a ‘good thing.’ “Use it well,” companies are often told, and you will reap the many rewards. But how exactly is design ‘used’ by the commercial organisation during NPD? As a complex activity that deals with at least as many intangible as tangible factors, how can design be constrained by any business process? And if businesses should adapt to gain more value from designers, in what ways should they change? Based on the results of Design Drivers, a three-year EPSRC-funded investigation, these are some of the questions that this paper seeks to answer.

Examining the way in which designers operate within different environments – either as an in-house designer or outsourced consultant; with different sized companies; in different industrial sectors – we will attempt to illustrate how designers can bring real value to their clients and indeed, the entire supply chain through innovation.
Design behaviours: the innovation advantage - the multi-faceted role of design in innovation

Introduction
“…All innovation requires a committed champion. Someone to maintain the momentum when nervousness or uncertainty appear” (D. Bone 2000)

Increasingly, design is often strategically employed to gain a competitive advantage, for example by differentiating products from those of competitors; identifying new markets, defending existing markets or incorporating new technology. Design can offer a range of solutions giving many different outcomes, which can be a valuable asset during uncertain times. By understanding the role of design in the business environment and the unique benefits that it can provide, managers can learn how best to utilise it, in a holistic sense, to help form an effective strategy for the future.

Evidence of effective design both within and outside the ‘design process’ illustrates how ‘the design perspective’ can be a strategic resource for companies. Today’s designers are equipped with a unique perspective and a diverse range of skills that have useful implications beyond the designing of products.

Design can also be viewed from a number of different perspectives. It can be an in-house function or can alternatively be out-sourced either from a consultancy or from a freelance designer. The size and structure of the organisation within which design is utilised will also have an impact upon the way in which the designer should work and be carefully managed.

Drawing on two case studies of the design of bathroom equipment and lighting products, this paper will illustrate the way in which, utilising their skills and behaviours, designers both ‘source’ and ‘extract’ innovation from the supply chain, drawing it into the client organisation in often invisible ways.

These case studies, along with another eight, provide the foundation of an analysis of the value designers bring to the supply chain, modelling design relationships and understanding how designers influence decisions governing product(s), markets, procurement and supply chain policy. Critical in this are the behaviours exhibited by designers, their personality and their operational environment. Comparisons are made between the personality traits of those involved in design projects, between company cultures, and between the operational models that occur.

Our research illustrates the need for organisations to capitalise on the holistic approach to innovation taken by designers – an approach that, falling outside of explicit business processes, is often invisible in nature.

The role of effective design management
It is widely accepted that design can lead to a variety of positive strategic benefits. However, for these to be commercially realised, a framework of organisation and planning is necessary. Design managers have traditionally assumed the role as intermediary, to organise the design process and manage relationships between designers and other managers. However, since the business environment has radically changed, design has become more involved with the goals of other business functions, playing a more significant part in company strategy. Inevitably, as the role of design has broadened, the responsibilities of the design manager have expanded. Morzota (1998) offers three levels of design management (Fig 1).


<table>
<thead>
<tr>
<th>Role</th>
<th>Design involving the improvement of a system or operation. Marketing / Engineering / Communications etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>Design as a tool in achieving a competitive advantage. Creation of new products / markets.</td>
</tr>
<tr>
<td>Strategic</td>
<td>Design operates at a corporate level by influencing and contributing directly to company vision.</td>
</tr>
</tbody>
</table>

Fig.1: Levels of Design Management – Morzota (1998)

However, Cooper and Press (1995) argue that the term Design Management contains a fundamental contradiction. Whereas design is based around exploration and risk-taking, management is founded on control and predictability. The outcome of combining the two presents a risk that the management framework might reduce the creative scope of the designer. For those ‘managing’ design the danger of restricting the flair and imagination of designers is an important concern and only the systems that leave space for innovation should be implemented. It is important that design managers truly understand the way designers work so that the project is managed well without inhibiting creativity.

**The designer**

Since every design task is unique, it possesses different conditions, constraints and resources. Designers must develop their own knowledge system and co-ordinate existing and new skills and knowledge together successfully in order to meet the requirements. ‘Designers use their innate skills to translate ideas and knowledge about the world around them into new products, messages and environments.’ (Cooper and Press, 1995). Although designers from different disciplines have particular strengths in their specialised field, Bruce and Cooper (1997) classify the skills of a ‘designer’ into two main categories – ‘practical’ and ‘cognitive.’ Traditional types of skills involved in undertaking design projects which distinguish the ‘designer’ from other professionals include visualising, model-making, simulating and testing, and technical drawing and diagrams.

**Supply chain relationships**

Companies are becoming more dependent upon relationships with suppliers, as these provide a vehicle by which to deliver ‘high quality, value for money products’. This involves close communication and data sharing, and exclusivity of designs (Bruce and Moger, 1999). It is also argued that companies should focus on closing the satisfaction gaps faced by customers in order to improve relationships (Harland, 1996). Benefits of building collaboration include a better understanding of needs and thus the ability to have the correct marketing mix (Eversman, 1999). Partnering enables companies to develop and transfer technologies (Hergert and Morris, 1987, cited in Bidault and Cummings, 1994). However, Bidault and Cummings (1994) themselves suggest that managerial hurdles that are often found in partnerships can commonly offset predicted innovation advantages, and that there is a considerable tension between innovation and partnering. Gomez Arias (1995) argues that although strategically guided networks can be highly successful, innovative and leading edge, it is often innovative organisations that enter into partnering and that a direct relationship between partnering and corporate performance is unclear.
Bruce et al (1995) highlight some of the problems associated with partnering, which include cost, a low success rate, an inability to meet expectations of collaborating parties and reduced control over the product development process. Porter (1990, cited in Bruce et al, 1995) argues that ‘most alliances are unstable’, attributed to the degree of trust between partners and a fear of leaking information (Hamel et al, 1989, cited in Bruce et al, 1995). Other problems of partnerships include disagreements regarding scope, pace and timing of decision; imbalances of power; dependency; uncertainty of ownership; mutual suspicion; conflicting loyalties and insufficient identity within the partnership, undermining credibility (Wilson, 1999).

Developing a climate for innovation

The history of new product development provides many examples of successful products (and indeed services) being inextricably linked to key individuals. It is through their active support and contribution to the process of innovation that without them, many new to world products and innovative solutions would remain on the drawing board. Hauschildt and Schewe (2000) discuss the role of key persons in agile and innovative organisations, arguing that: “...it has been shown that a key factor of success in managing innovative projects is the existence and active contribution of key persons. Key persons are able to overcome existing barriers that hinder the fluid process of innovation and success.” A vital part in allowing the key individual to flourish and prosper within the company, is the creation of an organisational context where creativity is unhindered and actively encouraged. Peter Cook (1998) defines creativity in this context where “…organisation creativity can be seen as a process where creativity can be seen as a process where creativity is the input to the processes that lead to innovation, competitiveness and returns on investment.”

Cook identifies the vital ingredients that are central to the process of innovation containing some or all of the following elements:

- Culture, leadership style and values
- Structure and systems
- Skills and resources.

Culture, leadership style and values:

This is predominantly concerning the values and attitudes of the organisation in the way they encourage creative thinking and risk tasking (Anderson et al., 1992; Jones and McFadzean, 1997). Elspeth McFadzean (1998) argues that “…employees can only be encouraged to think creatively if they are not afraid of criticism or punishment. For example, if a project fails and the champion is in fear of losing his job then he will never take the risk of thinking creatively again.” Therefore, it is important that senior management support a climate of innovative thinking and risk tasking, this can largely be enacted through encouraging employees to develop new ideas, providing the opportunity for individuals to pursue their own ‘pet projects’ and financial support. Lowe and Andriopoulos (2000) take this further, suggesting that: “creative professionals are aware of the risks associated with their work and therefore they are acting proactively by taking into consideration any potential pitfalls, so that the danger of massive exposure to risk minimised. Nevertheless, research has shown that incremental risk is very often cherished by creative organisations because it stretches employees’ capabilities which they can develop new knowledge and skills to be used in other projects.”

Structure and systems

Cook identifies that both formal and informal organisational structures play an equal part in enacting a creative strategy to effect innovative practice. Informal structures in this context allow the free and unhindered movement of networking / information processing and networking. As Swan et al (1999) puts its: “…as firms enter the 21st century, the context for many is flatter, less
bureaucratised and more decentralised, even virtual, organisational arrangements with key areas of expertise often being provided externally. This coupled with ever more sophisticated information technologies and pressures for dealing with global customers is placing a much greater emphasis on innovation that allows integration both within and across traditional organisational and inter-organisational boundaries.” Consequently, the creation of this environment where the cross fertilisation of learning across traditional professional disciplines allows individuals to share a common understanding or a common frame of reference. So, from this perspective, informal networking is viewed as a process of interrelating and sense making.

Skills and resources
These key components focus on the attraction and importantly - retention of creative individuals. This can be largely brought about by the opportunity facilitation, financial rewards for success and providing them with the freedom to take risks without the threat of criticism and failure. Echols and Neck (1998) suggest that: “…opportunity facilitation should allow individuals to ‘freely yet supportively challenge anyone in the firm; respect each other as a coach mentor in terms of others’ specialised areas of expertise instead of as bosses or authority figures.”

Innovative organisations in practice
These cases here are drawn from a larger study illustrating how the designer has utilised their skills and thinking to both ‘source’ and ‘extract’ innovation from the supply chain when involved in the development of new products.

Case example one: Company A - bathroom equipment
Company A based in the UK is primarily involved with the manufacturing and marketing of bathroom and sanitary equipment. Its parent company is based in North America. Total sales (which include bathrooms) exceeded $1.8 billion. The company has been significantly affected by market conditions in the recession of the early 1990's, but through massive restructuring of its product ranges it has managed to remain competitive.

The need to innovate
In 1998 Company A identified a suitable opportunity in the complex shower market, to introduce a new and progressive shower range that could be developed and promoted throughout Europe and North America. The shower market was in a period of slow growth and maturity, therefore the new range had to offer unique benefits to the customer in order to gain a firm foothold in this highly competitive arena. A design consultancy were identified and selected to work on the programme. The New Product Development Director at Company A was instrumental in developing the project brief that was then further refined with the design consultancy. Two main factors were crucial in the formulation of the brief; firstly, Company A were entering a highly competitive and mature marketplace, therefore it had to have a clear direction and focus on its long term aims. Secondly, although the company did not have an existing product range to work with, it did have a large inventory that could be ‘consolidated’ into a successful product range. During this critical early stage, suppliers connected to Company A joined the team.

Effective collaboration
This collaboration between Company A and the design consultancy led to a collection of hydro massage products that respond to how the user would want to feel when showering. This would be achieved through the touch of a single button on the control panel connected to the shower unit. The full range includes showers, baths and combination units of the two. The difference between the new range and the standard bath / shower is that it offers a range of different ‘sensations’ called ‘moods’ which further enhance the bathing / showering experience.
The role of innovation
The design consultancy was instrumental in providing two innovative approaches to the project at its initial stages. Firstly, they had a long and exemplary history of working with medical products technology, this was to determine their approach in the way they developed the user interface / controls for the shower units. In particular, they were keen to investigate pure technology and then apply it to the development programme. Following an exhaustive investigation of rival product offerings and developing a greater understanding of the manufacturing capabilities of Company A, the design consultancy was confident from the outset that the company had the right expertise to develop the new product range.

Principal Designer at the consultancy comments that: “…we were pretty sure from the outset that Company A had all the necessary skills, whether they could assemble them in together to make a product; but they had all the basics, they made baths, they made valves, they made shower kit etc…”

The originality of the whole concept manifests itself as innovation in terms of ‘presentation’ and ‘function.’ Very early on in the initial conceptual stages, the design team decided to pursue the feasibility of a pre-programmed user control panel that has pre-set showering options. This was a significant departure from product offerings of rivals to Company A. By investigating comparable products within the marketplace, the designers were able to identify design-led opportunities whereby they could differentiate the new product range, with clear and identifiable attributes and benefits to the consumer. The project team were quite clear and focused on developing a product range that is solid, robust with a strong emphasis on offering the product range not as a shower, but more importantly a ‘shower experience’ through ‘moods’.

Multidisciplinary team involvement
A key factor in the success of the project was the involvement of key stakeholders throughout the duration of the entire programme. The Product Manager for Company A worked closely with the designers providing invaluable input as to the viability of design concepts concerning design for manufacture and supply chain management. Over a period of 2-3 months, the project team developed, tested and at times rejected ideas, selecting the ‘moods’ concept for further development. Primary concern was to how the design development team could assemble the functional features of the showering system to create the specific moods, and then to develop this whole generic concept throughout the entire product range.

The benefits of design leadership
At the initial stages of the design programme the design consultants were very much outside the company, providing design expertise as a preferred supplier, liaising predominantly with NPD Director and the Product Manager. Design development meetings would occur on a weekly basis with Company A, principally working with the Technical Manager to develop the ‘moods’ concept. By working closely with the product manager, the designers developed a greater understanding of how Company A functioned; this included looking at their limitations and constraints of what they could or could not achieve, in particular their manufacturing capability.

Communicating the design message
As the project developed to the ramp up and manufacturing stages, the designers were suitably positioned within the organisation having direct access to all the suppliers knowledge and expertise; this strategic repositioning of the design consultant allowed the product to be further designed and developed that took clearly into account product limitations. By working from within the heart of Company A, the principal designer at the design consultancy could communicate the essence and
design ‘message’ of the ‘moods’ concept to marketing, finance, management and manufacturing – thus maintaining the integrity of the design.

Company A’s principal designer’s involvement throughout all stages of the project was enabling the integrity of the concept to be maintained. This was particularly critical when developing the point of sales advertising imagery and brochures to both European and American audiences. The principal designer at the design consultancy was not only designing and developing a full product range, but also developing a strong brand identity in the marketplace for the shower system. Also, he was the primary conduit for the relationship between the two companies, although he was supplied by a team of other designers, he led the project and the relationships; it was through his personal style and team leadership abilities that the relationship between the two companies developed in a manner that facilitated trust and the resulting brand concept and product line.

Discussion
This case illustrates how the company supported the New Product Development Director in embarking on the new product development programme. The key factors that greatly contributed to the successful outcome of the programme can be attributed to:

- Effective design management

The Product Manager for Company A was well positioned within the organisation to understand and embrace the full strategic potential of new product range carefully aligning it with business strategy. To effectively realise the potential of the idea, the Product Manager carefully managed the differing supply chain partners, accessing expertise and information throughout the entire chain from third and fourth tier suppliers through to the end users. By integrating knowledge inputs and feeding it to the design team, the NPD programme managed to incorporate new technologies to enable it to move smoothly forward whilst reducing the risk of failure.

- The designer

The designer brought to the project his vast experience and expertise that facilitated the application of new processes and ‘learning’ which enabled the company to incrementally innovate. Also, his ‘sensitive’ leadership skills set the agenda for innovation; this was particularly vital when presenting new ideas to Directors and key decision-makers both in Europe and the United States. Without this ability to subtly promote the project at these ‘hard-gates’ the integrity of the final concept would have been significantly lessened or lost. The close working relationship between the Director and designer; both had worked together before and each had developed a high degree of trust concerning their counterparts abilities and professional judgement. But, both were open to the sharing of ideas and suggestions coupled with a willingness to take risks and explore deeper concepts where appropriate.

- Culture

The company believed in allowing and promoting enough creative freedom for the key individuals involved in the programme to investigate new technologies and apply them to the new product range. This not only helped Company A to make the new venture a success but it also enabled them to expand into new business areas. Ahmed (1998) captures this sentiment perfectly, arguing that “...however, becoming innovative demands more than debate and resources; it requires an organisational culture that constantly guides organisational members to strive for innovation and a climate that is conducive to creativity.”
Case example two: Company B – lighting products
Company B is a well known lighting company based in the UK, they were established in 1930. They supply and manufacture products ranging from lighting to curtain poles. In 1999 they had an annual turnover of over £20 million, increasing their market share to 7% of the UK luminaires market. From 1998, the company had grown by 250% through developing new markets and heavily marketing their products. Their largest customers are Argos, Great Universal Stores (GUS), Index, Next Retail and are a highest graded supplier to the DIY chain B&Q.

The designer
The designer’s abilities around being ‘inventive’ started over twenty years ago when he developed a passion for electronics. He was so involved in his new interest that he was often studying for over twelve hours a day and was very soon proficient in television and computer electronics. His first invention was a small electronic device, housed in a little black box that enabled computer games players to improve on their performance scores by boosting the firing rate of the guns and improving the response rate of the games themselves. On returning to higher education in design, the designer set up his own design consultancy, specialising in novelty lighting products. At this time he was working on a concept for a novelty lamp which on completion he exhibited at the New Designers Exhibition in Angel Islington, London. Both Directors of Company B, travelled to London to meet the designer at the Design Business Centre. They were quite impressed with his exhibition piece and agreed to additionally sponsor him to develop it further and assess its market potential.

Product inception
The novelty light went through many different guises prior to its final form. To give an indication of its very inception the designer explains that “…I started off with baby oil at first…I wanted something quite viscous; this would fill the fish tank that I cut apart and reassembled. And also, I wanted to play about with different effects…between oils and water. And basically it was a case of finding oils that were very cheap and easy to get hold of. From then on, after refining, it developed into what you see now. But the initial concept…the initial concept came from very, very simple tests. I mean extremely simple tests.”

He is quick to point out that “…Once I had worked out how to make it work…by doing lots of little prototypes…to bring the whole lot together. So when I was happy that I’d cracked it, then I had to work out all the tolerance system which became a little more technical and also working out certain characteristics of the system. From that, I set up a presentation. I contacted [company B] and I said I am ready now willing to come in and present.”

Product development
Having viewed the novelty light in conceptual form, a legally binding partnership was established between Company B and the designer. In particular, two senior directors of the company developed a close working relationship with the designer – the Technical Director and the Special Projects Manager. Company B took the working prototype and began to work through its construction in order to design it for manufacture in a more cost-effective manner. Very early on, a technical problem arose regarding a valve design; The designer was contacted and after initial discussions he developed a working prototype made out of acrylic to provide a clear indication of how it functioned and means of construction. The revised valve design was then taken to Company B’s manufacturers for further refinement. They had similar valves already in production and by working closely with the Technical Director they advised Company B of the best one to use in the novelty light.
Strategic design
Historically, Company B has never fully utilised the services of a design consultancy or an individual designer. They have at present twelve suppliers throughout the UK and China supplying a broad range of lighting products that they then sell in the commercial marketplace. Although the Technical Director is quick to point out that “…nobody is employed by the company as a designer – we employ over 100 designers. Everybody in the business has got an idea; that’s pretty much how we run the business, it’s a very fluid system that we have. Although no formal design procedure exists as yet.” The majority of ‘new’ designs that they create are combinations or modifications to the products offered by their suppliers.

The role of innovation
Company B does have a ‘loose’ process for capturing and developing design within the organisation, but they do admit that it is one of their current weaknesses. Most new product development is channeled through the Technical Director, who has a keen eye for market conditions predicting what will and will not sell. Until quite recently, the Technical Director was the solely responsible for product development. But with the current expansion of the company and the introduction of many new product lines, they are now in the process of growing the new product development function into an integral resource for the company. He adds that “…now we have got a team of 12 here and five in charge. Plus, this is the resource that we have got in our suppliers. Its grown massively as a feature of the business and its looking very…it’s a very important supplier of service.”

The value of design
This case study has illustrated the role that design can offer, enabling Company B to break into new markets; seek a new focus through the establishment of a close working partnership with a professional designer. Prior to the novelty light project, they had no real experience of engaging professional designers in order to develop new products. Consequently, they had no established in-house design function or more importantly, an effective formalised structure to harness and utilise design. Through the development of this project, it has provided the company with an increased confidence to formalise their design management procedure and closely align new product introductions with their future business strategy and vision. The company is confident for their future focus, developing unique design products tailored to more specialist markets by embracing new product development and design as a strategic resource.

Discussion
Case study two illustrates how the designer gave the company confidence to use and value design as a key business tool. Prior to the project, Company B did not fully understand nor utilise design effectively. Since the introduction of the new product range, they have now developed a new focus with design at its core. However, through this partnership with the designer, the company now possesses a willingness to accept and adopt ‘external’ ideas. Other key factors, which greatly contributed to the successful outcome of the NPD programme, include:

- Supply chain integration

The company was successful in the way they developed a dynamic culture of interaction with their suppliers. By constantly ‘tapping into’ the expertise of knowledge within the supply chain, both designer and manager could extend, deepen and apply these skills in pursuit of innovative thinking and practice.
• Design management

The freedom to innovate; the close partnership between the Special Projects Manager and the designer created a mutually learning relationship whereby both could view problems from alternative perspectives and together they could constantly challenge conventional wisdom in order to innovate.

Summary
There are 2 domains within design in organisations – the designer and the client/organisation itself. When these are both brought together it is important to manage the ways in which the ‘client’ and the designer build their relationship in order to access and share knowledge, and also to innovate and make decisions. Also, the number of suppliers is a variable that will change from client to client, and this will affect the ways in which knowledge is transferred, and also the degrees of power held by the designer and the supply chain. The designer will have a more direct influence over a client with no supply chain.

It is important that there is a key individual/design champion to facilitate the designer client relationship, in order to maximise innovation. The role that this person would play would vary to some degree depending upon the model used. However some common characteristics would apply, namely: authority, access to people within the organisation, a gatekeeper, open to change and new ideas, empathetic, a designer or with designer characteristics, empowering, a good networker, persuasive, a good communicator, particularly of brand values of the organisation, and the ability to facilitate and manage relationships with users and suppliers. Within the intermediate model the key individual may be the managing director, and issues regarding finance will be of greater importance, due to limited resources. This requires openness and sharing of information with the designer, in order to get feasible design solutions. Tighter project management is also key in order to ensure that the project runs to schedule and hidden costs do not arise. If the design function is out-sourced it is important that the key individual has the skills to build relationships with the network of suppliers sourced by the designer, in order to be able to take over these once the designer has exited the company. In the ‘direct’ model trust is a key issue, communication must be open and transparent and the key individual and the designer must work together to understand suppliers and users, and to learn from them. However, clearly defined roles and boundaries of the project are important, and the organisation needs to understand the value of the designer and what they can expect.
References:


Contract research in design

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Abstract

The present paper reconsiders some of the activities that properly constitute design research, by focusing on case studies of contract research carried out by the Design Contract Research Unit at Nottingham Trent University. A review of recent UK papers seeking to define the nature of design research suggests that a consensus is still some way off. Contract research, which is a professional research service undertaken for commissioning clients, poses further questions again, since a commercial service may amount to little more than jobbing work. The aims of this paper are to identify the characteristics of contract research in design through particular examples and to consider how far such particulars assist the search for general consensus.
Contract research in design

In the UK, there is political pressure on academic communities to reach consensus about the nature and value of research in their chosen disciplines, most obviously evidenced in the introduction of Research Assessment Exercises. Politicians and civil servants seem increasingly drawn to the idea of fixing an apparently tangible value on the quality of public activity by creating new funding equations. An academic Oscar ceremony like the RAE is a useful means of demonstrating their diligence and the accountability of their fund management. However, success in such an exercise is not the beginning or end of funding support for design research. To the contrary, the most impressive research campuses I have seen recently are those belonging to the giant corporations Microsoft and Nestlé (Alcon Laboratories in Dallas). Armies of researchers also inhabit those campuses and it would be a serious misunderstanding in those of us less well accommodated on university campuses to believe that somehow, our industrial colleagues are working one level below us, tied as they are to the directions of greedy masters. Such masters may provide academics with patronage additional to that given by politicians and bureaucrats, whose motives are not obviously purer, appearing driven as much by self-maintenance as the public interest.

To get a picture of the value of the outcomes of corporate research, try to imagine operating a computer or taking care of your health without using the software and medical devices developed by researchers in such companies. Colleagues to whom I have made such a case have told me that such outcomes evidence “applied” research, which seems by implication to be a rung down the ladder from “pure” research. The distinction I think they are making is between research with a pre-determined goal, and research without the same, which is often called “fundamental” research in the sciences. An example of the former would be to find a way of preventing a carbon filament that becomes incandescent when an electrical current passes through it, from burning up after a few seconds. This was a major research project that led to the invention of the first durable electric light bulb by Edison.

An example of fundamental research would be to investigate what happens when electrical currents are passed through strands of different materials. In hindsight, this may seem a necessary precursor for inventing a light bulb, but in foresight, it does not appear to be a research programme guaranteed to add even to theoretical understanding of electromagnetic behaviour. It is invidious to value one approach more highly than another. Both exist in design research, yet goal led research is evidently the more dominant form because research programmes can be very expensive and so market forces in both public and private sectors favour the goal led form in design. Indeed, it is hard to imagine that design researchers could learn much of value from practice based activity unless there were commercial manufacturers and developers available to collaborate in essential realisation processes, such as tooling, fabrication and distribution. It is largely due to this consideration that my own unit has been led into accepting goals set by clients, rather than ourselves, and why the term "contract" prefixes our research activity.

Concerning the notion of practice in relation to research, Nigel Cross (1999) is persuasive in insisting that practice itself does not constitute a significant research activity, because in a community, others may feel that if they cannot gain access through public reports to the methods behind the outcome, they cannot easily assess their value or further applicability. In the case of craft production, many craftspeople would probably go to considerable lengths not to disclose their methods to others. The success of such an approach both in defending innovation as well as adding value or mystique to the products is well evidenced by the successful transition of famous Renaissance figures, such as Leonardo, from the status of craftsman to artist. Parallels are still to be found in contemporary design, where the status of designers such as Armani and Starck, indicates
that even in an industrial culture, mystique still plays an important role in the value systems of consumers and profit margins of manufacturers.

More commonly in industrial cultures, we have mechanisms for protecting personal innovation by actually disclosing outcomes in formal public ways. Patent and copyright are the most obvious examples and both are recognised as satisfactory research outcomes by UK research assessment exercises. Patents must by definition be: 1) new ideas, not previously disclosed in public, 2) involve an inventive step, such that 'when compared with what is already known, it would not be obvious to someone with a good knowledge and experience of the subject', 3) 'be capable of industrial application' (UK Patent Office 2001). In this respect, 'industry is meant in its broadest sense as anything distinct from purely intellectual or aesthetic activity'. Under such definition, natural discoveries, scientific theories, mathematical methods and aesthetic creations are excluded from patent protection. On the other hand, the specific form of an aesthetic creation, such as the exact words of a text, or the patterns and shapes of a designed object can be protected under copyright or design patent.

Patent definitions are then most instructive in telling us about the forms of knowledge which are pertinent to the definition of design research. Design practice primarily concerns the creation of apparatus, devices, processes or methods of operation that are capable of industrial application. Whilst it is by no means necessary that the outcomes of design practice are in any way inventive, many of them may be claimed to take a specific form that is novel and can be disclosed and protected. As the broad parameters of the UK RAE category "Art and Design", witness, design practice encompasses activities that add to public knowledge in two different forms. The ordinary patent, involves creating products, methods or processes, which can be described in such a way as to enable others to reproduce and apply the inventive steps. The design patent involves creating a specific arrangement of symbols, shapes, lines or patterns, which so differs to precursors, that just describing it in patent form prevents others from trying to reproduce the arrangement without permission. Of the two kinds of disclosure, the ordinary patent makes it far easier for others to gain insight into the particular research and creative processes giving rise to the outcome. Designers, like other professionals, may then wish to comment publicly through formal means such as publication, on the kinds of approaches and insights underlying particular design outcomes. This constitutes a third form of contribution to public knowledge, which is not patentable, but is recognised as a vital part of the research culture of any discipline.

As to the relationship between research and knowledge, the dictionary definitions of research include 'collecting information about a subject', in a way that is 'careful or diligent'. This diligent way may also involve a more complex 'investigation and experimentation aimed at the discovery and interpretation of new facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws' (Britannica Webster's 2002).

An attribute of research in general that is embedded in the official guidelines of organisations like the UK RAE is that it ‘contributes to knowledge’. In this sort of description, knowledge seems to be principally the public kind, and accordingly, a contribution may be seen as something that is new, or different enough, to add to a public ‘bank’ of knowledge. For patents there is a highly developed and complex method that allows professional examiners to determine the extent to which knowledge claims may be deemed new additions. Unfortunately, for forms of knowledge 'excluded' from patenting, such as intellectual discoveries and theories, it is far less clear cut how they come to be accepted as additions. The primary mechanism is that of peer review by academics, publishers and media editors.
As a relatively young and emergent discipline, design introduces problematic issues of its own. There seems to be consensus that design is very much an interdisciplinary activity, attracting inward a variety of research paradigms from longer established academic disciplines (Margolin 1999; Cross 1999). There also seems to be some agreement even between those with differing views of design research, that it is right and proper for all those different specialists gathered under the design umbrella to develop new research paradigms (Owen 1994; Manzini 1994).

Among the new paradigms entering design, is post-structuralism, or ‘the new criticism’ (e.g. Seago & Dunne 1999) which challenges traditional knowledge hierarchies. Although most evidenced in what used to be called literary criticism, the new approach is derived from the work of cross disciplinary mentors like the psychoanalyst Jacques Lacan and the philosopher Jacques Derrida. Derrida (1982) argues that no form of knowledge is “centred”, there is no unique “logos” or knowledge structure that is truer than any other. In fact, Derrida’s main point here has already been expressed by other philosophers, as different as Karl Popper and Richard Rorty. Popper (1972: 71-81) has argued that knowledge comprises a network of theories, in which even the firmest beliefs appear to be provisional, subject to the discovery of a better theory. Rorty (1980: 313-22) attacks the “foundational” view of knowledge, where philosophers have traditionally assumed a privileged view of knowledge in general, which portrays different forms of knowledge building up from a hard base layer of the cognitive kind to progressively softer layers of the hermeneutic kind. Popper seems to be one of these traditional philosophers, arguing (1972: 73-4) that objective knowledge, such as “it is true that 2 add 2 makes 4”, holds a special place because the veracity of such propositions does not appear to be open to subjective inclination. Objectivity is clearly an important feature of the way knowledge is viewed in the hard sciences and may help to explain why even great creations such as relativity theory are more usually described as "discoveries". As recognised in the earlier discussion of patenting, design activity may involve some form of new discovery which can be tested in a way that provides reproducible results. However, design also encompasses forms of creative output which can be recognised, described and evaluated, but only in the form of a critical activity that appeals to a sharing of personal experiences and aesthetic codes.

It is unlikely that many in design would want to claim that critical arguments impose the same sense of necessity on the understanding as do objective findings about, say, the physical performance of designed objects. Accordingly, design by its very nature seems divided between views of knowledge that differ according to the kind of activity undertaken and questions posed. Designers are frequently called upon to tackle different problems, which involve different forms of knowledge and thus, methodology. For instance, the writing of this paper involves critical discourse, which appeals to subjective experience, leaving the arguments open to a spectrum of personal interpretations. Whereas, some of the product design work we are about to show is not open to the same level of subjective interpretation, it either performs to an International Standard, makes valid patent claims, or it does not - and these issues can be resolved by reproducible testing and examination. Such work is not even typical of much product design, which concerns re-styling familiar objects, an activity that could be the subject of a design patent, but not an ordinary one. Differing research methodologies are bound to underlie such different tasks, and anyone working on three such projects is bound to adjust their goals, knowledge claims and research methods, without ceasing to be engaged in some form of worthwhile design research.

Whilst the new criticism has sought to introduce a plurality of discourses by dismantling traditional knowledge hierarchies, it has also introduced some unfortunate syntheses of methodologies. Consider the “Theory of the Gaze”, originated by Laura Mulvey’s article "Visual Pleasure and Narrative Cinema" (1975). This has been an influential critical stance on film narrative, based on an entirely uncritical acceptance of Freud’s theory of scopophilia, which although probably new to most in visual studies at the time, was already regarded as outmoded and unreliable by many in
psychology (Eysenck & Wilson 1973, pp1-13). Caution is required when introducing ideas and methods from contingent disciplines. It is better advised to select from them the methodologies that seem most appropriate to particular tasks. Through informed adaptation to specific requirements in design, existing methodologies may even be revised or expanded to become generally useful in design research. For instance, asking if a design is patentable is a useful way of assessing the sense in which workers from all disciplines may see it to be innovative, but not of regarding it critically.

Returning to the value of patents as indicators of worthwhile research activity, if numbers demonstrate anything, our colleagues in the corporate sector are making a far more prolific contribution in the field of product innovation than ourselves. However, to recognise this is not to exclude academic researchers from the field. In addition to the ‘live’ student/company projects, to which many departments such as the one at Brunel are already committed, there are many small to medium enterprises (SMEs) interested in what we have to offer, who cannot afford to maintain their own research and development units. To such organisations, we can offer what in today’s parlance is called a ‘transfer of knowledge’. Teaching Company Schemes are one well known method in the UK, less well known are a number of university design research units, such as those at UCE, Brunel and my own university, Nottingham Trent, who offer their services to companies of all sizes.

In university nomenclature, such activities are classed as ‘external consultancy’, but this is a label my own unit has struggled to resist, as witnessed by the words “contract research” in our title. The resistance is explained by three important factors. The first is that we are supported by European Regional Development Funding, with a remit to provide a subsidised knowledge transfer service to SMEs. The second is the corollary condition that we should not therefore be competing for work with local design agencies. The third is that we have followed a vocation in choosing academic, rather than commercial life. Our commercial counterparts like to tease us that we teach because we can’t do, and they may be right. In our defence, we would argue that we each do different things, which the other cannot, or will not. The most important of these is we academics have the benefit of being part of a much larger expert community whose presence greatly increases the range of methods, techniques and resources we can bring to bear in planning a goal led research programme. Few agencies either could or would want to compete with these resources and so that makes it easier for us to identify the kind of projects in which we want to get involved. Our rule of thumb is that we say “sorry” to any company asking us to “Design one of those”, but welcome collaboration with anyone asking us “Do you think it would be possible to design something that…?”, or “Are we going the right way about designing this?” A good demonstration of this principle is provided by our case study, a collaboration with a small, but successful plastics company in our catchment area.

Europalite Ltd. mould plastic products like road cones and grit bins by rotational methods. Essentially a rotationally moulded form is a single plastic surface bounding a closed volume - a hollow sphere is a typical primitive. On the other hand, an open form like a bowl is not typical, but could be made by sawing a rotationally moulded sphere in half. The process also allows more complex primitives, such as a form pierced through by a hole - “genus 1” in mathematical language - as well as genus 2, 3, and so on, provided the walls of the holes are all orientated on the same axis and do not “return” into the body of the basic form. Whilst the method is less flexible than other moulding processes in allowing a variety of geometries, plastic affords more opportunities for constructing complex forms than kindred processes such as clay slip casting. The vast majority of moulds are split into two parts, which are filled with finely ground plastic, sealed and then rotated bi-axially in a large oven that causes the polymer to melt and attach to the wall surfaces inside the mould, which may later be split open to release the finished product. The two great advantages of rotational moulding are that it can produce large products, and the mould tools are cheap to fabricate or cast, typically costing between 10-25% the price of much smaller injection tools. It is
then, a relatively simple process, often associated with large utilitarian products of relatively low production quality, and large tolerances of accuracy.

The managing director contacted us because he thought the process was capable of far more than his industry has demonstrated thus far. You may imagine our wonder when early in our association, he suggested to that we investigate the possibility of designing an adjustable builder’s trestle to compete with the tubular steel variety that are fabricated to meet stringent British Standards in safely supporting a working load of 650kg. His cheerful justification of why he should want to attempt such a thing was: “Because I make things in plastic”. Whilst this had scared away more sane design agencies, it proved irresistible bait to people who enjoy getting their students to build improbably strong bridges out of drinking straws. It was a project through which we felt we could learn, which made it seem an ideal form of knowledge transfer (Figure 1).

![Figure 1: Adjustable builder's trestle to BS 1139 650kg SWL](image)

As in our student bridge projects, we were astonished by what we found and greatly edified by what it taught us, not just about rotational moulding, but much else besides. Neither of us working on the project were trained engineers and so we felt a duty of care to buy in some more books on engineering design and against all advice, a basic Finite Element Analysis (FEA) package, Design Space. After driving us nearly mad, Design Space grudgingly started to give answers to some of our questions (Figure 2). It was not until we finished the project that we discovered we were actually asking the program to do more than it was designed to, by analysing hollow forms, rather than solids. Part of the benefit of this, was that it taught us how to fool Design Space into making calculations it was not supposed to.
Figure 2: Finite element analysis of trestle beam under 650kg point load

Mindful of the warnings we had received, we cross checked the solutions by taking small segments of a given part and calculating the answers manually. By such means, our confidence grew to the point where within a few weeks, we could not understand why such programs were not a standard component of the product design studio and indeed, our student computer resources. In the event, the loading simulations were within 12% of the real values found in the final design. Despite our reservations about the eventual commercial viability of the design, we sought throughout our programme to play to the strengths of a moulded trestle, by limiting the components to four forms that could be inexpensively moulded with few fabrication steps thereafter, and assembled from a flat pack by the user. The standards testing we were able to contract in house from our engineering laboratories and the dissemination of what we had learnt was in part publicised through the filing of a patent.

Another vital part of our mutual learning was an investigation into whether it was possible to increase the strength of the polyethylene polymer we were using, perhaps by glass fibre reinforcement. This investigation demonstrates the value of patent literature to design researchers, since we found two patents from the 1980s which showed the polymer suppliers to be wrong in their assertion that rotationally moulded plastics could not be successfully glass reinforced. Nevertheless, when we tried to replicate the methods disclosed in the patents, we were disappointed with the results, which showed the fibre tended to migrate into the inside of the product walls and was poorly packed, which made the strength of the compound less than the values that were to be expected by comparison to other moulding methods. Proceeding in a way more reminiscent of Edison’s empirical approach to the light bulb than of contemporary polymer engineers, we picked the brains of a major glass strand manufacturer, acquiring free information that seems to flow easily when the word “university” is introduced. We got free samples of a variety of glass strand types,
which we compounded in a variety of different test batches. We were perhaps unjustly fortunate in achieving the desired result within a few hours of moulding.

The next task was to further improve the strength of the glass to polymer bond by finding a more appropriate chemical coupling agent than those described in the patents. Despite superb support and advice from Akzo Nobel and Hoechst, we had far greater difficulty in these tests. The eventual solution was again derived from a leap of designer’s intuition, rather than good research method. We felt an instinctive discomfort in suggesting that the workforce introduced a rather unpleasant chemical into the moulding compound in liquid form. This led to a search for a powder based form, which we could not find, but we did come across an analogue product used in rheology, rather than coupling, that was based in a fine chalk powder of similar grain size to the polymer. Having empirically found the correct concentration to use after blackening the mould tools with incorrect quantities, the strengthening effect was so tangible we scarcely needed laboratory testing to tell us which measure and mixing method gave us the best coupling. Again, the results of this work are to be disclosed in a patent file.

The final example concerns a rather more disciplined project, more within our range of expertise, which arose from the company’s success in persuading us that there was untapped potential in rotational moulding. The problems to be overcome had more to do with the standards of toolmaking, than of product design. The tolerances of steel fabricated mould tools are at least 2mm and wall thickness can vary up to 20%. In theory, an aluminium tool cast from a wooden model, or pattern, can be made accurate to fractions of a millimetre, but then the patterns are hand built from the design drawings and therefore prone to larger error. In the trestle, we had to connect opposing walls in the hollow form to create a true structure, rather than a void enclosed by unconnected walls. This we did by dimpling key areas of the walls to create “kiss points” inside the form as the product moulded. The unconventional dimple forms we created did not endear us to the toolmakers, whose notions of tolerance did not endear them to us. If we could find a more accurate way of generating the patterns, we felt we could overcome the limitations of the process to liberate its potentials.

These are that the ovens can be as large as 4 metres in diameter, which means smaller products can be tooled as “parasites” that are just fixed into any space not filled by a larger product being moulded. Given tooling costs of as little as £3-5000 for a product the size of a torch, the parasites can act as prototype generators, which if successful, can be duplicated and arrays of these small products can be moulded 20 or 30 at a time, for half the cost of an injection moulding tool manufacturing them at a comparable rate. So here, rather than trying to apply rotational moulding to products never made before in plastic, we were seeking to advance rotational moulding into a more competitive form of making plastic products. A good vehicle for this idea turned out to be a hard hat, a product always injection moulded. Since the hard hat is essentially a shell supported by an adjustable webbing cradle, we set out to see if it were possible to turn the underside of a rotationally moulded hat into a webbing and find an alternative method of adjusting the headband to fit all sizes of head (Figure 3).
The design solutions seemed relatively simple. You need only to look at the adjustable back of a baseball cap to see how size adjustment could be made. Whilst the webbing could be created by making a template that could be put inside the inner skin of the helmet to provide guides for a small dentist-type drill that could cut out the unwanted material. The real problem was how to ensure the accuracy of tooling that was essential from a structural point of view and indeed an aesthetic one, because this was an apparel item. Contrary to what might be thought, construction workers seem to have a greater consciousness of their appearance than may popularly be believed. Evidence comes in the form of the Stetson hard hat, which is apparently a major seller in the US heartlands. The fact that our hat has ribs that form a Union Jack is completely fortuitous, a result of our mainly structural approach to the task. We would argue that it is no more an option to remove these than it would be to remove the ribs from the dome of Florence cathedral! However, that has not inhibited us from suggesting this hat be marketed as the “Jack Hat”, and we can imagine Prince Charles modelling it on industrial visits. On the other hand, if the best structural solution had been ribs that formed a swastika, then our awareness of the appropriate methodologies for the design of apparel would have led us to seek a different solution.

As to making an acceptably accurate model, we turned to colleagues in Nottingham University to help us with rapid prototyping, either by laminating or CNC cutting. Both methods involve generating an extremely accurate solid model direct from our original CAD files (Figure 4). For this relatively small product it was economically acceptable to use LOM, laminated object manufacture, which produces the “wood” model by scanning the CAD model in paper thin horizontal slices and then laser cutting the slice from a sheet of paper, running a glue impregnated roller over the slice and then repeating to generate the complete model. The casting from this model is taking place at the time of writing, so the results are not yet fully known. However, we are confident that our approach is the way forward to realising the larger objective of introducing accurate toolmaking into this industry in order to facilitate a new generation of products that conform both to consumer expectation and to necessary regulatory standards for public health and safety.
As to the lessons that can be learnt from the practice of contract research in design, the following seem instructive: The responsibility of working for an external client on real commercial projects need not be daunting, it can be enjoyable, indeed entertaining. We have found that the effect of working with academics seems to liberate the playfulness in our clients, which is a vital ingredient for both creativity and formulating interesting research questions. It may be surmised that clients have a perhaps unwarranted trust in our abilities, just because of our job titles, when all the time we are telling them that we too are trying to learn. Learning is another key ingredient for successful research and interdisciplinary collaboration. I believe part of the reason we have had considerable fortune in resolving challenging projects, is because we are shameless about wanting to learn about anything that might lead us closer to the goal that always looms over a contract research project. The goal is something that has to be achieved by practice, but such practice is unrealisable without a programmatic approach in which the designers endeavour to identify as best they can, the methods and techniques that best suit the various demands of the project.

We have tried to be candid about what our more expert colleagues would see as the shortcomings of some our research approaches. We are not ashamed by these, we defend them on the grounds that ends justify means in the market driven world of design practice. With due qualification, these reflections may be used to recommend that elements of a shared understanding of design research be allowed to emerge retrospectively from practice, not just prospectively from theoretical debate.
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The study of design and the ethically reflexive student

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Abstract

The core units in the Visual Culture course at the School of Visual Arts, Edith Cowan University, draw heavily upon key concepts in post-colonial theory. Particularly the premises of the social and political inequality of much cultural exchange, and the ultimate impossibility of cross-cultural understanding. These are considered essential for practice in a multi-culture such as Australia’s.

Despite this contextualisation, during a final year professional practice tutorial, a group of students dealing with Aboriginal copyright law argued that cultural appropriation was simply a matter of formal stylistic borrowing. They proposed that designing was an unproblematic union of expression and technical means, seemingly jettisoning notions of the social and contingent nature of meaning in visual culture. When confronted with the reality of Bhabha’s “unmanned, antagonistic, and unpredictable sites of cultural contestation” it appeared some of our students retreated into the disconnected world of specialist activity.

This paper proposes that whilst students could theoretically identify cultural transgression and its consequences, when faced with it intruding into their own lives they had no ethical framework by which to negotiate with it. It was evident that a sizeable minority of the student body saw the space offered to the individual by the subjectivities of post-structuralism as one in which all readings are of equal value. The concern is to develop an ethical design education, but how far does one educate the design student to become ethically self-reflexive (to use Giddens’ term) before substantial parts of the design profession’s practice become seen as ethically unsustainable?
The study of design and the ethically reflexive student

Studies in Visual Culture is a core course at the School of Visual Arts, Edith Cowan University, Perth, Australia. The school teaches across a range of visual disciplines which includes two dimensional and digital design. All the school’s students attend the Visual Culture lecture and tutorial programme which draws heavily upon key concepts in Critical and Post-Colonial theory. There are a number of conceptual premises that are deemed essential for student practitioners in the school working in a multi-culture such as Australia’s, and central to the conception and implementation of study in the course is the examination of the processes of cultural interpretation and exchange. The basic premises of this examination are, firstly, the often unequal nature of such exchanges, and secondly, the ultimate impossibility of cross-cultural understanding - what Homi Bhabha calls the ‘incommensurability’ between cultures. The shift in curriculum emphasis away from a traditional Eurocentric art and design history towards active cultural interpretation has led to the need for the student body to become ethically reflexive (1) in order that they can personally assimilate and act upon the consequences of the cultural information presented to them. In this way it is hoped students can more readily translate theoretical concepts into practice, and become people who ask questions rather than just answer them, and therefore become better practitioners. We have discovered that simply exposing students to basic access and equity paradigms through an uncritical multiculturalism is insufficient. I wish to suggest that the different lived experience of students must be located in their social, cultural and political context, and that post colonial theory can be part of the educational mechanism by which they are introduced to the need for ethical engagement with visual culture. This paper unravels this process and will pose a problem that has emerged in educating our students in this way – how far does one educate the design student to become ethically reflexive before a large part of the design profession’s practice is called into question and is framed as unsustainable?

The issue of ethical practice at the school became highlighted when, during a professional practice tutorial, a group of final year students dealing with the issue of Aboriginal copyright law (2) argued that cultural appropriation was simply a matter of formal stylistic borrowing. They proposed that image making was an unproblematic union of individual expression and technical means, seemingly jettisoning of all notions of the social and contingent nature of meaning in visual culture. After three years of study in which the unequal nature of cultural exchange had been theorised and in which the political contextualisation of cultural practice had been stressed, it was disturbing to hear this reading of an issue so central to Australian contemporary culture. Why was it that students who had been exposed to a course of study framed by post-colonial discourse were unable to translate those theoretical concepts and locate them in cultural practice? What was preventing praxis? These were not academically poor students, or students who were opposed to the objectives of the course. They were neither malicious nor unsympathetic towards Indigenous culture. They were simply students who, when confronted with the reality of Bhabha’s (1991: 16) unmanned, antagonistic, and unpredictable sites of cultural contestation, retreated into the safe, isolated, and disconnected world of specialist activity.

It appeared that our students were operating within the ideology of the individual as an autonomous subject, and not in terms of the individual’s relationship to the social. It was evident that a sizeable minority of the student body saw the space offered to the individual by the subjectivities of post-structuralism as one in which all readings were of equal value. Despite the constant pedagogical emphasis upon adopting a culturally negotiated position within the school, it is inevitable that it is always the individual reading emerges as paramount. This is because of the all consuming nature of the broader commodity culture the student exists in, and its emphasis on the immediate satisfaction of individual wants. It was clear that whilst our students could identify cultural transgression theoretically, when faced with it intruding into their own lives they had no ethical framework by
which to negotiate with it, and retreated back into the wider, non-confrontational cultural framework that surrounded them. It was evident that ideas of social justice, which were implicit in the theory program, needed to be made explicit.

I am, and continue to be, discomfited by the thought that a student can graduate from a course about the study of culture and not be critically and ethically reflexive. To be critically and ethically reflexive is to be able to enter into the dialogue characterised by Habermas (1980: 13) as that between the lifeworld and specialist spheres of practice. In order to arrive at this (utopian?) state it is becoming increasingly clear to me that an understanding of ethical practice is vital. In a multicultural society such as Australia’s the process of establishing a personal cultural taxonomy

“becomes more than the struggle over identifications, or a representational politics that unsettles and disrupts common sense; it is also a performative act grounded in the spaces and practices that connect people’s everyday lives and concerns with the reality of material relations of values and power” (Giroux, 2000: 106).

One of the problems of teaching an uncritical multiculturalism is that it is too easy for the study of visual culture to be removed from the bigger issues of the individual’s relationship with the power of the institution. As Giroux (2000: 69) observes, an investigation of cultural difference that doesn’t rigorously contextualise social politics becomes a hermetic process that degenerates into a celebration of formalist inter-textuality and a bland celebration of cultural indeterminacy. It is the difference between a radical affirmation of individual study to empower, and the possibility of the individual to engage in ‘culture spotting’. In retrospect it is disappointing, but hardly surprising, that students were unable to make the leap into ethical praxis on their own. For despite attempts to present them with an examination of cultural interaction that was analytical rather than just celebratory, the subjectivities of post-structuralism are so deeply embedded in the mass culture that surrounds them, and that mass culture is so constructed, that their allegiance to it is hard to break.

The failure of some of our students to identify cultural appropriation as a central issue in contemporary Australian visual culture was discouraging, if only because it demonstrated yet again the fragile rigour of educational programmes when set against the robust vigour of the mass media. Since its inception the visual culture course (3) has been framed to stress the importance of cultural difference and the issues of cultural negotiation and exchange. It is not a course that centres around the evolution of a European aesthetic, important though that aesthetic is. The course frames visual culture as a network of different cultural histories in constant dialogue, and the student is encouraged to think of their individual position as a practitioner within this network of culturally contingent meanings. The course attempts a socially progressive study of culture reflecting Australia’s, often difficult, struggle to come to terms with its contradictory cultural positioning. The course’s aspirations, however, have to be located within the context of an increasingly globalised academic and mass culture, where the products of the British and American cultural industries are seen by Australian teenagers as largely superior to anything produced in Australia (what was known to older generations as the cultural cringe). This attitude reinforces a sense of cultural dependency. From this dependency emerges a form of identification by the majority of the Caucasian population, not just with the language, ideas, and artefacts of those cultures, but also a sense of racial identification (in this particular case with an idealised view of the Anglo-Saxon aspects of Britain and America, and not with these countries’ many cultured reality). Visual culture in Australia, unless consciously framed otherwise within the education system, can be very easily framed as an exclusively Caucasian activity. For a student body that is not exclusively European in origin this is a profoundly problematic issue. For the student of European origin it provides a safe cultural space that, whilst not home, is nevertheless a place that can provide some sort of dysfunctional comfort.
This displaced sense of cultural geography plays an important part in the mapping of the dialogue between Australian and globalised culture. Contemporary Australia has a pre-colonial Indigenous culture with which it has still to become reconciled. Its physical location between the Indian and Pacific Oceans exposes it to a range of cultures and cultural experiences that are not mirrored in its consumption of mass culture, which as we have already observed casts Australia metaphorically adrift in the middle of the Atlantic Ocean. This disconnection between the lived experience in Australian cities’ multicultural suburbs and the land of television cannot be over-emphasised, and it is at this point that I wish to briefly unravel the ways in which this cultural schism is framed at the School of Art.

If one is to take Habermas’ model of cultural dialogue seriously, then the framework within which the Australian design student operates must be carefully considered. As the smaller nation states are subsumed under the power of national and supra-national trading blocks, the citizens of such states find themselves living, materially, in one set of conditions and, metaphorically and symbolically, under another. Those students at the centre of my discussion, living materially with the contradictions of the legacy of a brutal and racist colonial history, are also living in the de-historicised and de-politicised present of global consumerism. What are the means by which these issues of displacement, so deeply embedded at many levels in Australian culture, can be raised and articulated?

The geo-political reality of the Australian student working in visual culture militates against the adoption of a Marxist critique in order to understand their history of colonialism, as its origins lie within the European tradition of Humanism and the Enlightenment. When Marx (1973: 105) wrote that capitalist society ‘is the most developed and the most complex historic organisation of production ... [and] ... thereby allows insights into the structure and relations of production of all the vanished social formations out of whose ruins and elements it built itself up’, it was a double edged observation. On one hand it acted as the starting point for a trenchant critique of bourgeois capitalism and its project of colonialism. On the other it validated the idea that European Modernity was the single vantage point from which the rest of culture could be examined, that is, the vantage point of a ‘developed’ industrial Europe. Whilst Australia is one of the world’s most urbanised nations, it has never been especially industrialised. Because of its history of authoritarian government, and a racist immigration policy that reinforced an isolated and closed society, it came late to the transformative ideas of Modernity. One can agree with Jean-Paul Sartre’s (1967: 22) observation that ‘the European has only been able to become a man through creating slaves and monsters’, and happily (or perhaps ‘unhappily’ would be a more appropriate adverb) substitute Australian for European, but it is also the case that the projection of oppression onto all aspects of the European Enlightenment is in itself flawed. (The terror that followed the French revolution was not the result of ideas of liberty, equality and fraternity but their abrogation.) However, it is indisputably the case that notions of cultural egalitarianism made tangible in European nations were at the expense of their colonised territories. Multicultural Australia stands halfway between two worlds, its citizens having been both oppressed and oppressor. Franz Fanon (1967: 231) said, ‘Europe is literally the creation of the Third World’, and in the same way Australia is the creation of Aboriginal culture. Marx’s class analysis of the processes of development is a useful one, but it largely ignores the issues of race and culture, and racial and cultural conflicts are at the historical heart of modern Australia and impact continuously upon its present. For the Australian design student who wishes to negotiate the reality of politically charged decorative form, an understanding of race, culture, privilege and power is best informed from an awareness of post-colonial theories of unequal exchange and incommensurability.

For staff at the School of Art, part of the study of visual culture has to be what Stuart Hall (1990: 15) calls the ‘unmasking ... of the unstated presuppositions of the humanist tradition’. The racial
and cultural constituents of Australia are still largely European, but it is not geographically
European and remains othered by the European centre. It is part of the minority world but at once a
subject of the minority world’s cultural policies. It is both resentful of its Anglo-American
colonising cultures, but an enthusiastic consumer of them. It is like many colonial and post-colonial
cultures that are caught in the bind of being ‘simultaneously progressive and co-opted’ (West, 1990:
94); of critiquing the centre, but being consumed by it. Post-colonial theory provides a lens through
which the complexities of Australia’s power relationships can be read, and can play a valuable role
in exposing the contradictions of cultural exchange. And yet, as my opening anecdote
demonstrates, the demonstration of cultural inequality through abstract study alone remains
unassimilated by the individual unless it can be positioned into the student’s lived experience. To
know something and to have understood it as valuable, is to act upon it. Ideas can inform practice
and stimulate a desire to understand what practice would look like informed by such ideas. The
whole purpose of study is that theory and practice become mutually informative.

I propose that the demand for ethically aware practice could be articulated around John Rawls’s
(1971) ideas of social justice. In particular the sense of ‘rightness’. If, as Rawls argues, a sense of
the good is achieved through the individual’s satisfaction of rational desire, then what is right is that
which ensures the same possibility for other individuals to also achieve what is good for them.
Under this model the individual is constantly required to negotiate culturally, compelled to examine
whether what is good for one group is good for another, or at its expense. By necessity the
individual is engaged in dialogue with a network of cultural systems, that echoes Habermas’ model
(4). Because of the fractured nature of contemporary culture there are currently few other ways of
creating a coherent cultural space within which to communicate other than through a shared sense
of the ethical. The old essentialist divisions of race, gender, and class, whilst still absolutely central
to the way we have been culturally formed, need negotiating in an increasingly subtle way. Bhabha
(1994: 1) discusses the ‘move away from the singularities of “class” or “gender” as primary
conceptual and organizational categories’, which he sees as having resulted in the awareness of a
variety of subject positions currently informing ideas of identity. He argues that it is in the
negotiation of the range of subject positions in contemporary cultures, from the ‘periphery’ or
boundary to authorised rule, that dominant discourses in Western culture can be challenged. An
ethical critical awareness allows the analysis of cultural inequalities that emerge from post colonial
theory to be articulated personally rather than abstractly, but it forces a framing of the individual’s
negotiation with institutional mechanisms to go beyond the reflective, or self-referential. An ethical
critical awareness allows for cultural movement across and within the paradigms of race, class and
gender without the subject becoming narcissistic. I am arguing here for an ethical awareness that
locates the self in a broader historical context, a context that also requires an understanding of the
interconnecting networks of institutional power. To become ethically reflexive involves
understanding that contexts create meaning and values. These contexts are not merely abstract
notions and can be understood as power structures. For the design student to realise that the
appropriation of Aboriginal designs by non-Aboriginal people is a political act, is also to
understand the dynamics of power relationships.

Richard Sennet (2000: 175) has observed that ‘modern culture is flooded with identity-talk ... of
crude stories about “how I discovered the person I really am”.’ The critical position I wish my
students to aspire to is not about simplistic identity politics, rather it establishes ethical issues as a
way of understanding personal lived experiences that Henry Giroux says ‘bear witness to the ethical
and political dilemmas that animate both the specificity of such contexts and their connection to the
larger social landscape’ (Giroux, 2000: 129). I wish to place a creative responsibility on the student
to employ strategies that they can use to map and negotiate contemporary culture, avoiding
catharsis and narcissism as their exclusive creative resources. I think it imperative that individual
creativity can be seen as having a role in facilitating ideas beyond a sense of self. Anthony Giddens
and Will Hutton (2000: 217) warn that ‘individual choice alone - the key element of neo-liberal philosophy - cannot supply the social bonds necessary to sustain a stable and meaningful life.’ Design, after all, is about social communication, and it is at this point that my colleagues and I are on the edge of another dilemma. How far is the ethical debate within design education allowed to progress before it fundamentally disrupts whatever relationship there is between education and industry?

It is not as if the word ethics is never used in the design industry - the Universal Design project is of vast importance (flawed though it may be) - but generally ‘ethics’ as a concept operates within very closely defined paradigms. So; in the Australian Graphic Design Association’s ‘Code of Ethics’, the preamble singles out the way in which a Code of Ethics (2002: 1) “is a powerful tool in dealing with destructive practices such as competitive free pitching.” Simon Rogerson and Mary Prior (1999) deal exclusively with ethical behaviour within the enclosed system of the industry, and the American Society of Interior Designers (2002) provides a quiz that will “enhance” their members’ knowledge of “the principles of ethical design practice.” As I write the ICOGRADA conference for 2002, ‘Identity and Integrity’ has still to take place, but it announces in its website preamble (ICOGRADA 2002) that “at this conference designers and representatives of public institutions will gather to share their experiences and to carefully consider the future of corporate identity”. In a world in which Guy Debord’s spectacular rhetoric of thirty years ago has become reality, such tinkering within the paradigms of the workplace avoids confronting the fundamental ethical dilemma of the relationship between the rich minority world and the poor majority world. It avoids examining the collusion of the culture industry in perpetuating that relationship, and it also avoids the vexed question of the creative individual’s complicity in that process. As long as the creative individual is seen as autonomous, and as long as a sense of creative responsibility is seen solely in terms of ‘being true to oneself’, then the complexity of ethical responsibility will never be addressed.

It is difficult to promote the idea of ethical responsibility within a culture that promotes individualism whilst denying the emotional and intellectual resources necessary to live a full and satisfying communal life outside of a system of commodification. It is difficult too, to understand the demand for ethical practice in a culture that promotes the idea of individuality within the closed confines of a commodity culture, a culture that in addition is profoundly limited in its ability to reflect cultural difference. Unless consciously directed otherwise, the individual studying visual culture will always fall back upon established interpretive practices no matter how the curriculum content of study may change. Habermas’ dialogic model referred to earlier in the paper encourages the student of culture to move backwards and forwards between the institutions that define cultural paradigms and the individual’s own lived experience. This process suggests that curriculum content is almost irrelevant when compared to the potential power that the remaking of the context of study has.

Donna Haraway (1991: 151) talks engagingly of the illusory and frayed vision of the autonomous self, and argues for a re-invention of the individual as one committed to ‘irony, intimacy and perversity … oppositional, utopian and completely without innocence.’ I readily acknowledge the importance of strategic and transitional demands in the construction of cultural programs, but to give this rhetoric flesh I would argue that a study of culture has to expose the incommensurability that is at the heart of any relationship between the individual and the cultural institution. Without such an understanding, individuals cannot locate themselves as part of the complex and contradictory relationships between cultures. Unless a study of culture deals with the unequal exchanges that constitute cultural exchange at all levels of experience, what can be promoted is a superficial self-referentiality rather than reflexivity. I am arguing for a reflexivity that exposes the contingent nature of the individual’s relationship with any set of cultural institutions. I would wish
to go still further though, and suggest that rather than celebrate the ambiguous and the unpredictable nature of such a relationship, that contingency should be framed by an ethical demand for social justice. It is the de-centred, fragmented, unlocated self that permits the perpetuation of a system of social injustice in a commodity culture. I would like to think that design has little to do with entertainment but everything to do with social liberation.

Footnotes
(1) The concept of the ‘reflective practitioner’ first raised by Schon (1983) is a concept that is increasingly familiar. Its emphasis is upon the individual’s analysis of his or her practice, and the consideration of the way in which that practice operates within an explicitly acknowledged set of paradigms. In this way the practitioner becomes self aware and able to refine his or her practice according to established criteria. Reflexivity however, in the way I wish to use the term, takes reflection beyond the idea of paradigms of acceptable criteria. By reflexivity I mean a praxis that brings to the surface issues that expose the contingent, ambiguous and often contradictory implications of whatever system is being reflected upon. Reflexivity is far more unsettling than even the most rigorous reflection because it uncovers illusions of fixed meanings and stability of systems. Implicit in my use of the word is the idea that meanings must be frequently reconstructed in the light of the realisation that in any form of cultural enquiry the ‘subjects’ and ‘objects’ of that enquiry are difficult to separate. This sense of the use of reflexivity is based substantially on the discussions to be found in Lawson (1985). In addition I have used the word as it is used in sociology where it refers to the realisation that as cultural traditions are shattered there is increasing opportunity for the reflexive individual to act upon the world, as well as be acted upon. I would temper Beck’s (1992: 90) observation that ‘the individual becomes the reproduction unit of the social’ without denying its importance in recasting the potential of the individual for social action.

(2) The subjects and styles of Aboriginal culture are subject to Aboriginal law, and only certain social groupings are allowed to make art using certain stories from the dreaming, and using certain stylistic devices. This aspect of Aboriginal traditional law is reinforced by Federal Australian copyright law. It means that Aboriginal communities can protect what is often their main source of income, which is art based, from pirated mass produced versions of their art.


(4) For a thorough evaluation of the similarities and dis-similarities between Rawls and Habermas see McCarthy (1994).
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An interpretive framework for research on the history of materials

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Abstract

This paper describes an interpretive framework that can be applied to the history of materials in the modern era based on a triad of critical terms: fabrication, application and appreciation. Fabrication deals with the initial stages in the life cycle of materials. It refers to the extraction, refining and preparation of materials for initial use. Application deals with transformation of materials into products. Appreciation deals with the reception of materials by the entire community of users who come into contact with the material. In contrast to deterministic approaches to materials, the framework described here accepts the problematic nature of materiality in the modern era and allows historians and designers to integrate perspectives and methodologies from a variety of disciplines.
An interpretive framework for research on the history of materials

Design is the process by which abstract ideas assume concrete form and thus become active agents in human affairs. One of the critical parameters in any discussion of designed artifacts is material: what something is made of and how the material is employed affects the form, function and perception of the final design. This paper explores some of the issues surrounding the discussion of materials in the modern era and outlines an interpretive framework for developing a historically-based treatment of materials based on the triad of critical categories: fabrication, application, appreciation. This critical schema transcends the specifics of any single material and can support a broad range of research agendas.

That the story of materials, their discovery and subsequent manipulation constitutes a significant thread in the history of civilizations and of cultural discourse is obvious. In the long view of history, the degree to which humans were able to exploit different materials has been taken as an indication of the level of technological sophistication of different cultures. We speak of the Stone Age or the Bronze Age as readily identifiable chapters in the human story. In the more compact purview of the history of modernity, the advent of new materials is generally treated as one of the distinctive and determining factors in the modern design. Beyond serving as an index of technological sophistication, different materials have acquired readily discernable cultural associations. If, for example, I identify a particular period as constituting a “Golden Age” in the history of a civilization or describe a hero as having feet of clay the reader understands the judgements expressed in those phrases. Likewise, when, in the 1968 movie The Graduate, the character portrayed by Dustin Hoffman is offered career advice, the audience recognizes that an entire lifestyle has been devastatingly described with a single word: plastic.

In a conference devoted to exploring the common ground of design practice, research, theory and history, a discussion of materiality is, I suggest, also critically important. Materials can serve as a lens to focus insights derived from different disciplinary perspectives and methodologies. Design research – whether it is directed at the history of design, the refinement of design theory or the advancement of design practice – often requires that the researcher pursue knowledge and insights embedded in different disciplines. The challenge of interdisciplinary work involves the integration of insights gained from exposure to different disciplinary perspectives. In terms of the argument I wish to present here, the first step is to recognize the complex and frankly problematic nature of materiality in the modern era.

In 1956, the Reynolds Metals Company, one of the three major producers of aluminum in the United States, published a handsome two-volume survey of architectural uses for aluminum. *Aluminum in Modern Architecture* included a portfolio of recent buildings demonstrating architectural applications of aluminum, a technical section detailing the properties of the material, and a collection of interviews with twenty-seven architects and engineers in which, they described their enthusiasm for aluminum’s multiple applications in architectural design. One of the prominent voices included in this section belonged to Ludwig Mies van der Rohe and Mies began his discussion with a curious warning:

*The danger with aluminum is that you can do with it what you like; that it has no real limitations.*

(Peter 1956: 248)

I cite Mies here as a way to begin my discussion of modern materials because he suggested that we see the advent of new materials in the modern era as constituting a problem that required careful
attention rather than as a readily available solution to be embraced uncritically. In constructing accounts of the history of design in the modern era, design historians should be wary of deterministic approaches to the subject predicated on a positivist approach to history that suggests new materials naturally and inevitably generate new formal languages for design.

If Mies’s warning represented an isolated position by an eccentric figure, we could dismiss it. However, he was not alone in registering a note of caution when discussing the brave new world of modern materials. In his 1940 treatise on industrial design Design This Day: The Technique of Order in the Machine Age, Walter Dorwin Teague noted the epoch defining quality of modern materials. Today, he observed, designers are no longer limited to the catalog of materials available directly from nature:

_Our modern partnership between science and industry, with the great expansion of research laboratories and experimental stations through which it works, is able to meet our needs with reasonable promptness … so that our repertoire of available resources is far more extensive than any possessed by designers heretofore._ (Teague 1940: 69)

Teague went on to suggest that this partnership between science and industry presented designers with a challenging new context for professional practice, one they did not always handle well:

_These forces whose power we feel are not novel: they merely move more swiftly and so with greater impact, and they vary their direction more frequently, than they used to do. The peculiar difficulty of our position is that this interaction of forces is accelerated almost beyond our ability to keep pace with it in conscious mastery of our resources. …But the Machine Age in its multitude of inventions has not only included our long repertoire of new materials – it has enormously increased the number and kind of things we can do with materials, old as well as new. It is not surprising that as a result we have fumbled very clumsily with many of our familiar stuffs, while we ran wild in inept uses of those our forefathers understood so well._ (Teague 1940: 69-71)

Publications like _Aluminum in Modern Architecture_ and _Design This Day_ are often described as self-promoting celebrations of individual designers, the design profession as a whole or specific industries. A close reading of this mid-twentieth century literature reveals, however, a significant maturation in design thinking compared to the prophetic but often technologically uninformed discussion of materials by designers generated earlier in the century. In 1924, for example, Mies van der Rohe could write confidently:

_Industrialization of the building trade is a question of material. Hence the demand for a new building material is the first prerequisite. Our technology must and will succeed in inventing a building material that can be manufactured technologically and utilized industrially. …It will have to be a light material whose utilization does not merely permit but actually invites industrialization._ (Conrads, 1970: 82)

A quarter century latter, and now fully immersed in a technologically sophisticated and industrialized building culture, Mies moderated his tone a bit and tempered his enthusiasm with a warning concerning the “danger” of materials characterized by seemingly limitless potential. In the comments by Teague and Mies cited here we see the emerging recognition among modern designers of a daunting new level of complexity that rendered traditional ways of thinking about the relationship between material and form increasingly outmoded.
This recognition of the complex story of modern materials has shaped my own work, but I am hardly a lonely figure in this regard. Jeffrey Meikle opens his history of plastic with the following observation:

*Plastic itself, by its very nature, complicates efforts to think about it. Able to assume many degrees of shape, texture, hardness, density, resilience, or color, the myriad varieties are united only by a word – plastic – that has defied most attempts to promote specific trade names. What do we mean when we talk about plastic?* (Meikle 1995: 3)

In recent years, our understanding of what it means to use the word plastic – or aluminum, concrete, glass, etc. - has been enriched through the research of design historians like Giampiero Bosoni, Gwenaël Delhumeau, Clive Edwards, Robert Friedel, Hans Joliet, Jeffrey Meikle, and Penny Sparke. And, while not strictly speaking works of historical scholarship, the important contributions of Paolo Antonelli, Philip Ball and Ezio Manzini to the discussion of contemporary developments in materials technologies needs to be acknowledged here. The fruit of all this scholarship is, I suggest, a new framework for the discussion of materials based on the triad: fabrication, application and appreciation.

**Fabrication** deals with the initial stages in the life cycle of materials. It refers to the extraction, refining and preparation of materials for initial use. In the case of aluminum, for example, fabrication involves extracting alumina from bauxite ore and reducing it to aluminum through a process of electrolysis. While in the case of plastics, fabrication involves calculating the particular molecular composition of the polymers to be employed. A historical discussion of fabrication involves tracing the scientific insights leading to the discovery of ways to produce new materials with specific properties. Discovery is followed by production and a discussion of fabrication also encompasses the growth of an industrial base technologically and financially able to produce the material in commercially significant amounts.

**Application** deals with transformation of materials into products. It involves the efforts of designers to match new materials to existing product needs, to develop new uses for novel materials and to impose a formal vocabulary on materials. This formal vocabulary can be imitative of other materials or emphasize properties and characteristics unique to the material in question. Mapping the various applications of new materials is familiar terrain for design historians because it traces the role of designers in the product development process. In my own work on the history of aluminum, for example, I have argued that designers enter the story to a significant extent when advances in metallurgy and production technologies (i.e. developments belonging to the story of fabrication) no longer are enough to sustain the growth of the aluminum industry. Furthermore, that the activity of design (understood as distinct from that of science and engineering) grows in importance as the competitive nature of the industry grows.

**Appreciation** deals with the reception of materials by the entire community of users who come into contact with whatever material is being studied. A history of appreciation traces the multiple and shifting response of different constituencies as they encounter artifacts endowed with a distinctive material identity. Just as a concern for the application of materials shifts the focus from scientists and engineers to designers, the turn from exploring application to appreciation shifts the focus again, this time from designers to consumers and those critics, commentators and trends setters who shape the cultural understanding of materials.

At this point, some refinement of a framework based on this triad of terms is necessary because a simple listing of the terms fabrication, application and appreciation suggests they exist as discrete categories separate from each other chronologically and in terms of their ‘cast of characters’. In
working with these terms, however, researchers soon recognize areas of overlap between these terms and the role of feedback loops within the sequence fabrication, application, and appreciation. Designers, a group I have identified as key players in the discussion of the application of materials for example, routinely respond to feedback from consumers. In the same way, the type of basic research and development activities characteristic of the fabrication phase of the material story often involves input from constituencies located in later stages of the material life cycle. The critical terms described here are serviceable to the degree they can clarify the type of questions researchers should ask and suggest the type of sources to be consulted in pursuit of answers. Interdisciplinary research is complex and the interpretive framework proposed here brings into sharp relief what stage in the life cycle of materials is under review at any moment in the research process.

A second clarification involves the concept of time. It is not my intention to specify in a restrictive manner the temporal dimension of these terms. Any attempt to discuss the appreciation of aluminum, for example, must take into account the shifting perceptions of this material as it evolves from a precious material in the nineteenth century to a pervasive one in the twentieth century. The rapidity of social and technological change and the fluidity of cultural meaning are recognized as characteristic features of the modern era. In the modern era, discussions of what must always be coupled with an appreciation of when in order to capture the fine details as well as the big picture in terms of the story of materials in the modern era.

A third clarification involves the place of natural materials in the critical schema presented here. The Teague passage cited above reminds us that the catalog of materials available to designers has expanded dramatically in the modern era. But the arrival of new alloys, polymers and laminates did not mean the disappearance of traditional natural materials. Substitute cultivation for the term fabrication and the schema works just as well for materials like cotton, bamboo or oak as it does for aluminum and plastic.

At this point, I want to return to the theme of this conference and suggest how the critical framework I have outlined here contributes to interdisciplinary research and practice and the design community’s search for a common ground. In 1992, my colleague at Design Issues, Richard Buchanan published an article in the journal entitled Wicked Problems in Design Thinking. In this article, Buchanan introduced a conceptual tool he called the “doctrine of placements.” He used the concept of placements, which he described as broad areas of particular types of design activities, as a way to explore the nature of invention in design activity. He observed that the conceptual repositioning of a design problem from one place to another often sparked innovative solutions. In an attempt to refine the concept of placement he distinguished it from the more familiar concept of category.

*Categories have fixed meanings that are accepted within the framework of a theory or a philosophy, and serve as the basis for analyzing what already exists. Placements have boundaries to shape and constrain meaning, but are not rigidly fixed and determinate. The boundary of a placement gives a context or orientation to thinking, but the application to a specific situation can generate a new perception of that situation and, hence, a new possibility to be tested.*

(Buchanan: 1992: 10)

Buchanan is concerned here with design practice. If we substitute historical research for design practice and we consider my terms fabrication, application, and appreciation as designations for the different “placements” of research emphasis the topography of our common ground begins to come into relief. Using this schema, it is possible to visualize and map the process of interdisciplinary research through noting the relative sequence and position of the different disciplines drawn upon in an effort to understand the story of materials.
In the United States, academic libraries and the majority of large public libraries use the Library of Congress cataloging system. The Library of Congress is subject-based and uses an alphanumeric code to identify individual titles. (Participants in an international conference such as this one undoubtedly are familiar with the corresponding cataloging system in their respective countries.) Call numbers for titles pertaining to the history of design, for example, begin with the letters NK, the call numbers for books on aluminum begin with QD, and general works on materials technologies begin with TA. The Library of Congress classification system is not just a simple way to assign unique locators for each book in a library, it is an outline of knowledge arranged by subject discipline. If, as a design historian, I ask the question: what is it I need to know in order to understand the history of aluminum – its fabrication, application and appreciation – and I note the Library of Congress call numbers of the library materials I consult, the result is a description of an interdisciplinary research agenda. Admittedly, this is a crude example, because no research campaign can be confined to library-based resources. But it serves to make my point about the interdisciplinary nature of research involving the history of materials. Once design historians begin to listen to what designers like Teague and Mies van der Rohe were trying to tell us - that materials are not just a ‘given’, an a priori fact to be included in their calculations, but were part of the design problem itself – then the need to articulate a critical framework for the discussion of materials becomes obvious. Fabrication, application, and appreciation can provide just such a framework for sustaining the discussion through its different placements.

In a conference devoted to exploring areas of common interest and to celebrating the diversity and maturity of an interdisciplinary design community, we can all benefit from discussion of the interpretive frameworks different groups within this community employ to investigate a subject such as materiality.
References


Early car history – investigation of the establishment of a ‘design paradigm’

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Abstract

The early development of the car appears to have been a period of uncertainty, with a selection of component layouts being developed before manufacturers hit on a particular embodiment that became a definitive ‘car’. This paper investigates how car form and layout became what is termed a ‘Design Paradigm’ (Dowlen 1999) for the car, during the late 19th and early 20th centuries.

Layout and form variables are investigated from 453 colour-slide examples over the whole period of the existence of the car. The results show that the layout is significant to the concept of a car, and shows that a tightly constrained design layout paradigm develops around 1904, developing from a broad range of layout concepts. Form is less significant, but shows an appreciable change to a relatively stable condition over a period of about five years from 1904.

The tightly constrained layout consists of a front-mounted longitudinal engine and drive by shaft to the rear wheels. There are a significant number of other layout variables that describe the layout. Before this date designers had many different ways of laying the components out, and there are some clusters of layouts, particularly with the US cars. In terms of their form, early cars are generally taller and with shorter bonnets than later cars, and tend to have a squarer form.
Early car history – investigation of the establishment of a ‘design paradigm’

Introduction
The early development of the car appears to have been a period of uncertainty, with a selection of component layouts being developed before manufacturers hit on a particular embodiment that became a definitive ‘car’.

This paper investigates something of the way in which the many and various forms and layouts of cars, automobiles, horseless carriages and whatever one might wish to call them became what is termed a ‘Design Paradigm’ for the car. The paper brings together work that has been carried out on a pragmatic level. Firstly, this has been concerned with using car history in teaching students of both engineering and design (Dowlen 1997), and secondly, this was developed, again at a pragmatic level, into a general theory about the development of these ‘Design Paradigms’ (Dowlen 1999). In parallel with this paper an overview paper, looking at the general evolution of the car has also been produced (Dowlen 2002). This paper is also concerned with the parallels between evolutionary theory in life forms and the evolution of the product, in this case the car.

The assertion is that the degree of change seen in the layout and form of the product during these early years of development was significantly greater than the degree of change seen in the layout and form during the period after the definitive car form and layout became established.

Invention and evolution
Who invented the car? Andrew Whyte (Whyte 1984), along with general tradition, states (page 8) that the first motor car was made in Germany, and that traditionally has always said the honour belongs jointly to Carl Benz and Gottlieb Daimler who separately produced vehicles powered by internal combustion engines in 1885 and 1886. Benz patented his ‘carriage with gas engine’ in January 1885. But in going along with tradition, not only do we ignore the claims of Siegfried Marcus who may have built a petrol powered car in Vienna in perhaps 1875, but we also have to insist that cars have internal combustion engines, and it is quite obviously true that not all of them do – some are powered by steam, some electricity, some by sunlight and some even by pedals (and we still call these cars and not something else). However, it would be very difficult to describe Nicolas Cugnot’s steam powered gun carriage of 1770 or Robert Trevithick’s steam carriage of 1801 as cars; but perhaps not so difficult to describe Amédée Bollée’s steam vehicles of the late 1870s and 1880s or Count de Dion’s steamers of a similar date as such.

There is also the argument that neither Benz nor Daimler could lay claim to the invention in 1886: the former because although his carriage was purpose-built, it only had three wheels and therefore classed as a tricycle and not a car; and the latter because his four-wheeled powered vehicle consisted of one that was originally horse drawn and was adapted by the fitting of an engine between the front and rear seats, cutting off the horse shafts and adding some sort of steering device.

In any event, it perhaps seems strange that two people working separately should come up with the same invention, but it could be argued that the notion of self-powered vehicles was something that was almost bound to become a reality, given the social setting at the time, the existence of steam-powered road (and rail) vehicles and the earlier invention of the four stroke internal combustion engine by Otto in 1876, itself a development of Lenoir’s gas-burning engine of 1860.
Simonton (Simonton 1988) develops the proposition that ‘Creativity involves the participation of chance processes both in the origin of new ideas and in the social acceptance of those ideas by others’ (page 388), noting that the chance processes include obtaining of information and ideas from the social context as well as the acceptance of the outcomes into that social context. He goes on to cover the topic of multiple discovery and invention, where two or more people working independently make the same discovery or invention at the same or a similar time. He suggests that if the invention were given a generic name (he cites such as “steamboat” or “airplane”, p416) then such multiples are often completely different inventions. Looking at the 1886 vehicles of Daimler and Benz it is obvious that there are significant differences and that the major similarity is the accomplishment of self-powered transport using an internal combustion engine. Simonton’s theories on the mechanisms of creativity owe more to evolution than invention, and it is clear that this is the case in terms of the car.

**Design paradigm**

But one could assert that the car became in reality a car at a later date: that date when a definitive layout was established and when to build a car was to build a product that not only powered itself but that possessed the layout of a car and looked like one too. When students are asked the question about who invented the car, apart from the fact that most of them have no real idea, the most common answer is neither Benz nor Daimler, but Henry Ford: and they cite not his first conveyance of 1896 but relate more readily to Model T production, which started in 1908. This argument could be reasonably persuasive, but it needs a certain amount of clarification. If the car is going to be determined in these layout terms, it would be useful to, firstly, determine what the layout is, secondly how far removed from any definitive layout would a vehicle have to be in order to qualify as a ‘car’, as opposed to a cyclecar, a horseless carriage, a quadricycle or something else and thirdly, at what point in the history of powered road transport was such a concept determined. It would also be an interesting historical phenomenon to try to determine either which vehicle was the first with such a layout, who built it and whether subsequently that vehicle was taken up as being the original one that was looked to as the pioneer by the future car designers.

Thus the suggestion is that the answer to who invented what depends on the definition, and that this is in turn of a prototypical nature and is situation-dependent (Lakoff 1990; Shackleton and Sugiyama 1996). What we are seeking to determine is what was the original prototype (defined in these terms) for the car, what is the typical arrangement, layout of that car prototype and, if possible, who determined it and when. It is probably more easily understood if the term design paradigm for the car is used rather than prototype, as in the context of product development the term tends to mean the original example of a product that is later to be mass produced. It would be useful to know how closely defined this design paradigm would be, and at what stage either a car ceased to be a ‘car’ due to its distance from the typical example of the paradigm.

**Analysis**

This study forms part of a larger study to investigate the development and evolution of the car over the whole period of its existence. The data used in the study consists, initially, of the analysis of a series of cars, taken as being analogous to a series of fossils that might be used to investigate directions that natural evolution might have taken. As such, the fossils were considered by their existence to be examples that would have to be placed into the context rather than selected carefully as being representatives of whatever context was envisaged. What was required was a significant number of examples rather than a representative sample. It is debatable how such a representative sample could be achieved, as the criterion for selection would have to be that of influence over designers rather than, say, from sales or marketing figures, and this influence by its very nature is impossible to quantify. The series of cars used was 453 examples on colour slides covering cars from 1878 up to about 1999. These had been taken for interest rather than any other reason. At
some stage other examples of cars taken from published information, photographs can be added into the data set, and the hypotheses re-evaluated.

These car examples were divided for convenience into date periods of five years. This gave sufficient examples in most periods for a reasonable selection of results to be achieved, although the somewhat esoteric nature of the slide collection became obvious during the analysis. The periods with too few examples were the very early periods, because there were few cars and even fewer of the experimental examples were kept, the two world war periods, when, again, few cars were produced, and some of the more recent periods where the bias towards classic car events and the unusual became more obvious. They were analysed in qualitative terms for nineteen layout variables and forty-seven form variables. The country of origin was also noted.

Eight of the layout variables had what were taken as default values. These included such things as number of wheels (default, 4) and their orientation (default, 2F2R) and steering control (default, wheel). Most of the variables were taken as nominal, but a few were classed as ordinal, such as degrees of roundness (although these were described verbally) and a few, such as number of wheels, were obviously numerical in character. The nominal and ordinal variables were given categorical numerical values for analysis purposes.

The layout and form variables were reduced using the optimal scaling procedure within the SPSS program to two dimensions for the layout variables and three for the form ones.

**Overall study results**

The results over the whole period (not using the term in the five-year sense) showed some interesting progressions. Figure 1 outlines the results for the layout variables.
Figure 1: Optimally Scaled Layout Dimensions

Essentially, this demonstrates that in the early periods, car designers had little history to guide their developments and a design paradigm had not really been established. By about 1904, the first car in the cluster of results labelled ‘Vintage layout’ had been built, and this layout continued to be the prime layout for cars from this date right through what are known as the Edwardian (1905-1919) and Vintage (1919-1930) periods, and into the next five year period of the study (to 1934). During the 1930s, there is a significant shift and the layout develops in the direction shown. The general process is that a pioneer moves out in the general direction and then others come in ‘behind’ as it were, to fill the gap between the pioneer and the current paradigm.

Figures 2 and 3 show the results for Form variables, with the dimensions 1 and 2 plotted against each other and dimensions 2 and 3 plotted against each other.
Figure 2 has been annotated to indicate that a general direction of development occurs; with cars from the early periods almost exclusively being in the lower left quadrant, and those from the Edwardian periods moving towards the upper left one. The Vintage periods from 1919 to 1934 show results primarily in the upper left quadrant, with a significant move into the upper right quadrant from 1935 onwards. In the 1950s there is a further move into the lower right quadrant, from where there appears to be no significant movement to the present.

Figure 3 (and particularly dimension 3) shows little clear movement with period, but does show different types of cars in the different quadrants, with those with more rows of seats and more formality being in the upper left quadrant: two-seaters being in the lower right. Cars in the lower left quadrant tend to be those with rather skimpy bodywork, running boards and separate wings. In the upper right quadrant, the cars have longer bonnets and are more rounded.

It is a little difficult to ascertain exactly what the three form dimensions relate to, but it would appear that form dimension 1 relates to roundedness criteria, form dimension 2 relates to proportion, particularly the length of bonnet and position of the screen as well as simply length and height, and form dimension 3 seems to relate to formality and carrying capacity.
The early periods
These are the results for the whole study. It is particularly interesting to focus in more detail on the results for the early periods, as it would seem that something significant takes place at around 1904 both in terms of layout and the first two form dimensions.

The earliest car (if that be the correct title) in the slide survey was the Amedée Bollée’s La Mancelle of 1878. This was a steam driven vehicle designed for use by a wealthy individual with a driving position at the front, carriage compartment further towards the rear and boiler and firemen at the rear. It is the only vehicle in the first period, and there are no slides in the next period from 1880 to 1884. In period three there are four vehicles: two by Benz and two by Daimler. One of each of these is their first internally-powered vehicle, and the other is a development, but while Benz’s first three-wheeled effort looked more like a bicycle than Daimler’s modified carriage, Daimler’s development is more along cycle lines and Benz’s tends towards carriage form, although still a three wheeler. In period four there are five examples, three by Benz and one each by Panhard and Peugeot. However, in the next period, 1895-1899, there are as many as nineteen examples and in the sixth there are thirty-three. For the subsequent period, 1905-1909, there are sixteen cars. The larger number of cars in period six is simply because they are the most numerous period for the Veteran Car Club’s annual Brighton run, and many of the pictures were taken during this. Four countries are represented: France, Germany, Britain and the USA.
Layout development
As was perhaps expected, the major layout variables of engine position, crankshaft orientation and driven wheels show that the layout quickly settles down to a front mounted engine with longitudinal crankshaft and rear wheel drive. Table 1 shows the early variations:

These data on their own suggest that there is more of an evolution rather than a definite adoption of a particular way of thinking. Looking at the other, perhaps minor variables, including suspension characteristics, steering control, wheel sizes and tyre types, the development that stands out significantly in this early period is the take-up of the pneumatic tyre. The 1895 Peugeot was billed as the first car with pneumatic tyres. By 1900 any other form of tyre appears to be virtually dead. After that date there are only four cars in the total survey without pneumatic tyres: one of these is a half-track and one is a pedal car, leaving only two examples seriously putting forward the use of solids. Pneumatic tyres have the character of an invention rather than a development.

<table>
<thead>
<tr>
<th>Period</th>
<th>Dates</th>
<th>% Front engine</th>
<th>% Longitudinal Crankshaft</th>
<th>% Rear wheel drive</th>
<th>% all three</th>
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<tr>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>3</td>
<td>1885-89</td>
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<td>1890-94</td>
<td>20</td>
<td>100</td>
<td>100</td>
<td>20</td>
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<td>5</td>
<td>1895-99</td>
<td>32</td>
<td>38</td>
<td>95</td>
<td>21</td>
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<td>1900-04</td>
<td>55</td>
<td>64</td>
<td>100</td>
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<td>1905-09</td>
<td>86</td>
<td>73</td>
<td>100</td>
<td>67</td>
</tr>
<tr>
<td>8</td>
<td>1910-14</td>
<td>96</td>
<td>93</td>
<td>100</td>
<td>93</td>
</tr>
</tbody>
</table>

Table 1: Change towards front engine – rear wheel drive configuration

Values obtained from the optimally scaled outputs can only be regarded as comparative as the scaling doesn’t relate significantly to any particular variable, and the variables in any case have nominal values. But nevertheless it is interesting to compare the values obtained during this early period. Overall, the values for the first layout dimension vary from about –5 to +4, and for the second from about –1.5 to +7.4. During the early periods, up to 1904, the values for dimension 1 are all negative, and those for dimension 2 vary from –1.06 to +5.2. The nature of the clustering is interesting. Over the whole of the analysis, the ‘Vintage’ layout cluster contains fully 49 examples (11%) of all the cars within a square of ±0.05 in both axes, on the same scale. If the tolerance is opened out to ±0.2, this cluster contains 95 cars, or 21% of the whole. The characteristics of cars in this cluster are very closely determined.

Not only do they have front longitudinal engines and rear wheel drive using a shaft, but they also have channel chassis frames, coachbuilt bodies using ash framing and either aluminium or steel panelling and rigid axles at front and rear using semi-elliptic leaf springs. Steering is by steering wheel, with the driver sitting at one side the front, and the cars run on four equally sized wheels shod with pneumatic tyres. Their engines have four or six in line cylinders in an in-line configuration. The earliest cars in this cluster in the survey are three cars from period 6 (1900-1904): a 1902 Panhard Levassor, the 1904 Peerless Green Dragon and a 1903 Mors. The arrangement of front engine, rear wheel drive is generally known as the Système Panhard, and although it is actually named after the earlier, less defined layout that was produced in 1892, it would seem that Panhard were still in the position where they were influential, although of course there is not the completeness of the data that would be appreciated in determining this.
At a later date, starting during the late 1930s, there appears to be a developmental movement, moving in a line at about 30° from the vertical (dimension 2) axis. This could perhaps be described as a line of car development, with cars away from the line signifying their distance from being ‘cars’ or ‘real cars’ in general parlance.

Figure 4: 1902 Panhard and 1903 Mors
In the early periods, the movement appears to be from a position of uncertainty towards this ‘Vintage’ layout, with cars from the early periods, up to and including period 6, lying roughly in a sector to and pointing towards the ‘Vintage’ point.

Within this sector there are nevertheless a number of clusters of cars. Just behind the Vintage point is a small cluster with shaft drive, but a smaller number of cylinders, one or two, than the norm, and another cluster with chain drive rather than shaft drive: a smaller cluster slightly further away contains a small group of cars with steam engines under the driver’s seat, suspension by full elliptic front and rear on a pram frame: steering is by tiller. This cluster is perhaps epitomised by the Locomobile Steam Buggy. Although not part of the analysis, this entire cluster hails from the United States. Developments of this cluster, again mostly in the United States, move away from it when suspension systems are improved, engines become internal combustion and steering is by
wheel, but there are still examples of the arrangement – such as the Stanley Steamer, shown on the diagram in grey – being built up to the First World War. Thus although the cars are all in similar places in the layout analysis, the cluster becomes dispersed and confused by other cars such as early Panhards and Daimlers (front engine, chain drive, solid or iron tyres, twin cylinder engines) forming another loose cluster on top of them. An even broader group of cars is that formed by the early Benz models – calling them a group may be a little far-fetched, as they all seem to just appear somewhere in the same place on the diagram. The very early Benz models were three wheelers, and these seem to be very far away from the ‘car’ paradigm. Other three wheelers such as the Léon Bollée tri-cars are also far removed from the ‘car’ line.

Figure 6: Skene (top left), Mobile (top right) and Locomobile (lower) steamers
Form development
With the form variables, the clustering element is not so great, particularly with cars of this sort of date. This would appear to be an indication that every car at this sort of date would have been unique, particularly where the form of the body is concerned, which is what is being measured or at least compared. When the results of the first two form dimensions are inspected, there is a clear progression with time, although the precise positions of data points is still somewhat arbitrary due to the type of analysis performed. In the early periods, such as the ones being investigated particularly in this instance, most of the results for these two dimensions load into the lower left quadrant. With the next few periods, the entries tend to be moving into the upper left quadrant, and during the late 1930s the entries move into the upper right one, to reach the lower right quadrant in about the 1950s.

Looking at the components, the lower left quadrant loads on the height and window height variables, and negatively on the bonnet length and various roundedness variables. This means that in our period we should expect cars to be characterised by being relatively high and short, with short bonnets and a general lack of roundedness, which is in fact what we get. At the end of the period, cars start to become longer and lower, with longer bonnets, such as the 60HP Mercedes and Peerless Green Dragon. Jenatzy’s Land Speed Record car, which is in the same period, tends to be slightly out on a limb as it is considerably rounder than is normal in this period, being shaped like a pointed torpedo. It is in the upper left quadrant, almost into the upper right one.

Looking at the second and third dimensions a rather more confused picture emerges. The third form dimension does not really demonstrate much in the way of progression through time in the same way that the other dimensions do. Rather, it seems to load seat rows, rear of cockpit position, and numbers of doors in a positive direction – all things that contribute towards a more formal, staid car. Hence, in each period one might expect a selection of cars designed for carrying more people to have high values, and those designed for small numbers of people and sports use having low values. In our early periods, we would expect cars to have slightly lower values than in later periods, because of the relative absence of features such as doors, and indeed the mean value does rise a little. Typical cars with low values would be open two seaters with little formal bodywork such as...
the Locomobile Steam Buggies, with those with more formal, closed bodies such as the 1903 Panhard Levassor to have higher values, which does indeed happen.

![Image of Jenatzy's La Jamais Contente, 1904 Mercedes 60HP, and 1904 Peerless Green Dragon](image)

Figure 8: Jenatzy’s La Jamais Contente, (right) 1904 Mercedes 60HP (left) and 1904 Peerless Green Dragon (lower)

Generally, during the early periods of the car, the results are more scattered than they are during later periods, indicating that there was a greater variety of form solutions as well as layout solutions, but with form variables there is not the same clear-cut ‘car’ paradigm as there is with the layout variables.

**Progression**

One of the particular difficulties of the somewhat ‘messy’ set of data used for this analysis is that there are a significant number of unusual cars within the data set. This, and the non-representative nature of the data, makes it difficult to obtain meaning from such things as means and deviation figures. Having said that, it would appear that there are a greater variety of approaches towards the design of cars within this early period, meaning that there are a greater variety of proposed solutions to the powered vehicle transport problem. After about 1904, it would appear that the changes in car layout slow down, focusing more on making the car more comfortable and usable than on altering the layout. Both layout dimensions show this slowing down, the second one particularly so. With the form variables it is much harder to indicate whether change decreases until a much later date. The relative importance of the variables should be ascertained, and this may indicate that a change in the nature of the form occurs, thus agreeing with the perceived changes.

**Conclusions**

It is quite clear that a number of closely determined design paradigms exist for the layout design of cars. In particular, the layout that commenced around 1904 persisted for a considerable time. Before that time there are a number of different car designs that form small clusters, but the general movement of car design is towards this very clearly determined paradigm from a broad range of layout possibilities.
Car form develops in a less closely defined manner, but still shows a definite progression. The change of character is much less marked than with layout, and it happens more gradually, from around 1904 to be completed within about five years.

Further work
There is no shortage of ‘fossil’ car material. The object of this study was to demonstrate that even with ‘messy’ data some useful trends could be discovered. A car layout and form database has been built up and needs to be augmented in order to confirm the findings of this investigation. It has been suggested that other methods of study such as Repertory Grid, used for determining conceptual thinking processes, might be usefully used in order to ascertain whether the measurements obtained are those that are perceived. This is particularly important in terms of the form variables, and could establish their relative importance.
References


The use of the Internet by architectural practices in the UK

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Abstract

Since its evolution in 1962, the Internet has provided new services for people and enriched their life and knowledge. Earlier research has shown that the architectural profession in the UK has lagged behind other businesses in adopting and using new technologies and is only slowly absorbing the new innovations brought by the Internet. This lag coincides with a slip in the architect's lead role in the design team.

The research conducted at Cardiff University aims to examine how architectural practices are interacting with the Internet and to investigate any problems they are having in its use. Architectural practices in the UK were surveyed and the results confirm that practices are under-using the Internet. Architects are experiencing difficulties in using the Internet which the study has related to a number of potential causes.

The paper discusses one aspect of this research, which is the use of the Internet in project design and management. The paper explains some reasons for the rare use of the Internet in design tasks and why practitioners are not certain about the potential benefit of the Internet. It makes recommendations for factors that should be targeted in order to extract more benefits from the Internet and to fully utilize it for project design and management.
The use of the Internet by architectural practices in the UK

Introduction
In recent times the architectural profession has been experiencing unprecedented social, economical, political and environmental stresses. Building design had to embrace more complex information, technology and aesthetics (Jencks 1993). Clients became not only more experienced, but also more demanding, with more sophisticated needs (Kliment 1996). Architects were not prepared for the effects that rapid change brought to the level of demand on their services, and were not sufficiently skilled in identifying newly emergent market requirements and adopting new technologies (Seidel et al 1995, Cuff 1991). Many were reluctant to use new technology in their practice. As an example, when computers were first introduced, many practitioners decided that they would be of no help to them in producing artistic design (Fryer 1997). In this changing environment, other professions were able to take up a new specialization in project management, shifting architects from their historical role as design team leaders to become equal players in the design team (Stevens 2000).

Recently, there has been a revolution in communications brought about by Internet technology, which has imposed itself on people, life and business. People around the world have become wired to the Internet through personal computers, handheld computers, mobile phones and digital TVs. The use made of the Internet and computers by architects has been studied in a number of surveys (see Barbour 1997; Barbour 1999; RIBA 1989; RIBA 1996; RIBA 2000). These showed that the trend towards the adoption and use of networking technologies by architectural practice has been slow, and lagging behind other professionals.

A literature review conducted by the authors suggested that the Internet nevertheless has considerable potential for architectural practices, by supporting the recent use of computer tools, providing extra communication channels, and extending architects’ abilities and expertise in new ways. By taking greater initiative in the adoption of these technologies, architects might be able to gain back some of the ground they have lost in the design team.

Research theme
Part of the aim of the present research was to show how the Internet is being used by architectural practices. The range of uses to which architects put the Internet was compared with the potential uses available to them, and this revealed a number of shortcomings. Explanations for these shortcomings were then sought.

A sample survey was used to collect the required information about practices in 1999. There were two samples: a stratified random sample of 60 RIBA private practices and a random sample of 18 local authority practices. Information was collected by structured questionnaire. The questionnaire was targeted at the principal of the practice, and in most cases was completed by this person, or by others on his or her behalf. It supplied data about the use of the Internet and about some of the explanatory factors in a form that could be analysed statistically. This analysis will be referred to in what follows as the 'survey'.

A sub-sample of seven of the respondents were interviewed at their practices (referred to as the first interviews) to find out more about their attitudes towards the Internet. Observation at this time, and more protracted observation of one particular practice, provided additional insight.

After the main results had been compiled, there were follow-up interviews with thirteen of the respondents. These were designed to test whether the recommendations being made were realistic.
The sampling method used for the survey allows the results for the private practices to be projected with some confidence on the population. However, there were too few responses from local authorities to give this confidence, so that from an inferential point of view, all other results must be treated with caution.

**General view of Internet use in architectural practices**

Most private practices, and half local authority practices, report that the two purposes for which architects use the Internet most are e-mailing and obtaining professional information. Other Internet services are hardly used by architects or, in private practices, by architectural and CAD technicians. 70% of practices said that the services professional staff and architectural technicians make greatest use of are e-mail and other text communication, and the World Wide Web. In half the practices, CAD & computer technicians use e-mail but make little use of other services. The comparison of results between private and local authority practices shows that Internet services are used mostly by architects in the private practices, whereas the use is relatively more spread among the design team and other staff in the local authority practices.

Most private practices have exchanged informal file format types with the outside world. Nearly half of them exchange formal letters through the Internet. Half of local authority practices exchange graphic files with people outside the practice. But few practices exchange other file formats. Only 13% of both practices use the Internet to exchange video and audio files.

The study finds that a high percentage of local authority and private practices (i.e. more than 80%) do not use some of the more direct communication services, whether instant services such as video conferencing, chat, and project home page, or non-instant such as newsgroup, bulletin boards, and discussion groups.

These results suggest that the Internet is under-used by practices, in that:

- Many practices do not exchange graphic, DTP (i.e. Data Transfer Protocol) and HTML (i.e. Hyper Text Markup Language) information over the Internet;
- Many practices do not use some non instant and instant communication services;
- In-house design staff do not use all Internet services;
- Some design staff use more Internet services than other staff.

An analysis of the survey results was undertaken to help explain this under-use. Various factors included in the survey could be tested as explanatory variables using simple statistical tools such as cross tabulation. Cramers’ test of correlation was used to examine the strength of the relationship, and the Chi-square Pearson test to measure its significance; results with a significance level below 0.05 were accepted.

**Characteristics of the practice**

The size of the practice is found to relate to Internet use, the data suggesting that smaller practices are hindered in making good use of the Internet. Internet uses that suffer in smaller practices are the use of audio-visual communication services (e.g. video conferencing) by architects and architectural technicians, and the use of audio communication services (e.g. Voicenet) by architectural technicians. Most (i.e. 90%) of the private practices surveyed have under five professional staff.

Another characteristic of practices that has an effect on their use of the Internet is their turnover, as indicated by the size of the projects they undertake and the rise or fall in work load. 10% of private practices and 40% of local authority practices had handled projects with a total value exceeding £10
million in the year before the survey; at the other end of the scale, 32% and 5% respectively handled projects with a total value below £500,000. In the practices with higher project values, more architectural technicians use audio-visual and audio communication services, and more architects are using text communication services other than e-mail.

More than half the practices said they were as busy or busier than in the previous year. In the practices whose work loads are on the increase, more architects are using audio communication services.

The importance of financial resources was verified in the first interviews. Interviewees said that they evaluate the use of any Internet service according to available funding. One, when asked about the possibility of using the Internet to transfer remote video pictures, replied that it comes down to the budget. He commented: "a lot of people here like to have new technology, but because of budget, some of the Internet tools are out of our reach". A principal who had been pointing to the expense of computer technology went on: "but people like me can not afford to buy it all the time; I am trying to upgrade what I have because it is a lot cheaper".

The Internet system
The length of time practices have been connected to the Internet has some bearing on usage. 13% of private practices have no Internet connection, 70% connected in or after 1997 and 17% have a history of use going back before 1997. 90% of local authority practices connected to the Internet in 1997 or after. The survey showed that in those practices with a longer history of using the Internet, more computer, CAD and IT technicians make use of audio-visual, audio, and text communication services other than e-mail.

86% of the private practices sampled are connected to the Internet, and they are the main subject of this research. However, some practices are connected to other types of network. 35% of practices have a second network, either extranet or intranet, and 3% have all three types of network. 52% of LA practices have Internet, 72% have two networks, and around 5% have three types of network. The survey shows that this rough measure of the degree of network connectivity relates to Internet use. In practices that have more of these network types, more computer and CAD technicians and architects are using Internet services, particularly the World Wide Web, e-mail, and access to professional information. For instance, computer and CAD technicians who are in practices which have an Internet network use the e-mail service only, whereas those who work in practices which have both external and internal networks use more Internet services, whilst even more services are used by IT technicians in practices which have three types of network. The type of network also relates to the frequency of use of exchange services for graphic files, and of communication services using text (other than e-mail).

Most practices (i.e. 80%) reported that they have less than six computers connected to the Internet. More than two thirds of LA practices have less than six computers connected to the Internet. The survey results showed that some Internet services get more frequent use in practices having more computers connected to the Internet. These are audio-visual and audio communication services, and the World Wide Web.

The users' knowledge of IT
The survey respondents were asked to assess the knowledge of their staff about Information Technology (IT). In private practices most respondents think that their architects and administrative staff have only average knowledge of IT, whilst their CAD staff, architectural technicians, and other professional staff are more knowledgeable. Other staff are considered to have low knowledge of IT. In local authority practices, the pattern is similar, with architects and
architectural technicians having average knowledge of IT, and computer, CAD, and IT staff and other professional staff being more knowledgeable. Other staff are again considered to have low knowledge of IT.

The study found that the IT knowledge of the design team is related to its use of the Internet for some design tasks. For instance, professional staff thought by their principals to have greater IT knowledge make more use of the Internet for downloading computer software. Again, CAD & computer technicians and architectural technicians with greater IT knowledge make more use of the Internet for exchanging HTML files and DTP files respectively.

The first interviews indicated that some practices have problems in exchanging files through the Internet because their staff have insufficient knowledge of IT, which may explain the low use of the file exchange service. This problem was highlighted by one interviewee who pointed to problems when sending large or incompatible files to other consultants. He linked such problems to the level of understanding of staff, saying that there is sometimes a misunderstanding between staff who were separated by a great distance about what should be done. The observation showed that staff with only a passing or average knowledge of IT can create compatibility problems by making and exchanging non-standard files.

A focused view: Internet use for project design and management

So far, results have been presented about the general use of the Internet in architectural practices. The presentation now moves on to consider more specific uses of the Internet to assist in project design and management. A similar sequence is followed: the extent of Internet use for this purpose in practices will be examined and, shortcomings having been demonstrated, explanations will be sought.

The survey asked practices about the use of design-related information that is available on the web such as technical information and manufacturers' information. At least half of the practices said that they use manufacturers’ information, with a similar proportion using technical information.

It also asked them about the Internet's influence on design tasks. They thought that the Internet has a positive effect on communication between members of the design team and it has some positive influence on the quantity and quality of information available for design. Local authority practices thought that it also had a positive effect on the time taken for project design and construction, but private practices thought that it had a small negative influence on this.

The practices were asked in the survey about the likelihood of using the Internet in some design tasks in the foreseeable future. Local authority practices said that they were likely to use the Internet for discussing design sketches through the Internet and viewing remote drawings. However, all practices seem unsure about other such uses. They all said they were unlikely to use the Internet for downloading information to integrate into drawings and specifications, for discussing a sketch with the client, or for inviting the public to become involved in design decisions about public projects.

These results show that the Internet is not used to assist design in architectural practices to the extent that it might be. Many other ways can be suggested in which the Internet could help. For instance, it would be possible for architects to use the Internet to send free faxes and voicemails, to use freeware applications, to download CAD objects, to share design information online, to discuss 3D design models in real time with clients by using online virtual reality tools, to incorporate design information into intelligent 3D objects, and to view and mark up any type of document without the need to have the full software in-house. However, it must not be supposed without
good evidence that architects will actually find such potential applications useful in practice or relevant to their needs.

For this reason, follow-up interviews were carried out to test the opinion of a sample of architects on potential uses of the Internet. The subjects were shown a presentation about a number of advanced applications of the Internet for design tasks, and asked whether they would find them useful (see the table below). To get an idea of how useful they would be, they were also asked to assess, where applicable, what project savings, what size of project, and what distance of project would be needed before they would adopt the application.

More than half of the interviewees agreed that some of the suggested applications were potentially useful (the first five applications in the table). More than half of them said that they would be happy to use the Internet for automatically checking building design compliance with regulations, and for exchanging project information with standard pro-formas, whatever the project size and even if the project were next door.

Of the suggestions made to them, the one to which they applied the strictest constraints, that is, found the least useful, was the use of a 3D building model incorporating cost and purchase data to share information with members of the design team over the World Wide Web.

The interviewees considered that there are other constraints that could also play an important role in deciding the potential use of the Internet in design tasks, such as the type of CAD packages used by the practice, the complexity of the project, and whether the design information exchanged with other parties is parametric or non-parametric. They thought that whether they will make more use of Internet services for design will be influenced by the efficiency of the services provided, and by the ability of the Internet to act as an intelligent system capable of identifying and knowing the designer's needs.
<table>
<thead>
<tr>
<th>Constraint type</th>
<th>Usefulness</th>
<th>Required saving</th>
<th>Project size</th>
<th>Project distance</th>
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<tr>
<td>Level of constraint</td>
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<td>The type of design task</td>
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<td>Sharing project documents</td>
<td>X</td>
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<tr>
<td>Automatically checking building design compliance with regulations</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>Using specifications, technical indexes, and standards on-line</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Virtual reality and visualization of 3D building models</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Exchanging project information with standard pro-formas made available on the Internet.</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Collaborating, meeting, communicating and discussing project issues with other project team members</td>
<td>-</td>
<td>X</td>
<td>-</td>
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<tr>
<td>Sorting out design problems &amp; conflicts on-line</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Improving the quality of project design and construction</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Hyperlinking design information with on line manufacturers' products, and technical information</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sharing a 3D building model incorporating building cost data with design parties on the Web</td>
<td>-</td>
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</tbody>
</table>

X: more than half of interviewees agreed to use the Internet potentials under this level of constraint
-: The rest of the interviewees who do not agree to use the Internet potentials under this level of constraint, and they apply a medium or high constraint level on these potentials

Table 1: Potential uses of the Internet to assist project design and management found most useful by practitioners interviewed.
The results of the survey and the follow-up interviews together suggest that practices could make
greater use of the Internet to assist them in project design and management:

• Online design information is used by only half of the practices;
• Practitioners have divided opinions on whether the Internet has a positive or negative influence
  on the time taken for project design and management tasks;
• The potential of Internet use in design is not realised by many practices.

As before, explanations for this under-use were sought by analysing the survey data for correlating
variables.

A link is shown between the first problem listed (i.e. little use of on-line information) and the
design staff’s knowledge of IT. For instance, the use of manufacturers’ information services is
greater in practices whose architectural technicians have more knowledge of IT, and the use of
technical information is greater in those whose architects have more knowledge of IT. The first
interviews suggested other causes to the problem. Practitioners said that they found hard copies of
technical and manufacturers’ information easier to use and digest, and one of them, who has Mac
system, said that his system “is not compatible with information sent by manufacturers and
technical information. I have difficulty to find information on line.”

Regarding the other two problems listed, the study suggests that they are related: a reluctance to
realise the potential of the Internet reflects a poor impression so far of the Internet’s influence on
project design and management. That is, what respondents say about their intention to use the
Internet for new design tasks in the near future is related to their degree of satisfaction to date with
the Internet’s influence on related design tasks. In particular, the likelihood that practices will use
the Internet for managing design tasks in the office, or for communicating with outside people,
increases alongside their satisfaction with the Internet’s present influence both on project
management and on communications with the design team.

Thus, a negative attitude towards computers may explain the under-use of the Internet in design.
The first interviews showed how some practitioners do not like to use computers. One practitioner
explained: “The reason that I do not use the computer is that I do fast sketches and follow my brain.
If I am doing this sort of thing by computer, I cannot catch up, and it would be very frustrating to
me. I would have to think how to use the computer rather than what I am doing”. Another pointed out
the unsuitability of the Internet for evaluating building products: “by not seeing the building
components in exhibitions or getting samples, you will not get an indication of quality”.

Dissatisfaction with the Internet’s role in project design and management is probably a result of
problems encountered in using its services. Such problems are, at least in part, due to inexperience.

The first interviews showed how the interviewees’ level of IT knowledge could be a potential
cause. During the interviews, their knowledge was tested, and the results provided clear evidence
that not only do they not use many Internet services but that these services are unknown to them.
Furthermore, the tests revealed difficulties that they were finding in interacting with some of the
services, such as search engines and professional guidance on line, which they considered to be
non-friendly.

Some interviewees referred to problems from outside the practice, with partners or clients who have
little awareness or knowledge of computers. One principal mentioned that some of his clients do
not have the Internet. This prevents the practice from using the Internet effectively in this area. He
tried once to send a 3D model, with viewing software, to a client who uses the Internet, but found that he needed to demonstrate in person how to use it.

The first interviews showed that some interviewees had no clear plans about how to use the Internet for design tasks in the near future. This supports the survey figures, which show uncertainty towards the use of the Internet in design in the foreseeable future. However, there were interviewees who have plans, and said that they are planning to make links with associates or partners in business through the Internet and to manage projects online. Some practices are looking forward to utilizing the web for distributing information, performing electronic transactions, selling 3D models to other Internet users, and doing remote inspections on defective buildings.

Summary and conclusion
This paper makes the case that the Internet is under-used in architectural practices and that, more specifically, much of its potential use for project design and management is unrealized. The questionnaire survey and interviews suggest some of the hindrances to a greater adoption of Internet services.

Smaller practices and those with lesser financial resources use a more limited range of media on the Internet. The more years that practices have been connected, the greater the use that staff make of these media. The degree of connectivity that practices have, in terms of the number of networks and the number of connected computers, the more engaged with the Internet the staff become.

These results suggest that access and experience are important factors in creating an environment in which the Internet is used fully.

Insufficient knowledge of IT generally, and of its potential benefits in particular, is a significant barrier to staff engagement with the Internet. Staff have to develop new skills to use Internet services, and need support whilst doing so. This problem is exacerbated when services do not match their requirements well.

Poor skills lead to difficulties in using Internet services. Difficulties encountered in using the Internet now, give rise to dissatisfaction with the services. This dissatisfaction relates strongly to the staff’s readiness to explore the further potential of the Internet to help them with project design and management.

Nevertheless, there are practitioners who do make good use of the Internet. Practitioners, when asked, are able to see how useful some of the services they have not yet adopted can be. Some practitioners do have plans to tap their potential in the future.

If it is accepted that the Internet can bring benefits to practices, then ways must be found of overcoming the hindrances. This is important for the efficiency of architectural practice and for its ability to keep abreast of change in the industry. Some possible targets have been suggested by this research, and these are now expanded upon.

The components of the Internet system, including the software and hardware, are in need of regular updating and upgrading. Such procedures enable practices to utilize Internet resources more fully. Setting up and maintaining a system to give a sufficient standard of service would seem to require more funding than small practices can spare. How such a shortfall might be bridged is a matter to be debated.

Architectural staff must learn how better to implement the Internet in project design and management. With the rapid development of the Internet they will need to know, for example, how
to lead virtual design teams and manage remote information and data. It is important to realise that not all staff will manage this without support. The vicious cycle from past inexperience to dissatisfaction and onward to future inexperience, as outlined above, will hold many back.

Support could come from within practices, but present experience suggests that this has been insufficient to date. Consequently, some external support is needed, either through the practice or for practitioners directly. It would seem that the objective should be greater exposure to the Internet, which would build up experience, and help to break out of the cycle. Given a better chance to experience the Internet environment and to become more familiar with it, practitioners will be better able to perceive its benefits for themselves.

The implication is that some part of the necessary support should be delivered over the Internet, in conjunction with appropriate services. However, the present inertia found by the research to the take-up of new ideas over the Internet makes this only a partial route. At the very least, a programme of publicity, guidance and incentives is needed to back up the available support.

The conclusion towards which this line of reasoning leads, is that a lead needs to be taken by an influential organisation in co-ordinating the necessary steps. The professional institutes are the obvious candidates. Whatever the extent of their intervention, their leadership could prove valuable.
References


MAPLE/D: a systematic method for the architect of the future

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Abstract

This paper presents a systematic method for architects of complex buildings tasks working in interdisciplinary groups called MAPLE/D Method of Architectural Planning and Design. MAPLE/D was developed within the framework of an extensive research project sponsored by the DFG Deutsche Forschungsgemeinschaft.

The concept of MAPLE/D is based on

- the think tool of Creative Thinking which claims to separate and simultaneously combine analytical-theoretical and creative synthesising-practical tasks,
- the combination of five developed models: the Scientific Criteria Model, the Stakeholder Model, the Issue Model, the Process Model and the Competency Model and
- a number of methodological tools for the implementation of the models.

The combination of the think tool, the five models and the methodological tools is supposed to help architects managing complex planning and design tasks as well as making them aware of certain competencies, such as Soft Skills and Hard Skills, which they need for applying the systematic method MAPLE/D. This paper gives a detailed presentation of MAPLE/D.
MAPLE/D: a systematic method for the architect of the future

Introduction
A Systematic Approach to a Future-Oriented Planning and Design Method for Architects of Complex Building Tasks Working in Interdisciplinary Groups Called MAPLE/D Method for Architectural Design [1]. The double entendre of the title “The Architect of the Future” is chosen to express that this paper strives for a systematic method for architects who on the one hand plan and design in the future and who thus design the future on the other. Architects who want to work successfully also in the future and who want to be indispensable partners for the client while planning [2] and designing [3] complex buildings in the future have to work in interdisciplinary groups to develop architectural proposals for the future.

Framework
The framework of this paper is an extensive research project on planning and design methods which focuses on ways how architects could systematically develop goal-oriented architectural solutions for complex building tasks – e.g., for social facilities and healthcare buildings (more details in Fendl 2002).

Methodology

Study of literary sources
Initially, the study of literary sources was done to find the requirements made on the architects’ job and to identify issues that determine architecture and that are to be fulfilled. The basic research on the term and the essence of architecture and on the job profile of the architect produced the following central requirements for architects managing their tasks successfully. These requirements have been formulated as a hypothesis.

Hypothesis
To preserve their important role in the construction professions for the future within the planning and design process architects are expected

- to do their work systematically, comprehensibly, independently and reliably,
- to involve all important experts and to consider the stakeholders’ interests,
- to transform all essential issues into an effective architectural proposal,
- to proceed systematically and therefore efficiently and
- to fulfil a co-ordinator’s, presenter’s and mediator’s job as well as to contribute their own specific competencies regarding the creative development of a formally appealing architectural proposal with aesthetic value and
- to support the problem-solving process by using his/her analytical and synthesising abilities (Fendl 2002: chapter 2).

Objectives
To meet all of these requirements simultaneously, the architect is expected to use a systematic method for planning and designing. However, the question still stands: how can such a method be used? This question defines my research objective: The aim of this paper is to discuss a recently developed planning and design method for architects of complex building tasks. Meeting the
requirements mentioned above can be achieved especially by integrating interdisciplinary knowledge of other experts and stakeholders.

Main findings

The criteria catalogue for MAPLE/D
The result of the analysis of literary sources is a criteria catalogue as a basis for the development of future-oriented planning and design methods in architecture. It is thus the starting point for finding ways that support systematic architectural planning and designing. The criteria catalogue includes:

- the Scientific Criteria Model to support the architects to work systematically, comprehensibly, independently and reliably,
- the Stakeholder Model to identify all important experts and stakeholders,
- the Issue Model to record all essential issues completely and to transform them effectively,
- the Process Model to proceed systematically and efficiently and
- the Competency Model to present, co-ordinate the process and to mediate between those involved in the process as well as to contribute the architect’s personal specific creative and formal competencies and
- the principle of Creative Thinking considering the different abilities of the two brain hemispheres as an underlying “think tool”.

Combining these five models with the think tool Creative Thinking, a planning and design method for architects of complex building tasks working in interdisciplinary groups called MAPLE/D Method for Architectural Design can be derived:

The network of MAPLE/D
The idea of MAPLE/D is to provide a grid as an open basic structure. This grid consists of the five models embedded in the principle of Creative Thinking mentioned above and a number of methodological tools that dock the five models (see Figure 1).
This cross-linked network of the underlying think tool, the five models and the methodological tools, forms the heart of MAPLE/D. The methodological tools are named in the following chapter and are to be understood as an offer for the architect while developing an architectural proposal. This modular system works as a direction sign within the process of planning and designing and has to be assimilated to the specific building task. The architect has to prove in each individual case (building task) which of the methodological tools proposed suits his/her requirements best.
MAPLE/D
The detailed presentation of MAPLE/D is therefore carried out as follows: First, the principle of Creative Thinking as a think tool is explained. Then, the models are each described briefly and illustrated with a figure. Afterwards, the features and the objectives of each particular model are commented on and selected methodological tools are assigned.

Differentiation between the terms planning and design
This paper starts from the fact that there is a difference between the terms planning and designing just as between the German terms Planung and Entwerfen (Fendl 2002: chapter 2.3):

Planning (Planung) is defined in this paper as a systematic information processing procedure to develop a goal-oriented architectural proposal (which contains the elements Information and Control and the steps Planning/Design Impulse, Planning of Planning, Formulation of the Problem, Setting the Goals, Generation of Alternatives, Prognosis, Evaluation, Decision and Drawing up the Plan).

Designing (Entwerfen) is a creative process within and simultaneously to planning. Within this process, an unpredictable proposal for a unique architectural object for a certain use and for future construction is systematically or intuitively developed (in advance).

Planning is therefore a rather analytical-theoretical activity while designing is a rather creative synthesising-practical activity. Basically, the activities of the analysis of planning and of the synthesis of designing are inseparable. Both are run simultaneously during the whole process and cover the whole process of planning and designing from the Planning/Design Impulse up to Drawing up the Plan, i.e. the architectural proposal. But both activities, analysis and synthesis are carried out with varying intensity as shown in Figure 2.

![Figure 2: Inseparable Activities of Analytical Planning and Synthesising Designing](image)

The principle of creative thinking
This “inseparable subdivision” of these two entirely different activities is based on the investigation by Linneweh about Creative Thinking – kreatives Denken (Linneweh 1994). Linneweh demands the differentiation between analytical and creative work. The reason for this is that the two hemispheres of the brain work differently: Whilst the left hemisphere concentrates on talking, reading, writing, analysing and logical thinking, the right hemisphere is rather emotional,
intuitive, dynamic, it overviews situations instead of analysing them, it loves art, music, dance and other beautiful things (Weyh 1991: 102).

**The principle of convergent and divergent thinking**

![Intellect Model](image)

**Figure 3:** Structure of Intellect Model by Guilford and Components of Creativity (Linneweh 1994: 15 and 28)

Linneweh refers to Guilford who subdivides thinking into grasping, producing and evaluating thinking (see Figure 3). For the problem-solving process, i.e. for analysing the problem and developing a resolution, the architect is simultaneously grasping, producing and evaluating thinking and therefore needs both abilities of the brain. What the architect needs in the end is – in scientific terms – on the one hand *Convergent Thinking* and *Divergent Thinking* on the other (see Figure 3). *Convergent Thinking* is focussed, logical thinking in considerate, systematic steps. It starts from the *Reality Principle* by Freud. In contrast, *Divergent Thinking* is free, inordinate and visionary thinking which cannot be logically understood. It is based on the *Pleasure Principle* by Freud (Linneweh 1994: 17).

Unfortunately, the working intensity of the two hemispheres varies greatly over time and one cannot control them consciously. At any time, one of the two is dominating the other. In addition, there are right-brained people, whose right hemisphere tends to dominate in general. Of course, there are also left-brained people who generally proceed in a rather considerate and logical way. Therefore this paper proposes to consider this “inseparable subdivision” *consciously* when looking at planning and design method to support the problem-solving process.

A suitable methodological tool for the parallel consideration of *Convergent* and *Divergent Thinking* is the strategy of *Controlled Divergence*. The phrase *Productive Creativity is Controlled Divergence* by Linneweh (Linneweh 1994: 17) points out that creativity is *Divergent Thinking* combined with *Convergent Thinking*, i.e. with controlled thinking.
The approach of Controlled Divergence goes back to Freud who divides the psychic part of humans into consciousness and the sub-conscious. In addition, Freud presents the phenomenon of the pre-conscious as a kind of information memory of own experiences and knowledge. This knowledge is used as a Censor which controls problem-solving procedures (see Figure 4).

Way 1 is the exclusively convergent way, the direct way toward an idea only controlled by the Censor. Therefore, the Censor rejects all ideas which are not yet known to it.

Way 2 shows the exclusively divergent way, the inordinate creative search for ideas. It is not controlled by the Censor and is therefore just as unpromising as way 1.

Way 3 is the combination of way 1 and way 2. After – an uncensored – inordinate creative phase the Censor is used as a control element to exclude erroneous ideas and to identify other possibilities. (Linneweh 1994: 25ff.) In other words: When applying the approach of Controlled Divergence, Divergent and Convergent Thinking alternate.

This Model of Information Processing in Creativity is the basis for the differentiation between the terms and activities of planning and designing.

The scientific criteria model
The Scientific Criteria Model shown in Figure 5 is a normative model that appeals to architects to do their job of planning and designing in a certain “scientific” way, i.e. to follow a procedure which is comprehensible for anyone involved. The aim of a scientific procedure is to produce
architectural proposals which are systematically developed, objectively well-founded, therefore transferable, intersubjectively transformable and last but not least evaluable.

The **Scientific Criteria Model** consists of a normative list of criteria that have to be fulfilled when working “scientifically”, i.e. comprehensibly and rationally. The purpose of this model is to help the architect be conscious of the requirement to work orderly, to give specific reasons for decisions, to provide logically reasoned arguments, to prove the correctness of statements, to give other people involved the opportunity to prove that black is white and to discuss and criticise statements (see left column). In addition, the model is supposed to make the architect aware of the necessity of being independent, impartial, to act value-free, to make the other stakeholders involved understand decisions, to strive for significant, valid and firm decisions (see column on the right).

Methodological tools for the implementation of the scientific criteria model are, e.g. text, diagrams, checklists, questioning (Rogge et al. 1995).
The stakeholder model

The *Stakeholder Model* helps the architect to identify the stakeholders of the architectural proposal. The example of a *Stakeholder Model* in Figure 6 shows stakeholders and groups of stakeholders in the field of hospital design. By detailing or expanding this model again and again, all persons with a *stake* in the architectural proposal can be identified. The model includes users of the future building as well as planners. The identification of the stakeholders is beneficial to discover the information potential and knowledge that any of the stakeholders can provide and eventually to encourage communication and interaction between the stakeholders.

![Figure 6: Example of a Stakeholder Model](image)

The *Stakeholder Model* is based on the *Stakeholder Approach* which is explained by Carroll (Carroll 1989, Jennings, no year: 1-7, Freeman 1984: 25). The *Stakeholder Theory* claims to involve all individual people and groups who have a stake – an interest or a share – in a project (Carroll 1989: 56f.). In this model, the stakeholders basically consist of the two groups *users* and *planners* – and the overlapping group who are called *contributors*. The *Stakeholder Model* helps the architect to identify the specific stakeholders of a project and to include them into the planning and design process in order to ascertain their knowledge and their experiences which are helpful for the development of an architectural proposal. Methodological tools for the implementation of the *Stakeholder Model* are, e.g. tables, graphs, set models, mind maps (Grothe-Sent 1999: 119ff.), stakeholder/responsibility matrix (Carroll 1989: 71).

The issue model

The *Issue Model* shown in Figure 7 contains a basic framework of issues (features) which determine the quality of architecture and which have to be fulfilled to achieve certain goals. These goals are in turn derived from the *Physical* and *Psychological Needs of Users*. The issues need further specification and can consequently serve as a basis for the development of an architectural proposal.
Figure 7: Issue Model

The Issue Model represents the Physical and Psychological Needs of Users which have to be ascertained. The issues which determine the quality of buildings and of architecture, respectively, can be derived from these needs. These issues are Formal Design Issues, Constructive, Technical, Economic, Ecological Issues as well as Building Regulations Issues. The architect must take into account these issues theoretically and transform them practically into an architectural proposal. This procedure of theoretical consideration (= planning) and practical transformation (= designing) is accompanied by a precise progressive refinement of the issues. Methodological tools for the implementation of the Issue Model are, e.g. study of literary sources, questionings, the application of the Building Performance Concept (Preiser et al. 1997), the concept of Total Quality Management (Müller-Böling 1993: 3636ff.) or of the House of Quality (Hauser and Clausing 1988: 63ff., Steed et al., no year: 1-7). The overall aim of the Issue Model is to help the architect draw up a goal-oriented, effective architectural proposal.

The process model

The Process Model in Figure 8 breaks the process of architectural planning and designing down into steps and adds two extra elements. The starting element is Information and the basic element is Control. The key steps of planning and designing in the core of the Process Model are: Planning/Design Impulse, Planning of Planning, Formulation of the Problem, Setting the Goals, Generation of Alternatives, Prognosis, Evaluation, Decision and Drawing up the Plan. The steps cannot be followed mechanically much like a recipe, they are not a recipe for success. The elements and steps are rather supposed to advise contributors and planners which the substantial steps are.
Thus, the *Process Model* supports a systematic procedure while structuring the process of planning and designing. Each of the steps has to be checked to find out if it is essential or unnecessary. But not every step has to be followed one after the other. Far from it. Any step can be taken, skipped or repeated during the planning and design process at any time and if necessary. This is why the single steps are not directly connected in this diagram.

Let us have a closer look at the elements and steps of the *Process Model*:

- The purpose of the *starting element Information* is to gather, record and process information as completely and correctly as possible. Appropriate quantity and good quality of information can be reached, e.g., by using the methodological tools of *Information Technology* or *Empirical Social Research* (Bea et al. 1997: 280ff.).

- The step *Planning/Design Impulse* serves to clarify whether the general decision for a building type at the specific location is right or wrong. To get adequate information at this early stage, the methodological tool *Expert Questioning* (Bischoff et al. 1995: 113f.) can be helpful, for example.

- *Planning of Planning* is supposed to prepare the systematic procedure of planning, designing and including the stakeholders. To consider all important aspects, *Planning of
Planning can be carried out systematically by applying, e.g., the systematic Critical Path Method (Meyer-Meierling 2000: 307).

- The Formulation of the Problem is the precise description of the planning and design task. The methodological tool Cross-Linked Thinking (Grothe-Senf 1999: 106ff.) may be helpful to include all important critical issues and subtasks.

- Setting the Goals is the derivation of goals from the Formulation of the Problem. The goals have to be set as precisely as necessary and as imprecisely as possible to give architects the creative freedom they need for the development of alternative architectural proposals. An example for a methodological tool is Goal Programming (Schierenbeck 1993: 251).

- Generation of Alternatives is the discovery, collection, further development and combination of different resolutions. Systematic Brainstorming Techniques (Bronner 1999: 61f.) may be useful, for example, to stimulate the contributors’ fantasy and to utilise their ideas.

- Prognosis is the forecast of the consequences of the alternative architectural proposals for people and the environment. The methodological tool Delphi Technique (Hansmann 1993: 3551) can be applied to obtain sufficient information, a high degree of certainty and therefore a high-quality prognosis.

- The step Evaluation of the alternative proposals considers the original planning and design task, the problems and the goals to place the alternatives in a certain order. If the architect wants to assess values objectively and correctly, i.e., in a way that is comprehensible to the stakeholders, he/she can apply the methodological tool Value Benefit Analysis (Schulte 1996: 538ff.), for example.

- Decision is either the rational confirmation of the order mentioned above or an independent selection process by a single person or a heterogeneous group. Decision Matrices (Bronner 1999: 56) are a useful methodological tool for making rational, comprehensible decisions.

- The step Drawing up the Plan aims at a clear, complete and correct illustration of the architectural proposal. To avoid misunderstandings, incompleteness and mistakes – and consequently construction deficiencies – precisely and systematically carried out Verbal, Visual and Virtual Illustrations (Fendl 2002: glossary) are particularly helpful.

- On the one hand, the basic element Control supports the feedback monitoring and feed forward guidance. On the other, it supports the effectiveness and efficiency of the procedure of planning and designing. Control is therefore supposed to avoid planning and design mistakes that would cause high expenses unless noticed before the structure is built. Checklists or the methodological tool of Design Control (Fendl 2001), which has been elaborated by the author, are suitable to implement the Control step within the Process Model.

The overall aim of the Process Model is to help the architect be efficient while planning and designing systematically.
The competency model

The models we have presented so far cover the more rational aspects of planning and designing. In addition, the previous models are all more or less instructions advising the architect how to proceed and what to do. But to apply these models successfully within the planning and design process, the architect needs to possess certain abilities. Therefore, the following Competency Model was developed to provide a knowledge grid which contains and describes these abilities. Moreover, the Competency Model represents the rather non-rational aspects of planning and designing in terms of the social structure of the interdisciplinary groups and of the creative and formal design abilities:

The Competency Model in Figure 9 shows Soft Skills and Hard Skills.

- The Soft Skills are derived from the stakeholders, i.e. from the interdisciplinary groups of users and planners, who are supposed to communicate and interact being guided and accompanied by the architect. Therefore, the Soft Skills include the Communication Competency and the Interaction Competency.

- The Hard Skills are derived from the issues which are considered and transformed into a formally appealing architectural proposal. Therefore, Creative Design Competency and Formal Design Competency are mentioned in the Competency Model.

![Architecture-Specific Competency Model](image-url)

Figure 9: Architecture-Specific Competency Model

Soft skills

The basis for any problem-solving activities is communication. Communication is in turn the basis for any group interaction. The essential Soft Skills that an architect should possess are therefore supposed to support his/her task to foster the communication in the form of a presenter’s job and
the interaction within and between the groups in the form of a co-ordinator’s job. The consequently required Communication Competency consists mainly of social competency, problem sensitivity, discrimination, ability of conflict resolution and the understanding and recognition of hierarchies. The Interaction Competency comprises team orientation, organisational talent, motivation, flexibility and the ability to assert oneself. Methodological tools for the implementation of the Communication Competency are, e.g., Presentation Techniques (Wahren 1994: 236f. and Blin 2001: 11ff.) and Meta Communication (Bischoff et al. 1995: 137ff.) for presentations; and for the Interaction Competency these are, e.g., Workshop (Sanoff 2000: 80ff.) and Mediation (Bischoff et al. 1995: 75ff.) which are beneficial to co-ordinate stakeholders.

**Hard skills**

In addition to the interdisciplinary work in groups, the architect works in a design team. This team is supposed to develop a formally appealing architectural proposal. The essential specialised knowledge of the architect – the Hard Skills – should support his/her ability to design. In other words, he/she is expected to transform the theoretical requirements into a practical architectural proposal using his/her Creative Design Competency on the one hand and to develop a formally appealing architectural proposal using his/her Formal Design Competency on the other. Therefore, the Creative Design Competency requires knowledge, intuition and inspiration, gift and talent, creativity and the ability of analytical and logical thinking. The Formal Design Competency of the architect takes a lot of different aspects into account, including the following: expression, aesthetics, proportion and order, space and form and environmental psychology. Methodological tools for the implementation of the Creative Design Competency are, e.g., Map Exercise (Blin 2001: 13ff.) and Semantic Intuition (Warfield et al. 1975) to put the theoretical issues into practice. Useful implements for the Formal Design Competency are Design Games (Sanoff 2000: 76ff.) and Charrette (Sanoff 2000: 48ff. and Healey 1991) which are advantageous for the development of a formally appealing architectural proposal.

**Analysis of existing methods**

After this closer look at the components of the theoretically developed criteria catalogue including the five models, the think tool and the methodological tools, it seems to be reasonable to find out whether there are other methods in architecture which take account of these components. The criteria catalogue is therefore the basis for the analysis of existing planning and design methods for complex building tasks focusing on social facilities and healthcare buildings. The results of this analysis are summarised in Figure 10.
This classification is broad rather than narrow, in other words: if one of the methods deals in the slightest with one of the aspects of the think tool or the models, it has been considered and marked with a diamond. An absolute intersubjective correspondence is therefore not possible. Most of the planning and design methods deal merely with aspects of descriptive planning and design logic rather than with aspects of a normative process-oriented planning and design methodology. In addition, it is obvious that not one of the analysed methods covers all components of the criteria catalogue.

The results of this analysis of existing methods combined with the theoretical findings regarding the requirements of the architects’ job and the features of architecture confirmed the author in her opinion that it could be advantageous to elaborate on the integral approach using the five models, the think tool and methodological tools mentioned above.

**Empirical study**

Therefore, it is planned that MAPLE/D will be empirically tested by architects who will practically apply and evaluate the method MAPLE/D itself and who will also evaluate the architectural proposal to find out whether MAPLE/D is useful for the practising architect. Work on this empirical study which is already being prepared (Fendl 2001 and Fendl 2002: chapter 6), started in April 2002 and will be completed in July 2002. It can be presented and discussed at the conference.
Summary
To sum up the concept of MAPLE/D (see Figure 11) it can be said that the Scientific Criteria Model is a tool to support the architect while he/she develops a comprehensible architectural proposal. The Stakeholder Model helps to identify the stakeholders. The architect's interest focuses on the stakeholders and their needs because they determine the issues. The latter are ascertained by implementing and detailing the Issue Model. The theoretical planning activity analyses the needs and issues, while the practical designing activity synthesises them into an architectural proposal. The basis for this “inseparable subdivision” of theoretical and practical activities is the think tool Creative Thinking comprising Convergent and Divergent Thinking. In doing so, the stakeholders, i.e., the interdisciplinary users and planners, are permanently involved through communicating and interacting with each other. This calls for the architect’s Soft Skills which are shown in the Competency Model. This model goes even further by supporting the practical transformation and the aesthetic value of the architectural proposal: it contains important Hard Skills of the architect, e.g., the Creative Design Competency and the Formal Design Competency. It explains central terms to the architect and provides a corresponding methodological body. With that, MAPLE/D is not only a systematic method for the planning and design process, is also answers the question, how to use such a systematic method, particularly with the Competency Model.

![Figure 11: Concept of MAPLE/D](image)

The overall aim of MAPLE/D is to provide a systematic method for architects of complex building tasks working in interdisciplinary groups, e.g. social facilities and healthcare buildings (see Figure 10), by making the architect aware of important aspects of planning and designing, which is important for the future of the architectural profession. MAPLE/D is therefore an offer for architects to deal with the aspects mentioned earlier, to prioritise in each specific case and to effectively and efficiently plan and design future buildings and thus our future. But only a conscious
architect can make MAPLE/D an effective and efficient tool while planning and designing, because:

“A fool with a tool is still a fool.”

Conclusion and outlook
With MAPLE/D, this paper presents a planning and design method for the architect of the future. The first step has already been made by developing a theoretical normative basis for this method. It is followed by the second step: the evaluation of the effectiveness and the efficiency of the method through an empirical study. Furthermore, the long-term objective of this research project is to develop a knowledge-based database for methodological architectural design – especially for social facilities and healthcare buildings. In addition, the method is meant to be a basis for further research as well as for architectural education. Moreover, this method is intended to be a basis for further discussion among researchers and a starting point for teachers to redesign the curriculum concept in architecture.

Finally, the applicability of MAPLE/D to design professions other than architectural is conceivable to a certain extent: The think tool Creative Thinking comprising Convergent and Divergent Thinking can be applied within any problem-solving process as well as the Scientific Criteria Model. The Stakeholder Model and the Issue Model can be adapted to other design professions with regard to the respective stakeholders and the specific issues, i.e. performance requirements of the “product” to be designed. The Process Model is especially applicable in architecture because of the long-term process and the consequences of architectural planning and designing. The Competency Model is design specific in its way of considering communication and interaction as well as creative and formal design competencies. Wherever these are important issues, the Competency Model might be of help to structure and to overlook competencies necessary for designing. It may be adapted and broadened.

Your comments, questions and proposals are most welcome. Please contact: Monika.Fendl@web.de.

Acknowledgements
This research project on planning and design methods in architecture has been funded since May 2000 by the DFG Deutsche Forschungsgemeinschaft represented by Dr Juergen Hoefeld whom I would like to thank very much for his support. My special thanks go to Ms Katrin Poenisch-Poerschke from the Language Centre of Dresden University of Technology who committed herself greatly to the proof-reading of this conference paper.

Footnotes
[2] The term planning is used synonymously to the German word Planung which covers the analytical-theoretical part of the English term design.
[3] The term designing is used synonymously to the German word Entwerfen which covers the synthesising-practical part of the English term design.


[8] These are the analysed methods which are relevant for the systematic architectural design of social facilities and healthcare buildings:

USA
a = AIA Design Process (AIA Handbook 1994)
b = AIA Design Guidelines (AIA Guidelines 2001)
c = Universal Design (Preiser and Ostroff 2001)
d = Pena u. a.: Programming (Pena and Parshall 2001)
e = Sanoff: Community Participation (Sanoff 2000)
f = Hardy und Lammers: Hospital Planning and Design Process (Hardy and Lammers 1986)
g = Preiser: POE Post-Occupancy Evaluation (Preiser et al. 1988)

UK
h = RIBA Plan of Work (RIBA 1983)
i = NHS: Health Building Notes (NHS HBNs, various years of publication)
j = Inclusive Design (Hall and Imrie 2001)
k = Salisbury: Briefing (Salisbury 1998)
l = NHS: CIM (NHS CIM 1994)
m = DHSS: CAPRICODE (Department Capricode 1986)
n = MARU: Route Map (MARU 1994-2000)

GERMANY
o = HOAI: §15 Leistungsphasen (HOAI 1995)
p = Dirichlet u. a.: Krankenhausbau (Dirichlet et al. 1980)
q = Neufert: Bauentwurfsllehre (Neufert et al. 2000)
r = Barrierefreies Planen und Entwerfen (DIN 1995, for innovative application of the DIN norms see: Schmieg and Fendl 1999a and Schmieg and Fendl 1999b)
s = Schmieg: Zielplanung und Hospital Extension (Schmieg 1997 and Fendl and Schmieg 2001)
t = Joedicke: Entwurfsmethodik und Krankenhausbau (Joedicke 1976 and Joedicke et al. 1995)
u = Lohfert: Methodik der Krankenhausplanung (Lohfert 1973)
v = Ottow: Krankenhausplanung (Ottow 1990)
w = Tsavalos: Grundrissplanung (Tsavalos 1997)
References


Automobile instrument panels for the real world

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Abstract

A design research study was conducted to investigate a topic that many are calling an imminent crisis – the needs of older drivers. Undertaken in conjunction with the Ergonomics and Biomechanics Department at New York University and the Design Department at the University of the Arts in Philadelphia, this study explores automobile instrument panel design and the driving capabilities of younger and older drivers. The study looks at the following factors pertinent to the design of instrument panels:

1) the affect of deterred visual attention on vehicle control.
2) drivers’ abilities to reach for the instrument panel without looking.
3) differences in reach accuracy between younger and older drivers.
4) differences in vehicle control between younger and older drivers.

Forty-eight drivers, aged 20 to 40 and 60 to 80 years, participated. Findings include:

- For all drivers, steering accuracy is impaired when reaching.
- Steering impairment is worse for older drivers.
- Controls both closest and furthest from the steering wheel elicit better accuracy.
- Locating the control by touch, rather than glance, results in more accurate reaches.
- Older drivers are less accurate than younger drivers.
- Older drivers reach faster, possibly the result of driving strategy.
- Errors are systematic - drivers consistently reached too far and too low.

This study was designed and conducted to address the specific needs of a vehicle design team. Recommendations for automobile instrument panel design, as well as design methodology, are discussed.
Automobile instrument panels for the real world

Overview
Since the 1920’s the United States has invested heavily in highways, forgoing alternative methods of public transportation. As a result we have become highly reliant on personal vehicles for a variety of day-to-day activities, and for our personal independence. For most people giving up the right to drive is unthinkable. Unfortunately the highway system was never designed with older drivers in mind. Similarly, automobiles have traditionally been marketed to appeal to our sense of romance and adventure. Few companies have envisioned a way to wed this history with current reality. While driving has generally become safer in recent years, the fatality rate for older drivers is increasing.

The number of older drivers in the United States continues to grow. In 1999 there were more than 11 million drivers aged 75 and older. Forty five percent of people aged 85 and older, approximately 1.8 million, are licensed drivers.

While significant improvements have been made in vehicle safety in recent years the proliferation of in-car electronics has complicated matters. Cellular phones are first among the in-car electronics that have been shown to severely compromise safety (Redelmeier and Tibshirani 1997).

Current instrument panels show that automobile companies have not embraced the concept of inclusive design. Small, black-on-black controls that require extended visual attention are commonplace, and not a proper solution. In personal conversations, automobile component designers admit working without regard to driving tasks or environment. These components are later placed on the instrument panel by the automobile interior designers. The same radio, therefore, may be placed high or low, regardless of button size, reach abilities, visual access or required glance times. The process is inadequate.

Primary controls within the automobile, the basic controls required to operate the vehicle, include controls such as the steering wheel, accelerator and brake. These controls, of course, are accessed by "blind reach", meaning they do not require the driver to glance at them prior to use. Other controls, such as heating, air conditioning and audio controls are secondary and in almost all cases require some level of visual attention.

Driving can be described as an act of “continuous crash avoidance”. Drivers need to maintain forward view at all times. The main risk associated with improper design of secondary controls is the amount of visual attention required to perform the task. Glances away from forward view are possible, but typically will last only 0.6 to 1.0 seconds (Figure 1). Within that time a driver must search, light adapt, focus, obtain the visual information, manipulate, return to forward view, refocus and light adapt. While this is a challenge for all drivers, these processes are typically slowed with age. Therefore while deterred visual attention is a problem for all drivers, older drivers are more affected.
Figure 1: Glance length. While driving, a typical glance away from the forward view lasts between 0.6 and 1.0 second (adapted from Wierwille, 1993).

**Goals**
The following questions were addressed in the study:

**Steering Accuracy**

1. Is steering accuracy affected by in-vehicle reach tasks, and to what extent?

2. Are drivers of different ages affected differently (i.e., will steering accuracy for older drivers be more severely affected when compared with younger drivers)?

**Accuracy of reach**

3. Is reach accuracy a function of the distance to the control on the instrument panel? That is, as the reach distance increases, will accuracy worsen?

4. If the driver locates the control through touch (by touching it, returning the hand to the steering wheel, then reaching again), will the reach be more accurate than locating the control by glance?

5. Will older drivers demonstrate poorer accuracy than younger drivers?

**Motor reaction time**

6. Will older drivers exhibit significantly slower movements than younger drivers?

**Methods**
Forty-eight drivers, aged 20 to 40 and 60 to 80 years, participated in the study. Each age group included 12 males and 12 females. The drivers were asked to operate a driving simulator, steering through a predefined course. The driving simulator positioned the driver on the left, as standard in the US. While steering, various reach tasks were performed with the right hand to the instrument panel. The instrument panel area was divided into a grid of twenty-five points, five columns across and five rows high, spaced 100 mm. apart. These points represent possible placements for push buttons or other controls on the instrument panel. The two lowest targets in the column closest to the steering wheel were eliminated because the driver's knee would occupy this area, resulting in a total of twenty-three targets. Only one target was visible at a time, made possible by back lighting.
the target. Drivers were asked to glance and reach for the target at various times during the driving simulation.

For each of the twenty-three targets drivers steered by following a 90-second driving simulation. Drivers were asked to reach using two methods of locating the target. In one method, drivers glanced at the target, then reached for it without looking. In the second method drivers looked at the target, placed their finger on it, and memorised it's location through touch. Their hand returned to the steering wheel, and they were asked to reach for that target without looking. Both methods could be expected during real-world driving. Each subject underwent two practice sessions prior to data collection.

The simulator, along with instrumentation developed specifically for this study, collected information on steering accuracy, reaction times, hand movement times and reach accuracy. The data was plotted to help visualise the results and display differences and patterns. It was then analysed to quantify the difference and show statistical significance for a number of variables.

**Results**

**Steering Accuracy**

For younger drivers, when glancing at the target, steering accuracy worsened by 40% (relative to their baseline performance, with both hands on the steering wheel and eyes on the road ahead). When reaching for the target without looking, eyes on the road ahead, steering accuracy worsened by 49%.

The steering accuracy of older drivers was affected to a greater extent by the glance and reach tasks. For older drivers, these numbers were 53% and 65%, respectively.

When the younger drivers were asked to touch and hold their finger on the target, steering accuracy worsened by 40%. When the younger drivers then reached for that target without looking their steering accuracy worsened by 49%. For older drivers, these numbers were 78% and 52%.

This answered both questions falling under the category of Steering Accuracy. For both age groups, steering is adversely affected during glance and reach tasks to the instrument panel. Older drivers are more severely affected than younger drivers.

Statistical analyses showed these results to be highly significant. The results of the Analysis of Variance for the effects of Age Group, Subject (nested within Age Group), Target Location, and Steering Sequence show that glance and reach tasks had a significant effect on steering accuracy (p < .0001). The effects of Age Groups, Individual Subject Performances, and the Target Locations were also highly significant (p < .0001). The Tukey-Kramer test indicated that the steering accuracy during each of the four glance and reach tasks was significantly different from the baseline steering performance.

In comparing the steering performance, Analysis of Variance showed differences between younger and older driver groups to be significant at p < .0001.

**Accuracy of reach**

Results show that reaches to targets closest to the steering wheel were most accurate. Accuracy worsened as reach distance increased. However, in some cases accuracy improved at the furthest
extent of reach. Reach accuracy is plotted in Figures 2a and 2b. The steering wheel is shown as a grey circle. The twenty-three targets are located at the intersections of the grid, spaced 100 mm. apart. The driver's knee occupies the position of two lower grid point closest to the steering wheel, therefore those targets were not included. Reach accuracy is plotted using ellipses. Based on the obtained results, each ellipse encompasses the area in which 90% of reaches can be expected to fall.

Figure 2a: Reach accuracy for younger drivers. The intended targets are at the intersections of the grid. The ellipses indicate the area encompassing 90% of the reaches made to that target.

Figure 2b: Reach accuracy for older drivers. The intended targets are at the intersections of the grid. The ellipses indicate the area encompassing 90% of the reaches to that target.

As a group, older drivers were less accurate than the younger drivers, indicated by the larger ellipses in the diagrams. Although the intended targets are located at the intersections of the grid, it can be seen that the actual hit locations tended to be low and to the right. The centres of the ellipses
represent the average locations of the reaches, and for all ellipses the centres show drivers reaching too far and too low. In addition, it is typical for a pushbutton on an instrument panel to be as small as 10 mm. wide, even smaller in some cases. Audio controls, for example, tend to be minuscule. Superimposing a 10 by 10 mm. button over the ellipse diagrams would indicate how inaccurate the reaches would be.

A series of ellipse diagrams were generated. They indicate that reaches were more accurate when drivers memorised the target position by touching it, then reached for the target again without looking. Locating the target visually, and then reaching for that target without looking, resulted in less accurate reaches.

Results from the statistical analysis show that accuracy as a function of reach distance, the method used to locate the target (by touch or by glance), and the differences between age groups, were all highly significant (p < .0001). Reach accuracy was better for shorter reach distances, for reaches in which the target location was detected by touching the target, and for reaches performed by younger drivers.

**Motor reaction time**

Many studies show a slowing of movement with age. It was therefore expected in this study that older drivers would reach more slowly than younger drivers. The results, however, show the opposite to occur. Older drivers demonstrated faster reaction times than younger drivers. Median motor reaction times were faster for older drivers by up to 0.15 second when compared with younger drivers.

The median motor reaction times for younger drivers were 1.07 seconds when targets were located by touch, and 1.18 seconds when targets were located by glance. For older drivers, times were 0.95 seconds and 1.03 seconds respectively. These differences were highly significant, at p < .0001.

Fractions of a second can be meaningful when driving. A vehicle travelling 88 kilometres per hour (or 55 miles per hour, the standard speed limit on many roads in the US) would travel approximately 3 meters (almost 10 feet) in 0.12 second.

It is possible that the difference in reach times between younger and older drivers is a function of driving strategy. Older drivers were more affected by the challenges of divided attention. Steering accuracy worsened appreciably when older drivers performed reach tasks, being affected to a greater extent than younger drivers.

Older drivers may have been less confident when performing the reach tasks, and may have compensated by reaching more quickly in order to return their attention to steering, placing both hands on the steering wheel as soon as possible for better control.

**Discussion**

The reason for comparing drivers in different age groups is certainly not to develop separate age-related vehicles – it is difficult to imagine a car being successfully marketed for “older drivers”. The two age groups were selected to help vehicle designers understand the needs of both younger and older drivers. Driving abilities fall along a continuum, and individual capabilities vary. The division into age groups is intended to determine general trends. Within each group, a wide range of abilities was demonstrated.

Highway injuries and fatalities are daily occurrences and driving safety is a primary concern for all drivers. Proper handling of a vehicle requires constant visual attention. Even so, attention to
secondary tasks within the vehicle is inevitable. Among other distractions, heat and ventilation controls, audio systems, cellular phones and electronic navigation systems all vie for attention. The development of instrument panels that reduce or eliminate the need for visual attention is a worthwhile goal. The advantages have been verified by the results of this study.

Driving requires constant visual attention. The findings from this study show that all glance and reach tasks performed by drivers, regardless of age, resulted in a loss of steering control. This fact alone implies that, to improve safety, vehicle manufacturers need to design instrument panels that reduce the amount of visual attention and reach required. Wherever possible the need for visual attention and reach should be reduced or eliminated. This would maximise the time that drivers are able to command the vehicle with both hands on the steering wheel and eyes on the road ahead.

Steering accuracy for older drivers was more severely affected, and considering the increase in the number of older drivers in the coming years, this is rather disconcerting.

In exploring reach accuracy, this study found that, in all cases, younger drivers reached more accurately than older drivers. This finding is consistent with a number of other studies on age and proprioception (the ability to accurately position body segments without visual assistance).

Push-button controls on automobile instrument panels come in a range of shapes and sizes. Audio controls tend to be the smallest, sometimes as small as buttons found on desktop calculators, spaced approximately 15 mm. center to center. Neither the younger or older drivers were able to consistently reach within this level of accuracy. If the design objective is to reduce the amount of visual attention, these designs are not appropriate for automobile instrument panel components. In designing proper controls, older drivers present the greater challenge, since they demonstrate less accuracy and larger variation of reach to all areas of the instrument panel.

The faster reach times performed by older drivers contradict presumptions that would be inferred from other studies that show older subjects to be slower. Brogmus (1991), Greateorex (1991), and Stelmach and Nahom (1991) all point to slowed movements with age. Brogmus asked subjects to “be accurate in hitting the target and at the same time maintain maximum speed” Greateorex asked subjects to reach as fast as possible. Stelmach reviews a variety of studies that emphasise speed of movement. Walker, Fein, Fisk and McGuire (1997) found older drivers to be slower in making decisions while driving. These other studies were not conducted in the same context as the current study, however. The instructions in the current study were not to react as quickly as possible, but to reach accurately while maintaining steering accuracy on the driving simulator. If task strategy plays an influential role in motor reaction time, then expectations of slower performance by older subjects need to be reconsidered. Predictions based on tasks that concern the effects of age on the speed of reach movements may not be applicable in real-world situations. Speed of movement, as observed in this study, can be dependent on other the tasks being performed. This study may be unique in that respect. Comparisons with movement time studies that do not include dual tasks would be unfair.

These results may not be applicable when the context is different. This study investigated hand movements in a simulation of normal driving and did not investigate emergency situations. The results seen here may not apply to emergencies, where the younger or older driver’s strategy would be to reach as quickly as possible. Based on the findings of others, it is likely that younger drivers would be faster in emergencies. However, emergency response was not addressed in this study.

The implication on design methodologies should be clear. Instrument panels, controls and displays should only be designed in the context of driving. The risks associated with glances away from forward view, and with divided attention, need to be considered.
Two factors are pertinent: 1) consumers are placing more value on automobile safety, and 2) drivers are getting older. The next step will therefore be to refine design methodologies and solutions that can lead to better, safer automobiles. Small black on black controls that require extended visual attention and reach times need to be eliminated. Radical redesign may be required. The concept of flat instrument panels, dependent on visual search and reach from the shoulder, has been standard practice in the automobile industry for decades. This solution needs to be reevaluated.
References


Designing within a computer-mediated-communications environment: a current investigation.

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Abstract

This paper describes ongoing research that is located within the context of the changing culture of the design classroom and the rapid growth in the exploitation of telecommunication networks on teaching and learning. The research investigates the use of ICT for international collaboration in the design classroom and the implications this might have for design curriculum development. Design education could benefit from the 'added value' of communication technology as could design students from being exposed to cross-cultural and international perspectives. If developing technology is to impact successfully on educational design practice then design teachers need to adopt a professional attitude towards the use of ICT while students will need to develop skills and abilities to deal with it for learning and research. Developments such as computer conferencing already offer alternative pathways for collaborative activities and group-to-group collaboration is now possible at a distance and encourages shared experience and co-operation. Incorporating aspects of this technology into design education could develop students’ cognitive abilities in making decisions, problem solving and being flexible in formulating ideas and handling information (Goodfellow & Kukulska-Holme, 1996).
Designing within a computer-mediated-communications environment: a current investigation.

Introduction
This paper describes ongoing research that is located within the context of the changing culture of the design classroom and the rapid growth in the exploitation of telecommunication networks on teaching and learning. The research investigates the use of ICT for international collaboration in the design classroom and the implications this might have for design curriculum development. Design education could benefit from the 'added value' of communication technology as could design students from being exposed to cross-cultural and international perspectives. If developing technology is to impact successfully on educational design practice then design teachers need to adopt a professional attitude towards the use of ICT while students will need to develop skills and abilities to deal with it for learning and research. Developments such as computer conferencing already offer alternative pathways for collaborative activities and group-to-group collaboration is now possible at a distance and encourages shared experience and co-operation. Incorporating aspects of this technology into design education could develop students’ cognitive abilities in making decisions, problem solving and being flexible in formulating ideas and handling information (Goodfellow & Kukulska-Holme, 1996).

Late modernity requires openness of mind and a continual re-evaluation of assumptions and frameworks of knowledge. A critical design education could provide the reflexiveness that the complexity of modern society deserves. Although it may be uncomfortable for teachers, design students need to test ideas and themselves with critical evaluation in a collective environment. Design educators should provide an educational environment in which students acquire critical capacities not taught but won by the students. Consequently design educators should provide for a pedagogical environment that allows for epistemological space and personal space as well as practical space (Barnett, 1997). Critical perspectives need critical frameworks and so design educators should organise pedagogical practice that relates to contemporary design practice and the increasingly global world. Despite the growth in the use of computers within education over the recent past the large scale uptake of computer-based techniques for teaching and learning has only recently begun to occur. This research could contribute to the development of effective methods for incorporating ICT into future collaborative design group work projects. The introduction of ICT into the classroom could alter the pattern of design education. At the same time by introducing alternative sources of authority, via the Internet, and multiple frameworks of knowledge, through multi-disciplinary collaboration, it could enhance design students learning.

The research question
The results obtained from the first stages of this research indicate that the introduction of international collaboration into the design curriculum, bringing with it a global and multicultural perspective, motivates design students (Fraser, 2001). Computer mediated communication (CMC) by ‘collapsing’ space make international collaboration more feasible in joint design projects by allowing students who might otherwise be unable to meet, to share ideas and work together. This research investigates design students design-making while using CMC for communicative interaction. In order to reflect the contemporary design context as well as the increasingly global nature of teaching and learning the students were drawn from internationally disparate educational institutions. While acknowledging the importance of cultural difference on international collaboration this research focuses on how design students go about negotiating meaning and making decisions as they generate ideas and develop artwork for a design brief. The research investigates the collaboration between design students when working on joint projects at a distance via technological interfaces including 'Blackboard' and other audio and visual links. Specifically the
investigation examines how and when group decisions are made during the period of the collaboration and assesses the effectiveness and efficiency of the students social interaction and collective performance to this end when using CMC in their project work. Communicative interaction can be thought of as the changing relationships which occur between internal states and sets of intentions as the students gather information, discussion and ideas are generated, sketching and reflection takes place and solutions are arrived at by the design groups. Data-collection is designed to elicit students understanding of their own communicative interaction while designing and their descriptions of how they negotiated meaning collaboratively through their actions and behavior.

The primary and abductive part of the designing process often involves brainstorming sessions, group discussions of a tangential nature and general playing around with the most unlikely of ideas. Can designers being able to access on-line information and participate in on-line discussion forums using the Internet enable the process of abductive reasoning? Can designing strategies be enhanced through the collaboration of different minds from different positions in virtual space by resolving their different definitions of the problem and working together to come up with a joint solution? It could be considered that contemporary designers have obvious advantages in researching sources via the Internet and then engaging creatively with their material through collaborative use of digital technology to produce design solutions. One could question the influence of the development of virtual interactive and collaborative spaces on this secondary solution-focusing stage of the design process. Can the nature of non-verbal modes of reasoning be altered by interaction with design group members in on-line environments and collaborative working through shared online use of ICT?

The methodological approach of the research

The approach that was adopted for this research is intrinsically linked to the aims for the study and the research questions and has been influenced by the work of Asimov, 1926; Rowe, 1991; Cross et al, 1994; and Scrivener and Vernon, 1998. The research is essentially interpretative and involves a detailed analysis of aspects of the social interaction that the students engage in while working on their collaborative projects. The methodology focuses on context and meaning and uses a holistic approach that recognises that what happens in the classroom generally has complex layers of meaning, interpretation, values and attitudes. However it has been suggested that there is no single best description of what might be happening in the design studio and that the selection of what is seen or recorded might be influenced by the purposes which the description is to serve. Therefore participant observation through reflective journals and semi-structured interviews was used. This allows for qualification of actions, ideas, values and meanings through the eyes of the participating students. The research stance hypothesises that the reality of designing is subjective and multiple as seen by the participants in the study. Consequently the research adopted a basically qualitative and ethnographic methodology.

Interaction is an important element in this research and the relationship that exists between the tutors and the students is informal, value-laden and biased. This approach lends an essentially interpretive ontology to the research in which the act of designing is regarded as the product of processes through which the students together negotiate the meanings and understandings that underpin their design actions and processes. As they develop solutions to the design problem each student group record: the means and extent of their collaboration; the amount, type and quality of their communication; and the contribution and integration of their design ideas. The research focus is on the way design students go about negotiating meaning and making decisions as they generate ideas, develop artwork and focus on solutions to a design brief. The initial questionnaire established the students past experience, skills and attitude toward using blackboard as a communication medium. The final questionnaire concentrates on concrete details of their experience while working
on the project. The videotaped interviews focus on encouraging the students to reflect on the meaning for them of the project experience. Each of these three stages provides a level of detail that helps to illuminate the next stage. Epistemologically knowledge about designing is derived from the students’ re-descriptions of their role in the design process. Participant observation is used to gain insight into the activities taking place through students’ descriptions of the sequence and timing of their activities. Qualitative discourse analysis through structured interpretation of language is made of recordings of ‘on-line’ and taped discourse to evaluate the communications stratagems developed by the groups and how meaning is negotiated. An initial analysis of the data focused on identifying common themes and categories related to design process stages. The identified material was further analysed and coded and compared to the information obtained from a quantitative analysis of the questionnaires. Methodological triangulation was used to ensure some substantiation of the data collected from the different instruments.

The research design
‘DesignLinks’ is the title of a collaborative design program currently involving nine universities in five countries. The first stage of this program focuses on designing within a CMC environment. It does this by: investigating the collaboration between design students when working on joint projects at a distance via technological interfaces including ‘Blackboard’ and other audio and visual links; assessing the behavior of groups of students to using CMC in their project work; and by questioning the effectiveness and efficiency of their social interaction and collective performance when engaged in the work. Junior and Senior Design and Communication students from the University of Nebraska at Kearney (UNK) and Richmond American International University in London (RAIUL) took part in the first stages of this research in the spring of 2001. The research compared the communication and collaboration that took place between co-located pairs of students working on the same campus and distributed pairs who were assigned to work ‘at a distance’. The program’s curricular objective was to give design students the opportunity to produce artwork for a four-week course project while working collaboratively across national and cultural borders. The research objective was to examine the decision-making involved during idea generating and solution-seeking. Primary data gathering methods consisted of a student questionnaire, students systematic recording of their ‘on-line’ discourse and collaboration and video taped semi-structured interviews. An analysis was made of the various design and communication stratagems developed by the groups. The brief for the graphic design project required each team to collaborate to gain approval for their proposal, organise logistics, communication, and individual responsibilities and develop final artwork. Each group collaborated using proprietary computer-conferencing software set up on Richmond's server. This allowed them to e-mail, use discussion lists, use a whiteboard and exchange graphic files. A web page on the RAIUL web site was set up to serve as a portal for the project. This page included a hyperlink that connected the student design groups to the DesignLinks web site.

A summary and analysis of the data from the first phase
The students were asked to complete on-line questionnaires at the start and end of the project. Questions were set identifying the students, their discipline area and their assessment of their computer skills and previous experience. This section was followed by sets of questions dealing with the perceived usefulness of ICT at various stages in the design process, student assessment of facilities available and finally student attitude towards the use of ICT (see figure 1).
Figure 1: The questionnaire

The responses from six distributed groups and six co-located groups were analysed. On comparing the distributed groups (D) to the co-located groups (C) certain significant differences can be established (see Table 1). The C groups opted for ‘Blackboard’ being most useful during the initial stages of problem identification and idea-generation whereas the D groups who had to rely on using it felt it came into its own during the later stages of verification and finalising the artwork. The C groups tended to use ‘Blackboard’ even when working together in the same studio. This might be attributed to the fact that the project emphasises communication, deadlines for the project were tight and ‘Blackboard’ allowed students to continue developing their projects outside class times. At the same time the C groups did not have the problems of time differences and benefited from initial communication being verbal and face-to-face. A frequent comment from D groups was the difficulty in fixing meeting times due to time differences, different class times on each campus and so the different deadlines. Although the D groups expressed more prior experience it was the C groups who rated their computer skills higher. This may have something to do with a more realistic assessment on the part of the D groups about the demands of the collaborative project.
<table>
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<tr>
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<td>Developing idea</td>
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<td>Executing idea</td>
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<td>Use Bb if co-located</td>
<td>.17</td>
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<td>Add features</td>
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<td>Improves design skills</td>
<td>.17</td>
<td>5</td>
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Figure 2: Averaged responses of the six distributed and the six co-located groups. (Values range from 1 indicating the most positive response to -1 the most negative response)

The questionnaires from both phases indicate that the students considered the lack of face-to-face contact most problematic. This was also identified as a major concern in the semi-structured interviews (see below). Students were less bothered about the question of anonymity. This contrast with many studies where the fear of not being able to cope with the equipment and therefore looking stupid to your peers is often quoted. Generally however they were less positive about the notion that ICT provided easy communications. Surprisingly, given the popularity of the Internet for researching information only a minority of students used this facility during the projects. This might however simply reflect the tight time scale and subject matter of the project. Interestingly both the C and the D groups felt the project was very exciting, not in the least frightening or a waste of time. They felt ‘Blackboard’ was easy or very easy to learn and was of positive benefit in improving their designing skills. The D groups were much less confident initially in their computer skills that might indicate a concern about using computer-mediated-communications (CMC). After working on the project eighty-five percent agreed that using ICT would improve their design skills. Interestingly eighty percent of both C and D groups would use ICT even when collaborating in teams on the same campus. Most students were not concerned about showing themselves up when
using the equipment and felt positively about sharing Internet research and very positive about working jointly on the artwork.

The D groups were very positive in suggesting that ‘Blackboard’ was of most use during the second and third stages of the designing process while being negative about its use in the early stages. This contrasts with results from the C groups where the students felt it was most useful during the early stages. They expressed a negative feeling to the idea of using ‘Blackboard’ for collaboration if the team were co-located perhaps reflecting some frustration about their experience with the application.

There was a quite a lot of agreement among all students about the central question. Most agreed that ICT was neither frightening nor a waste of time and were supportive of the idea of using ICT in design work. They felt positive and excited about the benefits ICT might have for developing and communicating ideas. What was most striking was the similar attitudes that all students whether working together or at a distance held. In general they all felt that using ICT benefited their design skills and supported incorporating ICT into their design studies.

A set of categories was devised to code student activities such as reflection, decision making general discussion, informal conversation, brainstorming, and idea-generation, sketching and drawing. The students were asked to keep timed and coded observations logs of those various activities they engaged in during the problem-solving process. The advantage of this sort of log is that it records the sequence of major events although it omits minute-by-minute detail and other real time variations in design behaviour.

Figure 3: The activities sheet.

The data gathered from the activities sheets was inconclusive. Records were either produced later on reflection or were sketchy. Sometimes they were summations of total activity ignoring either sequence or short intervals of activity that might have highlighted their thought processes during the design process. In other words the detail of the collaborative nature of the work was often recorded as for instance ‘half an hour spent e-mailing during the first week’.
Students were asked to list their timed activities sequentially as well as completing a graphic representation. Graphs illustrating each student’s activities were produced. However an analysis of the time sheet graphs would not support the idea that problem solving can be explained adequately by observing the participant’s measurable and replicable patterns of physical behaviour. Rather the random and different sequences of activity recorded by the students in this study would support Rowe’s (1991) assertion that designing is a complex business influenced by the initial constraints of the problem and sometimes by the personal attitudes of the designers (see Diagrams 3, 4 & 5 below).

Figure 4: London – Nebraska Link: Time Sheet of a Distributed Group. Note the regularity of movement between partner discussion and use of software.
Figure 5: London – Nebraska Link: Time Sheet of a Co-located Group. Note the irregularity of pattern between the group members.

Here is one example of one distributed groups use of the chat room. It highlights some of the difficulties the students were having with their communications and with the technology: It is also one example of the way students went about their work.

• Joe,
  I am on-line and trying to get in touch with you. It is 7 my time. I am going to scan the CD cover and send it to you. Write back if you get this. [1 Message]
[All]
• April,
  I am here now as well. It is 12:30 Wed. The message you sent may be from yesterday, I did not get here until later. I could not see your ideas, (I'm sorry if you keep hearing that, I am not sure which message will get to you) it would not let me view them through Blackboard, and when I downloaded them, the programs had trouble recognizing the file type. I'll try again. Joe [No Messages]
• Monday....1:15
  I am now online it is Mon at 1:15. The virtual classroom is not opening up fully for me. I sent you some preliminary ideas. The X looking pict I though could be reversed out to emulater spotlights, with the background a solid color. The type shown on some is very rough, but Dave uses a lot of san-serif font. Also, picture the hand idea as degraded by copying the black and white image of someones hand upraised, as in cheering for the band, but degraded by photocopying it, taking that image and degrading it further (by crumpling or folding the copy) then running that damaged image back through the copy machine. Each time it goes through it will get more unrecognizable until it becomes almost a texture that will 'diffuse' into the background (Saying we decide on a black background) I will send you an example. Anouther thing is that sence we are both from the States, My instructor asked if we design the poster for a concert in London, or surrounding area. Maybe if you have an idea how concert posters might differ in their appearence from here that would help. Also, any info on a concert
hall or event we could use locally to have this show be held in would be needed. I'm gonna try the virtual classroom one more time...It's 1:35 here.

* Tues @ 1pm
* April,

Did not see you in pogo. Thats alright I think I confused you a little with that long explanation. I am sending you some more work on a further idea from one of my thumbnails. Any word on information for a concert event in your area for Dave Matthews? Or a location for a show we may want to invent? Let me know please. Anyway I will remain online for awhile today. If you read this write me back on the discussion board, this computer does not have java, i guess, and will not connect to the classroom. Joe

* Problem

I did what you said and downloaded the files. The file types are photoshop '.psd'. Photoshop will not open the files saying that there is not a suitable graphics importer. I then tried picking the application to download to (photoshop) and was told that the files are invalid. I honestly do not know why they are not opening. The case was the same when I downloaded and tried to open them at my home system. When the files I sent are opened, they are viewed directly in Blackboard. Please see if there is something we may have overlooked. Try clicking on your files and see if they work for you there. I would like to see them. I will also send some images of the band and what I have been working on as well. Could you try saving a copy of the files as a TIFF and attach to an e-mail to my hotmail account, that way I could at least view it there. Thanks Joe

* Virtual Class

It is Fri Apr 20 at 12 noon. The Virtual classroom will not open here at school. Cannot talk in real time. Check the file exchange for files.

Figure 6: Example of a discussion board debate.

Unlike the example of group collaboration illustrated in figure 6 above many students did not make enough effort to set up synchronous and asynchronous communications until late into the project.

Another way of understanding the students’ collaborations is through the semi-structured interviews, which afforded an opportunity to gain valuable insights into the business of designing which was not necessarily available through observation. The interviews contained information that is rich both in its depth and in its detail. It allowed the students to expand on their ideas, explain their views and identify what they regarded as crucial in their designing activities. At the same time the interviews allowed the students the opportunity to give a detailed record of their rationale thus providing greater insight than simply observation of surface activity. Examples of questions are: How positive did you feel in using CMC for designing at different periods during the projects? How confident are you with CMC as a medium for exchanging and developing ideas? Can you describe how the project developed? The data obtained from these interviews were assessed in an attempt to identify the views, ideas and attitude of the student to the advantages and limitations of working collaboratively either face to face or at a distance. The data obtained were examined to identify themes and categories that would relate to the research questions. The categories and themes that were used were students’ identification of problems, students’ identification of benefits, these problems or benefits related to identified stages in the design process, students’ attitudes and behaviour when working on the project, students’ opinion as to how the project developed.

The students were less bothered by there being only digital forms of communication. At the same time the students were keen to have some form of visual contact such as a digital camcorder facility. In the interviews many students talked about the difficulties, particularly at the beginning.
of the project, of being able to establish a necessary relationship and get across their varying points of view. Some students indicated that they were not too concerned about having immediate feedback on their ideas. However this was at odds with most students who said that their greatest difficulty was not being able to communicate directly with their partners. This attitude was confirmed in the interviews where again the students expressed frustration about a lack of immediacy and the difficulty with CMC when trying to develop their ideas together. They were much happier about facilities for exchanging artwork. The file exchange facility was identified as both one of the most used as well as the most preferred facilities. E-mail was the other popular communicative device. However these are both generally asynchronous methods of communication and one extra facility that many students identified as necessary was some form of easy to use synchronous chat device. For reasons mainly to do with time differences and different class days most students found the chat room facility difficult to use. However some students managed to work with the chat room facility successfully. There was a significant difference in opinion between co-located and distributed groups as to when CMC was most useful. Most co-located groups felt happy using it during the earlier stages. Sara, a Richmond co-located group member, when asked about when ‘Blackboard’ was of most use during the project, said:

‘I think maybe at the beginning stages where you’re coming up with ideas and you’re both (sic) are coming from two separate ideas. At the end we ended up working together side by side and that was our most productive time (sic) is when we were sitting at two computers side by side working together’

This was typical of most co-located students who found ‘Blackboard’ very useful for communicating their ideas in the time between classes and for research but used it less and less in the later stages of their work. Again Justin another co-located student said ‘during the week Deidre and myself we don’t have any other classes together, we don’t live in the same dorm, so we would be able to communicate by going on to Blackboard but we found ourselves on it for a good amount of time. I think it worked well. It helped us out a lot Justin went on to say that in the later stages they spent most of the time face to face finalising the work.

This use of ‘Blackboard’ contrasted quite significantly with Richmond students who were in distributed groups working with a partner in Nebraska. Julia identifying a common complaint from distributed groups about using computer mediated communication for collaborating in this kind of creative work said

‘we couldn’t just sit down face to face and talk to each other. It took maybe about two or four or five e-mails back and forward – ‘do you like this’ or ‘do you want to do this’ which made it kind of difficult. Maybe a five or ten minute conversation took us about two weeks.’

and Shannon was more explicit about using ‘Blackboard’ in a distributed group saying

‘I think definitely at the end. That’s when it works out the best when you sit down and exchange thoughts. At the beginning, at the very raw stages – just a pain.’

Students from both RAIUL and UNK described an increase in their levels of interest and motivation when working on the collaborative projects. This is supported by findings from a range of research including surveys and evaluation studies undertaken in the early to mid nineties evaluating the use of CMC in education in the UK (Starling, 1994; Schnurr & Smith, 1995; Mumford, 1996; Howard et al 1996). These studies found a lessening of problems of social isolation and students being keener after the introduction of communication software into the classroom.
One student described the excitement that many of the students reported about being involved in the project.

‘File Exchange Oh Yeah that was a big help with us because its so much faster and easier than e-mailing. Just drop the image in and it comes right up on her screen and she can see it. Oh Yeah and we had the chat on at the same time. The virtual chat room chat. Oh Yeah ‘I like that one that you did’ or ‘No maybe that could be changed a little bit’. Just back and forth. We had so many images. Like I’d alter one Drop it in. She’d look. Alter it. Alter it a little bit more and drop it back to me. That was very convenient very fast.’

The interviews did not seem to support some findings from previous reports which indicated that students will often erect resistance barriers when dealing with CMC in an attempt to avoid the fear of looking stupid to their peers when encountering problems with the interface. Similarly the students did not report worries about breaking the equipment, or being spied upon when they were effectively in a private study situation (Goodfellow & Kukulska-Hulme, 1996).

The weakness of the time sheets as a method of data collection was carried over into the second study. It might be that the design for future work reconsiders the appropriateness of using this data collection method. Recording of e-mails of some of the groups produced a comprehensive record of their communications, which was of interest in illustrating the way they began to overcome distance in developing ideas and a body of work. This data collection might be of greater relevance than time sheets. It might be sensible to include written material handed in by the students as another source for collecting data in future work.

**Conclusion**

What is common to all research is the goal of being able to apply the findings of the research undertaken to other contexts, to enhance its generalisability, to predicate from a particular sample to a larger population of which the sample is representative. I hope that as a result of this ongoing research a little more light may be shed on the processes and procedures involved in designing. The results so far indicate the potential of information and communication technology (ICT) for design and designing. The continuing research will focus on designing as a social process. Stumpf and McDonnell (2002) suggest that the design process dynamics for the social process paradigm highlight a move towards a consensus through an argumentative process. This they say results in a design method comprising of negotiation and conflict resolution which results in completed designs which realise collective approval. Initial results indicate that one of the ways that design students can develop their decision-making skills is by participation in collaborative projects using computer-mediated communication.
References


Theory construction in design research. Criteria, approaches, and methods.

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Abstract

Design involves creating something new or transforming a less desirable situation to a preferred situation. To do this, designers must know how things work and why. Understanding how things work and why requires explanation, and it sometimes requires prediction. To explain and predict, we must construct and test theories.

Theories are propositions or sets of propositions that allow us to analyze or explain subjects. Some theories are complex and sophisticated. Others are simple.

Theory can be described in many ways. In its most basic form, a theory is a model. It is an illustration describing how something works by showing its elements in their dynamic relationship to one another. The dynamic demonstration of working elements in action as part of a structure distinguishes a theoretical model from a simple taxonomy or catalogue. A theory predicts what will happen when elements interact.

Understanding design process and design outcomes now implies the kinds of theory construction common in the natural and social sciences. This paper argues that successful design is inherently theory-rich.

The paper outlines a framework for understanding theory construction in design. This framework will clarify the meaning of theory and theorizing. It will explain the nature and uses of theory as a general concept. It will propose necessary and sufficient conditions for theory construction in design. Finally, it will outline potential areas for future inquiry in design theory.
Theory construction in design research. Criteria, approaches, and methods.

Definitions: design, research, theory
Before addressing the theme of theory construction in design research, it will help to establish a few basic definitions and parameters. These definitions are not complete and all-inclusive. Rather, they establish terms as I use them in this paper. Establishing clear definitions also encourages reflection on central themes in theoretical inquiry, and each definition is supported by references to multiple sources.

Clarity is important in understanding theory. Theoretical sensitivity and methodological sophistication rest on understanding the concepts we use. None of us is obliged to accept any specific definition of a term such as design, research, or theory. Some of us find that no single definition suits us, and we are often obliged to restate or reshape definitions to the task. Precisely because there is no need for adherence to a single definition, we are obliged to make our usage clear. This does more than help others to understand terms as we use them. It also helps to ensure that we understand what we are saying.

There seems to be a range of emerging agreements on ways to define design. While there are differences in approach and the technical use of the term, most definitions converge on a range of common understandings. Three common understandings involve a goal-oriented process that is used to solve a problem, meet a need, solve a problem, improve a situation, or create something new or useful. There is much room for different positions within this broad and open range of possibilities.

While acknowledging that many definitions of design are possible, this paper uses a definition built on linguistic research, empirical observation, and the contributions of Buckminster Fuller (1969, 1981) and Herbert Simon (1982, 1998). (Those familiar with my work will recognize some of the material in these definitions. I use these definitions to develop a new inquiry here, and add new material that bears on the topic of theory construction.)

Design research is a relatively new field. We have fewer scholars and scientists with research education and training than other fields do. This means that the term research is often confused or misused. The problem is made worse by the fact that design is inherently interdisciplinary. We therefore find ourselves in a situation where terms are often confused. The current generation of design research specialists comes mostly to research from a practitioner education. This gives us a corps of researchers with solid practitioner skills and deep gaps in research skills. This is understandable in people who have devoted their educational training and most of their professional work to practice. This leads to a common problem. Those who are new to research adapt terms and definitions from a wide range of fields in which they have little solid foundation.

The term theory suffers from similar problems. The problem is even greater because of the fact that relatively few scholars or scientists in established fields specifically study the issues and topics involved in theory construction. While the knowledge base of most fields provides a rich array of resources in research methods and methodology studies, few fields offer much material on theory construction.

There comes a moment in the evolution of every field or discipline when central intellectual issues come into focus as the field and the discipline on which it rests shift from a rough, ambiguous
territory to an arena of reasoned inquiry. At such a time, scholars, scientists, researchers, and their students begin to focus articulate attention on such issues as research methods, methodology (the comparative study of methods), philosophy, philosophy of science, and related issues in the metanarrative through which a research field takes shape. In many fields today, this also entails the articulate study of theory construction.

This paper will explore the issue of theory construction in design research. To do so requires establishing a range of concepts around such terms as research and theory. While defining the terms research and theory is more difficult in our field than in others, any attempt to develop the topic of theory construction requires an adequate definition. This paper therefore offers definitions. While these definitions are robust enough for wider use, I do not explore their general properties or the many uses to which they may be put. I use them here to establish a foundation for the consideration of theory construction offered here.

**Defining design**

In using the word design, I refer to a process that involves creating something new (or reshaping something that exists) for a purpose, to meet a need, to solve a problem or to transform a less desirable situation to a preferred situation.

Herbert Simon (1982: 129, 1998: 112) defines design as the process by which we “[devise] courses of action aimed at changing existing situations into preferred ones.” To the degree that creating something new (or reshaping something that exists) for a purpose, to meet a need, to solve a problem are also courses of action toward a preferred situation even though we may not yet be able to articulate the preferred situation, this definition covers most forms of design. Without accepting all of Simon’s views on how to design, it is a useful starting point.

Design is a process. Merriam-Webster’s (1993: 343) defines design as: “1 a : to conceive and plan out in the mind <he ~ed a perfect crime> b : to have as a purpose : intend <he ~ed to excel in his studies> c : to devise for a specific function or end <a book ~ed primarily as a college textbook> 2 archaic : to indicate with a distinctive mark, sign or name 3 a : to make a drawing, pattern or sketch of b : to draw the plans for c : to create, fashion, execute or construct according to plan : devise, contrive…” (See also: ARTFL Webster’s 1913: 397-8; Britannica Webster’s 2002: unpaged; Cambridge 1999: unpaged; Friedman 2001: 36-40; Link 1999: unpaged; OED Online 2002: unpaged; SOED 1993: 645; Wordsmyth 2002: unpaged.)

Buckminster Fuller (1969: 319) describes the design process as an event flow. He divides the process into two steps. The first is a subjective process of search and research. The second is a generalizable process that moves from prototype to practice.

The subjective process of search and research, Fuller outlines a series of steps:

- teleology
- intuition
- conception
- apprehension
- comprehension
- experiment
- feedback

Under generalization and objective development leading to practice, he lists:

- prototyping #1
- prototyping #2
- prototyping #3
- production design
- production modification
- tooling
- production
- distribution
- installation
- maintenance
- service
For Fuller, the design process is a comprehensive sequence leading from teleology – the goal or purpose toward which the process aims – to practice and finally to regeneration. This last step, regeneration, creates a new stock of material on which the designer may again act. The specific terms may change for process design or services design. The essential concept remains the same. Fuller also used the term design science, though he used it in a different context than Simon did (Fuller 1969, 1981; see also Fuller 1964, 1965, 1967; and Fuller and Dil 1983).

A designer is a thinker whose job it is to move from thought to action. A taxonomy of design knowledge domains (Friedman 1992, 2000, 2001) describes the frames within which a designer must act. Each domain requires a broad range of skills, knowledge, and awareness. Design, properly defined, is the entire process across the full range of domains required for any given outcome.

The field organized around design can be seen as a profession, a discipline, and a field. The profession of design involves the professional practice of design. The discipline of design involves inquiry into the several domains of design. The field of design embraces the profession, the discipline, and a shifting and often ambiguous range of related cognate fields and areas of inquiry. When we speak of theorizing, we necessarily speak of the discipline. The foundation of design theory rests on the fact that design is by nature an interdisciplinary, integrative discipline.

The nature of design as an integrative discipline places it at the intersection of several large fields. In one dimension, design is a field of thinking and pure research. In another, it is a field of practice and applied research. When applications are used to solve specific problems in a specific setting, it is a field of clinical research.

My model for the field of design is a circle of six fields. A horizon bisects the circle into fields of theoretical study and fields of practice and application.

The triangles represent six general domains of design. Moving clockwise from the left-most triangle, these domains are (1) natural sciences, (2) humanities and liberal arts, (3) social and behavioral sciences, (4) human professions and services, (5) creative and applied arts, and (6) technology and engineering.

Design may involve any or all of these domains, in differing aspect and proportion depending on the nature of the project at hand or the problem to be solved.

With this as a background, we are prepared to examine how – and why – theory construction is important to design, the design process, the field of design, the discipline, and the profession.

Let us return to the definition of design as the process by which we “[devise] courses of action aimed at changing existing situations into preferred ones.” Those who cannot change existing situations into preferred ones fail in the process of design. There are many causes of design failure. These include lack of will, ability, or method. Designers also fail due to context or client, lack of proper training or a failure to understand the design process.

Fuller (1981: 229-231) describes design as the difference between class-one evolution and class-two evolution. Class-two evolution involves “all those events that seem to be resultant upon human initiative-taking or political reforms that adjust to the change wrought by the progressive introduction of environment-altering artifacts” (Fuller 1981: 229).
One argument for the importance of design is the increasing number of areas that are now subject to human initiative. The vast range of technologies that surround us mediate most of the human world and influence our daily lives. These include the artifacts of information technology, mass media, telecommunication, chemistry, pharmacology, chemical engineering, and mechanical engineering, along with the designed processes of nearly every service industry and public good now available other than public access to nature. Within the next few years, these areas will come to include the artifacts of biotechnology, nanotechnology, and possible hybrid technologies that meet at what Ray Kurzweil calls “the singularity.”

Kurzweil, a leading authority on artificial intelligence, argues, “We are entering a new era. I call it ‘the Singularity.’ It’s a merger between human intelligence and machine intelligence that is going to create something bigger than itself. It’s the cutting edge of evolution on our planet. One can make a strong case that it’s actually the cutting edge of the evolution of intelligence in general, because there’s no indication that it’s occurred anywhere else. To me, that is what human civilization is all about. It is part of our destiny and part of the destiny of evolution to continue to progress ever faster, and to grow the power of intelligence exponentially. To contemplate stopping that — to think human beings are fine the way they are — is a misplaced fond remembrance of what human beings used to be. What human beings are is a species that has undergone a cultural and technological evolution, and it’s the nature of evolution that it accelerates, and that its powers grow exponentially, and that’s what we’re talking about. The next stage of this will be to amplify our own intellectual powers with the results of our technology” (Kurzweil 2001: unpaged, see also Kurzweil 1990, 1999).

Fuller’s metaphor of the critical path shows a world that can disintegrate as well as grow better. Whether Kurzweil’s optimism is justified or not, his description of how the artificial world affects the natural world has immense ramifications that parallel Fuller’s idea of class-two evolution.

Design plays a role in this evolution, and the design process takes on new meaning, as designers are required to take on increasingly important tasks. These tasks are important not because designers are more visible and prestigious, but because design has greater effects and wider scope than ever before.

Profound design and brilliant concepts are uncommon in design, much as they are in physics, engineering, poetry, or painting. Even so, the success of evolutionary artifacts and craft traditions suggests that most human beings are able to do a competent job of design. Design failures are nevertheless common. The most common reasons include lack of method and absence of systematic and comprehensive understanding. These, in turn, rest on gaps in knowledge and preparation.

It is here that research and theory play a role.

**Defining research**

Webster’s Dictionary defines research with elegant simplicity. The noun dates from 1577: “re-search noun Pronunciation: ri-`s&rch, ‘rE-” Etymology: Middle French recerche, from recercher to investigate thoroughly, from Old French, from re- + cercher to search -- more at SEARCH Date: 1577 1 : careful or diligent search 2 : studious inquiry or examination; especially: investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws 3 : the collecting of information about a particular subject. (Merriam-Webster’s 1993: 1002; see also: ARTFL Webster’s 1913: 1224; Britannica Webster’s 2002: unpaged; Cambridge 1999: unpaged; Link 1999: unpaged; OED Online 2002: unpaged; SOED 1993: 2558; Wordsmyth 2002: unpaged).
The verb follows in 1593. As a transitive verb, it means “to search or investigate exhaustively” or “to do research for” something, as to research a book. The intransitive verb means, “to engage in research (Merriam-Webster’s 1993: 1002; see also sources above).

Design research discussions that label research as a purely retrospective practice have been misleading. Statements that conflate research with positivism are equally misleading. So, too, are essays that proclaim systematic, rigorous research to be inflexible or uncreative. One recent note asked plaintively, “where’s the search in research?” as though rigorous research involves little more than tedious cataloguing of established facts. While some aspects of creative research involve tedium, so do some aspects of painting, music, and dance.

It does not require a comprehensive linguistic analysis of the word research to understand that the prefix “re” came to this word from outside English. The prefix does not modify the core word in the direction of past or retrospective conditions, but it emphasizes or strengthens it.

As the dictionaries note (Merriam-Webster’s 1993: 1002; see others), the word research is, in fact, closely linked to the word and concept of search in general. Webster’s defines the word search this way: “Middle English cerchen, from Middle French cercher to go about, survey, search, from Late Latin circare to go about, from Latin circum round about -- more at CIRCUM- Date: 14th century transitive senses 1: to look into or over carefully or thoroughly in an effort to find or discover something: as a: to examine in seeking something<searched the north field> b: to look through or explore by inspecting possible places of concealment or investigating suspicious circumstances c: to read thoroughly: CHECK; especially: to examine a public record or register for information about<search land titles> d: to examine for articles concealed on the person e: to look at as if to discover or penetrate intention or nature 2: to uncover, find, or come to know by inquiry or scrutiny -- usually used with out intransitive senses 1: to look or inquire carefully<searched for the papers> 2: to make painstaking investigation or examination” (Merriam-Webster’s 1993: 1059; see others).

Many aspects of design involve search and research together. It is helpful to consider this issue in terms of a triad formed by the concepts of clinical research, basic research, and applied research. This shapes a dynamic milieu closer to the reality of professional practice than the common dyadic division between basic research and applied research. While the dyadic division may suffice for the natural sciences, it is not adequate for understanding research in the technical and social sciences or the professions they support.

Basic research involves a search for general principles. These principles are abstracted and generalized to cover a variety of situations and cases. Basic research generates theory on several levels. This may involve macro level theories covering wide areas or fields, midlevel theories covering specific ranges of issues or micro level theories focused on narrow questions. Truly general principles often have broad application beyond their field of original, and their generative nature sometimes gives them surprising predictive power.

Applied research adapts the findings of basic research to classes of problems. It may also involve developing and testing theories for these classes of problems. Applied research tends to be midlevel or micro level research. At the same time, applied research may develop or generate questions that become the subject of basic research.

Clinical research involves specific cases. Clinical research applies the findings of basic research and applied research to specific situations. It may also generate and test new questions, and it may test
the findings of basic and applied research in a clinical situation. Clinical research may also develop or generate questions that become the subject of basic research or applied research.

Any of the three frames of research may generate questions for the other frames. Each may test the theories and findings of other kinds of research. It is important to note that clinical research generally involves specific forms of professional engagement. In the rough and tumble of daily practice, most design practice is restricted to clinical research. There isn’t time for anything else.

In today’s complex environment, a designer must identify problems, select appropriate goals, and realize solutions. Because so much design work takes place in teams, a senior designer may also be expected to assemble and lead a team to realize goals and solutions. Designers work on several levels. The designer is an analyst who discovers problems. The designer is a synthesist who helps to solve problems and a generalist who understands the range of talents that must be engaged to realize solutions. The designer is a leader who organizes teams when one range of talents is not enough. Moreover, the designer is a critic whose post-solution analysis ensures that the right problem has been solved. Each of these tasks may involve working with research questions. All of them involve interpreting or applying some aspect or element that research discloses.

Because a designer is a thinker whose job it is to move from thought to action, the designer uses capacities of mind to solve problems for clients in an appropriate and empathic way. In cases where the client is not the customer or end-user of the designer’s work, the designer may also work to meet customer needs, testing design outcomes and following through on solutions.

This provides the first benefit of research training for the professional designer. Design practice is inevitably located in a specific, clinical situation. A broad understanding of general principles based on research gives the practicing designer a background stock of knowledge on which to draw. This stock of knowledge includes principles, facts, and theories. This stock forms a theoretically comprehensive background that no one person can master. Rather, this constitutes the knowledge of the field. This knowledge is embodied in the minds and working practices of millions of people. These people, their minds, and their practices, are distributed in the social and organizational memory of tens of thousands of organizations.

Even if one person could in theory master any major fraction of the general stock of knowledge, there would be little point. The general and comprehensive stock of design knowledge can never be used completely in any practical context.

Good design solutions are always based on and embedded in specific problems. In Jens Bernsen’s (1986) memorable phrase, in design, the problem comes first. Each problem implies partially new solutions located in a specific context. The continual interaction of design problems and design solutions generates the problematics and knowledge stock of the field in tandem.

Developing a comprehensive background through practice therefore takes years. In contrast, a solid foundation of design knowledge anchored in broad research traditions gives each practitioner the access to the cumulative results of many other minds and the overall experience of a far larger field.

In addition to those who shape research at the clinical edge of practice, there are other forms of research that serve the field and other kinds of researchers develop them.

Research is a way of asking questions. All forms of research ask questions, basic, applied, and clinical. The different forms and levels of research ask questions in different ways.
One of the problems in understanding design research emerges specifically from this distinction. Design practitioners are always involved in some form of research, but practice itself is not research. While many designers and design scholars have heard the term “reflective practice,” reflective practice is also not research, and reflective practice is not a research method as is sometimes mistakenly suggested.

What distinguishes research from reflection? Both involve thinking. Both seek to render the unknown explicit. Reflection, however, develops engaged knowledge from individual and group experience. It is a personal act or a community act, and it is an existential act. Reflection engages the felt, personal world of the individual. It is intimately linked to the process of personal learning (Friedman and Olaisen 1999; Kolb 1984). Reflection arises from and addresses the experience of the individual.

Research, in contrast, addresses the question itself, as distinct from the personal or communal. The issues and articulations of reflective practice may become the subject of research, for example. This includes forms of participant research or action research by the same people who engaged in the reflection that became the data. Research may also address questions beyond or outside the researcher.

Research asks questions in a systematic way. The systems vary by field and purpose. There are many kinds of research: hermeneutic, naturalistic inquiry, statistical, analytical, mathematical, physical, historical, sociological, ethnographic, ethnological, biological, medical, chemical and many more. They draw on many methods and traditions. Each has its own foundations and values. All involve some form of systematic inquiry, and all involve a formal level of theorizing and inquiry beyond the specific research at hand.

Comparing two distinct research streams focused on design practice will shed light on some of these issues.

In one of the most interesting research programs of the past decade, Henry Petroski (1992, 1994a, 1994b, 1996, 1997) has studied design failures, the role of failure in moving toward success, and the relationship between the different aspects of the design process. Among the key elements in success are systemic understanding, together with the ability to render tacit learning explicit for analysis and improvement. These are the same factors involved in organizational learning and reflective practice (see Argyris 1977, 1990, 1991, 1992, Argyris and Schon 1974, 1978, 1996; Schon 1983, 1987; Senge 1990; Senge et al. 1994, 1999).

Petroski is engaged in research on the elements of successful design practice. So are Argyris, Schon, and Senge. Reflective practice is a technique that builds successful practice. It is not a form of research into practice. To the contrary, Argyris and others have developed a range of research techniques linked to reflective practice. This is described in Argyris, Putnam, and Smith’s (1985) book on action science, a presentation of concepts, methods, and skills for research and intervention. Argyris and Schon (1990) later contrasted normal science with action science. More recently, Argyris (1993) wrote on ways to apply the findings of action science to practicing professional life, closing the circle in a continuous loop between theory and practice.

What is significant about this, however, is that neither practice nor reflective practice is itself seen a research method. Instead, reflective practice is one of an array of conceptual tools used in understanding any practice – including the practice of research.
In short, research is the “methodical search for knowledge. Original research tackles new problems or checks previous findings. Rigorous research is the mark of science, technology, and the ‘living’ branches of the humanities” (Bunge 1999: 251). Exploration, investigation, and inquiry are synonyms for research.

Design knowledge grows in part from practice. Design knowledge and research overlap, but even though the practice of design is a foundation of design knowledge, it is the action of systematic and methodical inquiry that constitutes research.

Critical thinking and systemic inquiry form the foundation of theory. Research offers us the tools that allow critical thinking and systemic inquiry to bring answers out of the field of action. It is theory and the models that theory provides through which we link what we know to what we do.

**Defining theory**

In its most basic form, a theory is a model. It is an illustration describing how something works by showing its elements in their dynamic relationship to one another. It is the dynamic demonstration of working elements in action as part of a structure that distinguishes a model from a simple taxonomy or catalogue.

The word *theory* entered the English language in 1597 via Latin from the original Greek. Merriam-Webster (1990: 1223) defines theory as:

“1 : the analysis of a set of facts in their relation to one another 2 : abstract thought : speculation 3 : the general or abstract principles of a body of fact, a science or an art <music ~> 4 a : a belief, policy, or procedure proposed or followed as the basis of action <her method is based on the ~> that all children want to learn> b : an ideal or hypothetical set of facts, principles or circumstances – often used in the phrase *in theory* <in ~> we have always advocated freedom for all> 5 : a plausible or scientifically accepted general principle or body of principles offered to explain phenomena <wave ~> of light> 6 a : a hypothesis assumed for the sake of argument or investigation b : an unproved assumption : conjecture c : a body of theorems presenting a concise systematic view of a subject <~ of equations>.”

The first theorists were the Greek philosophers. They developed a vocabulary of theoretical distinctions in their effort to explain the world around them. They considered the distinctions between *epistem*, the knowledge that can be explained or demonstrated to the satisfaction of others, either through experimentation or presentation, *episteme haplos*, unconditional knowledge of principles which always hold true and *hos epi to polu*, knowledge which holds true for the most part. They considered different kinds of practical knowledge and skill: *praxis*, doing, performing, accomplishing through practical knowledge or know-how; *poiesis*, knowledge needed to put things together, for instance a poem; *phronesis*, practical knowledge needed to address political or ethical issues; *téchne*, now translated as what we would call skill. To the Greeks, *theoria*, meditation, speculation, contemplation, involved seeking to know the highest and eternal principles. Aristotle believed this to be life’s highest function.

In Plato’s *Phaedo*, Socrates says that, “the superlative thing to know is the explanation of everything, why it comes to be, why it perishes, why it is.” Explanation makes empirical demands. Aristotle understood this, and he was a practitioner of empirical observation. Although limited by human imperfection and available technology, Aristotle was concerned with apprehending the mortal, physical world in an attempt to explain. Aristotle, as much an empirical biologist as a speculative philosopher (Morowitz 1993: 160-163), has been ill served by the work of scholastic philosophers who concentrated on his other work to the neglect of his research and writing on the life sciences. By the
Middle Ages, Aristotle was the hostage of empty scholasticism. Ignorance of the central role that biology and philosophy of science held in Aristotle’s Academy continues to this day.

Nevertheless, something was missing, even in the Academy. Of the “three great conceptual approaches to science – observation, experimentation, and theory – experimentation was unknown to the classical Greek savants. They worked back and forth between observation and theory and therefore lacked the powerful weapon of falsification to prune wrong theories” (Morowitz 1993: 161-2). Plato’s science stood on one leg, Aristotle’s on two. In the great age of physics, Galileo, Newton, and Bacon developed the concept of robust experiment. This made scientific progress possible by stabilizing scientific method with its third leg. Experiment allows us to choose among alternative theories, moving in increasingly better directions.

The distinction between a science and a craft is systematic thought organized in theory. Craft involves doing. Some craft involves experimentation. Theory allows us to frame and organize our observations. Theory permits us to question what we see and do. It helps us to develop generalizable answers that can be put to use by other human beings in other times and places.

This, in effect, is the central issue in design. To “[devise] courses of action aimed at changing existing situations into preferred ones” on a predictable basis means understanding “things: how they are and how they work,” which is Simon’s (1982: 129) explanation of science. One form of design practice is allied to art and craft. It is intuitive. It sometimes produces desired results. On occasion, this practice of design produces desirable results that may have been unpredictable, but results that can nevertheless be seized retrospectively as the useable result of muddling through.

The other face of design practice involves predictability. It is created by the effective response to problems, and it has similarities to science, engineering, and technology. The basis of design science is the idea of applicable theories of how to devise courses of action aimed at changing existing situations into preferred ones. This science is geared to industrial production, including production in the digital industries of the knowledge economy.

Industry now meets the vast majority of the world’s physical needs, and industrial productivity is a necessity in a world of billions of people. Industrial production, and therefore design, touches nearly everything we do, use or consume. It begins with the morning newspaper that we read while we eat breakfast, to the food itself. It moves on as we drive a car, take a bus or train, and it involves the computers most of us now plug in at work – if we are not commuting to work from a computer in our home office. Some of the day’s events will take place on the phone, and therefore, we will be reaching out via switchboards, long-distance networks or even satellite. From the start of the day until the end, designed artifacts, industrial artifacts, information artifacts, technical artifacts, and graphic artifacts in hundreds of combinations and forms will surround us. We will interact with them, and they will shape our waking experience. The designers who plan and create these artifacts are not simple artisans. They are involved in the industrial process whether or not they think of themselves in industrial terms.

Design is of necessity in transition from art and craft practice to a form of technical and social science focused on how to do things to accomplish goals. To meet the challenges of the design process requires understanding the actions that lead from existing situations to preferred ones. This means understanding the principles of predicting and measuring outcomes based on what W. Edwards Deming (1993: 94-118) terms profound knowledge. This knowledge is comprised of “four parts, all related to each other: appreciation for a system; knowledge about variation; theory of knowledge; psychology” (Deming 1993: 96). According to Deming (1986: 19), “Experience will answer a question, and a question comes from theory.”
Theory can be described in many ways. Some theories are complex and sophisticated. Others are simple. Mautner (1996: 426) defines theory as “a set of propositions which provides principles of analysis or explanation of a subject matter. Even a single proposition can be called a theory.” This often depends on the nature of the subject.

McNeil (1993: 8) proposes eleven characteristics of any general theory. 1) A theory has a constitutive core of concepts mutually interrelated with one another. 2) A theory has a mutually productive, generative connection between central concepts and the peripheral concepts where theory verges onto practice. 3) The core concepts of a theory are stated in algorithmic compression, parsimonious statements from which the phenomena in the theory can be reproduced. 4) A theory has an irreducible core of concepts, a set of concepts in which no central concept can be removed without altering the scope and productivity of the theory or perhaps destroying it entirely. 5) Two or more of the core concepts in a theory must be complementary to each other. 6) The central concepts of a theory must be well defined and must harmonize as much as possible with similar concepts of enlightened discourse. 7) The central concepts of a theory must be expressed at a uniform level of discourse. Different levels of discourse must be distinguished and used consistently. 8) More general theories (higher-level theories) must relate to less general theories (lower-level theories) and to special cases through a principle of correspondence. This principle confirms and guarantees the consistency of the more particular theories and their applications. 9) Explicitly or implicitly, a theory describes dynamic flows with contours that trace relatively closed loops as well as relatively open links. 10) A theory states invariant entities in its assumptions or formulas that provide standards for measurement. 11) Theories describe phenomena in the context of a conceptual space. This implicitly establishes a relationship between the observer and the phenomena observed.

The ability to theorize design enables the designer to move from an endless succession of unique cases to broad explanatory principles that can help to solve many kinds of problems. Warfield (in Francois 1997:100) describes the generic aspect of design as “that part of the process of design that is indifferent to what is being designed, being applicable whatever the target may be.” He contrasts this with the specific aspect of design, “that part of the design process that is particular to the target class.” Warfield (1990, 1994) identifies thirty-two basic postulates of the generic design process, which he groups under six categories: the human being, language, reasoning through relationships, archival representation, the design situation, and the design process. This generic design process is inevitably theory-rich. But it is not entirely abstract, any more than science is abstract. Quite the contrary, theory relies on an engagement with empirical reality.

Brockhampton (1994: 507) defines theory as “a set of ideas, concepts, principles or methods used to explain a wide set of observed facts.” A designer who fails to observe facts cannot theorize them. Design requires humility in the face of empirical facts. Design based on the idea of individual genius or artistic imagination involves the externalization of internalized images. This involves a priori ideas and images. The designer comes first in this model of the design process. In contrast, solving problems demands robust engagement with the problem itself. The problem comes first.

The problem sets the premise by establishing the boundary conditions of a solution. At the same time, the problem opens a forum for the imagination and expertise of the designer. Social science depends on what Mills (1967) described as “the sociological imagination.” Mathematical invention involves a journey of psychological discovery through what Hadamard (1996) termed “the mathematician’s mind.” Across the many fields of the natural and social sciences, progress comes when individuals and groups apply their genius to the understanding of how the world works and why. Understanding why things come to be, why they perish, and why they are as they are involves discipline and imagination both. Thus, Weick (1989) describes theory building as “an act of disciplined imagination.”
How theory works
Sutherland (1975: 9) describes theory as “an ordered set of assertions about a generic behavior or structure assumed to hold throughout a significantly broad range of specific instances.” To understand the nature of a behavior and organize an ordered set of assertions that describe it in a valid and verifiable way requires the characteristics described by McNeil (1993: 8).

Weick (1989) addresses the question of shaping a theory that fulfills these criteria – or similar criteria – while functioning at a sufficiently rich and non-trivial level to be useful. A body of writings equivalent to the rich literature of inquiry on theory construction in the natural and social sciences has yet to be developed in design studies. This is understandable in a discipline that is quite new compared with information science, physics or sociology, let alone philosophy, mathematics or geometry. This is also understandable in a field where the graduate programs, doctoral seminars, and research conferences that constitute the forums of theory development are just now beginning to blossom.

Having defined theory, we must therefore ask the question, “What constitutes a theoretical contribution?” David A. Whetten (1989) explored this question in an article of the same title.

Whetten (1989) begins by identifying the four elements of any theory. These four elements answer six questions: 1) “what,” 2) “how,” 3) “why,” and 4) “who-where-when.” The “what” element articulates the factors that must be considered part of an explanation of the phenomena under study. Whetten identifies two criteria as central to judging the value of a “what.” These are comprehensiveness and parsimony. Are all the elements identified? Are there enough elements to account for all issues without a surplus? Whetten (1989: 490) describes “sensitivity to the competing virtues of parsimony and comprehensiveness” as the mark of a good theorist.

The “how” of a theory shows how the factors identified in the “what” are related. Whetten (1989: 491) describes this as a process of using metaphorical arrows to connect the boxes in a model. This delineates the patterns that show elements of a phenomenon in their dynamic relationship to one another (Friedman 1996). This description often reveals causality, and it builds a foundation for the explanatory power of the model represented by a theory (Friedman 1996).

The “why” element involves the underlying “dynamics that justify the selection of factors and the proposed causal relationships…” (this rationale constitutes the theory’s assumptions – the theoretical glue that welds the model together… What and how describe. Only why explains” (Whetten 1989: 491).

Finally, the “who, where, and when” of a theory substantiate theory with empirical data while setting limits on its uses and applications.

According to Whetten, there are several ways to make significant contributions to theory. Discovering or amending new items in the “what” of an existing theory will generally make only a marginal improvement, but the ability to identify the ways in which the structural relationships of a theory change under the influence of new elements is often the beginning of new perspectives. New explanations – changes in the “why” of a theory – offer the most fruitful, and most difficult avenue of theory development. As an editor of a leading journal, Whetten (1989: 494-5) asks seven key questions of theoretical contributions. Of these, three apply to theory-construction in general: 1) what’s new? 2) so what? 3) why so? Two of the remaining four questions involve the internal qualities of the contribution as a paper, 4) well done? and 5) done well? The last two deal with context and the field within which the contribution is offered. 6) why now?, and 7) who cares?
Sheth, Gardner, and Garrett (1988: 29-33) have developed a matrix of metatheoretical criteria for evaluating theories. These consist of three categories with two criteria in each. The categories are syntax criteria, semantics criteria, and pragmatics criteria. Within syntax, they place the criteria of structure and specification; within semantics, testability, and empirical support; within pragmatics, richness, and simplicity.

Syntax criteria involve the organization and composition of a theory. Structure involves the systematic modeling of relationships. Specification involves specifying the relationships among theoretical concepts in a way that allow the theorist to delimit hypotheses. Semantics criteria involve reality and evaluate the relationship of a theory to reality. Testability means that the theory permits operational definition to permit testing and the development of intersubjective agreement. Empirical support refers to the degree to which empirical evidence supports the theory. Pragmatics criteria involve relevance. The criterion of richness involves the degree to which a theory is comprehensive and generalizable. The simplicity criterion is akin to the standard of parsimony, and it involves the degree to which a theory can be explained readily while accounting in a powerful manner for the observed phenomena.

Parsons and Shils (1951: 49-51) describe several levels of theoretical systems. They state that “in one sense, every carefully defined and logically integrated conceptual scheme constitutes a ‘system,’ and in the sense, scientific theory of any kind consists of systems” (49). They go beyond this, to ask three questions about theoretical systems. The first question involves generality and complexity. The second involves what they call “closure,” the degree to which a system is self-consistent, and the degree to which the assertions of any one part of the theory are supported or contradicted by the other parts. The third question involves what they label “the level of systematization.” This involves the degree to which theory moves toward general scientific goals.

Parsons and Shils (1951: 50) propose four different levels of systematization for theories, moving from the most primitive to the most advanced. These are 1) ad hoc classification systems, 2) systems of categories, 3) theoretical systems, and 4) empirical-theoretical systems.

This implies a schema of increasingly useful kinds of theories based on the relations among the parts of a theoretical system. In Parsons’s and Shils’s schema, theoretical development implies a “hierarchy from ad hoc classification systems (in which categories are used to summarize empirical observations), to taxonomies (in which the relationships between the categories can be described), to conceptual frameworks (in which propositions summarize explanations and predictions), to theoretical systems (in which laws are contained within axiomatic or formal theories)” (Webster and Watson (2002: xiii).

While it is useful to distinguish between taxonomy and theory, it is fair to say that at some points, taxonomy is a kind of theory because it offers a model of existing data and demonstrates the relationships between and among facts.

The importance of taxonomy is often underestimated. An interesting case in point is the discovery of a new genus of centipede, *Nannarup hoffmani* (Bjerklie 2002: 39). The decline in taxonomic skills since the grand era of taxonomy in the nineteenth century means that it took four years between the time that Richard Hoffman decided that he had found a new kind of centipede and the final identification, classification, and naming. Hoffman attributes this to the current preoccupation with molecular biology, but he points out the problem inherent in the dearth of skilled taxonomists: “We’re coasting on the glamour of biodiversity, but losing the ability to identify the creatures on this planet” (Quoted in
Bjerklie 2002: 39). This, in turn, renders theory development more difficult in several major fields, including economy, biology, and environmental studies.

Theories that describe structures offer models without moving parts. In this sense, theories are models that resemble maps or model houses. Theories that describe processes, activities, or systems generally require dynamic descriptions. In this sense, theories are models that resemble model engines or model train sets, and they must move to demonstrate the properties of the systems they resemble.

Hal Varian (1997) addresses some of these issues in a playfully titled but scientifically astute article, “How to Build an Economic Model in Your Spare Time.”

“How most of my work in economics involves constructing theoretical models,” writes Varian (1997: 1). The article discusses the challenges of theory construction and some of the approaches that Varian himself found helpful. “Over the years, I have developed some ways of doing this that may be worth describing to those who aspire to practice this art. In reality, the process is much more haphazard than my description would suggest – the model of research that I describe is an idealization of reality, much like the economic models that I create. But there is probably enough connection with reality to make the description useful – which I hope is also true for my economic models.”

Varian’s key involves representing aspects of reality in robust yet simple ways. Rather than starting with literature or seeking general features, he advocates seeking useful data on interesting issues:

“So let’s skip the literature part for now and try to get to the modeling. Lucky for you, all economics models look pretty much the same. There are some economic agents. They make choices in order to advance their objectives. The choices have to satisfy various constraints so there’s something that adjusts to make all these choices consistent. This basic structure suggests a plan of attack: Who are the people making the choices? What are the constraints they face? How do they interact? What adjusts if the choices aren’t mutually consistent?

“Asking questions like this can help you to identify the pieces of a model. Once you’ve got a pretty good idea of what the pieces look like, you can move on to the next stage. Most students think that the next stage is to prove a theorem or run a regression. No! The next stage is to work an example. Take the simplest example --- one period, 2 goods, 2 people, linear utility --- whatever it takes to get to something simple enough to see what is going on.

“Once you’ve got an example, work another one, then another one. See what is common to your examples. Is there something interesting happening here? When your examples have given you an inkling of what is going on, then you can try to write down a model. The critical advice here is KISS: keep it simple, stupid. Write down the simplest possible model you can think of, and see if it still exhibits some interesting behavior. If it does, then make it even simpler.

“Several years ago I gave a seminar about some of my research. I started out with a very simple example. One of the faculty in the audience interrupted me to say that he had worked on something like this several years ago, but his model was ‘much more complex.’ I replied ‘My model was complex when I started, too, but I just kept working on it till it got simple!’

“And that’s what you should do: keep at it till it gets simple. The whole point of a model is to give a simplified representation of reality. Einstein once said ‘Everything should be as simple as possible but no simpler.’ A model is supposed to reveal the essence of what is going on: your model should be reduced to just those pieces that are required to make it work.”
The point of modeling – and of theory construction – is showing how things work.

**Theory construction problems in design research**

Until recently, the field of design has hitherto been an adjunct to art and craft. With the transformation of design into an industrial discipline come responsibilities that the field of design studies has only recently begun to address.

Design is now becoming a generalizable discipline that may as readily be applied to processes, interfaces between media or information artifacts as to tools, clothing, furniture, or advertisements. To understand design as a discipline that can function within any of these frames means developing a general theory of design. This general theory should support application theories and operational programs. Moving from a general theory of design to the task of solving problems involves a significantly different mode of conceptualization and explicit knowledge management than adapting the tacit knowledge of individual design experience.

So far, most design theories involve clinical situations or micro-level grounded theories developed through induction. This is necessary, but it is not sufficient for the kinds of progress we need.

In the social sciences, grounded theory has developed into a robust and sophisticated system for generating theory across levels. These theories ultimately lead to larger ranges of understanding, and the literature of grounded theory is rich in discussions of theory construction and theoretical sensitivity (Glaser 1978, 1992; Glaser and Strauss 1967; Strauss 1991; Strauss and Corbin 1990, 1994).

One of the deep problems in design research is the failure to engage in grounded theory, developing theory out of practice. Instead, designers often confuse practice with research. Instead of developing theory from practice through articulation and inductive inquiry, some designers simply argue that practice is research and practice-based research is, in itself, a form of theory construction.

Many of the problems in design research arise from category confusions. In recent years, designers have become acquainted with the term “tacit knowledge” articulated by Michael Polanyi (1966) in *The Tacit Dimension*. Proposing tacit knowledge as the primary foundation of design research reflects a surface acquaintance with the term by people who have not read Polanyi’s work.

Tacit knowledge is an important knowledge category. All professional practice – including the practice of research – rests on a rich stock of tacit knowledge. This stock consists of behavioral patterns and embodied practice embedded in personal action. Some aspects of tacit knowledge also involve facts and information committed to long-term memory. This includes ideas and information on which we draw without necessarily realizing that we do so, and it includes ideas and information that we can easily render explicit with a moment’s thought. It also includes concepts, issues, ideas, and information that can only be rendered explicit with deep reflection and serious work.

In social life and professional work, tacit knowledge is also reflected in the larger body of distributed knowledge embedded in social memory and collective work practice. Our stock of tacit knowledge enables us to practice. Putting tacit knowledge to use in theory construction requires rendering tacit knowledge explicit through the process of knowledge conversion (Friedman 2001: 44; Kriger and Friedman 2002; Nonaka and Takeuchi 1995: 59-73).

Tacit knowledge is necessary for human action. Without tacit knowledge, embodied and habitual, nothing human beings do would be possible. Each action would require explicit conceptualization and...
planning each time. The limits on immediate attention and cognition means that it would be impossible to store and act on enough knowledge for effective individual practice in any art or science, let alone accumulate the knowledge on which a field depends (Friedman 2001: 42-44; Friedman and Olaisen 1999: 16-22). All fields of practice rest, in part, on tacit knowledge. (See, f.ex., Chaiklin and Lave 1993; Bourdieu 1977, 1990; Friedman 2001: 42-44).

To say that tacit knowledge is not research and that design theory is not identical with the tacit knowledge of design practice does not diminish the importance of tacit knowledge. It merely states that mistaken arguments about tacit knowledge as design knowledge demonstrate the confusion of the scholars who make such statements. The confusion rests on a simple failing, the failure to read Polanyi. The notion that tacit knowledge and design knowledge are identical as sources of theory development is linked with the idea that practice is a research method. Both rest on category confusions and both arguments are generally supported by references to Polanyi and Schon by scholars who have not read the works they cite.

If there is any confusion on Polanyi’s views, however, he settles the matter at the beginning of another book, *Personal Knowledge*. Where tacit knowledge is embodied and experiential knowledge, theory requires more. “It seems to me,” he writes, “that we have sound reason for . . . considering theoretical knowledge more objective than immediate experience. (a) A theory is something other than myself. It may be set out on paper as a system, of rules, and it is the more truly a theory the more completely it can be put down in such terms” (Polanyi 1974: 4).

Polanyi’s (1974: 3-9) discussion of the Copernican Revolution uses different language to state some of the significant themes that are seen in Varian (1997), Deming (1986, 1993), and McNeil (1993). These address such concepts as descriptive richness, theory as a guide to discovery, and modeling. As a guide to theory construction, this is also linked to Herbert Blumer’s idea of sensitizing concepts (Blumer 1969; see also Baugh 1990, van den Hoonard 1997). All of these possibilities require explicit knowledge, rendered articulate for shared communication and reflection.

One of the little noted points in many design research debates is the fact that reflective practice itself rests on explicit knowledge rather than on tacit knowledge. While Schon’s concept of reflective practice is not a method of theorizing, (1991: 5-11), but it does raise many questions on the kinds of thinking and reflection that contribute to effective practice in many fields. Central to most of these is the struggle of rendering tacit knowledge explicit in some way. While Schon (1994: 9) suggests that there may be more possibilities for reflection than words alone, he clearly distinguishes between the epistemology of theoretical research and reflective inquiry.

Much of this confusion is linked to an ambiguous definition of design research proposed by Frayling in a 1993 paper. Frayling (1993) suggested that there are three models of design research, research into design, research by design, and research for design. Frayling is unclear about what “research by design” actually means and he seems never to have defined the term in an operational way. In a 1997 discussion (UK Council 1997: 21), he notes that it is “distantly derived from Herbert Read’s famous teaching through art and teaching to art.” This leads to serious conceptual problems.

Read’s (1944, 1974) distinctions deal with education and with pedagogy, not with research. The failure to distinguish between pedagogy and research is a significant weak area in the argument for the concept of research by design. In addition to the difficulties this has caused in debates on the notion of the practice-based Ph.D., it also creates confusion for those who have come to believe that practice is research. The confusion rests, again, on a failure to read.
Frayling’s proposal seems to have been an effort to establish possible new research categories. As an inquiry or probe, this is a worthy effort. The problem arises among those who mistake an intellectual probe with a statement of fact. To suggest that such a category is possible does not mean that it exists in reality. Dragons may exist, but we have no evidence that they do. Medieval mapmakers created great confusion and limited the growth of knowledge for many years by filling in the empty edges of their maps with such phrases as “here there be dragons” rather than admitting, “we know nothing about what lies beyond this point.”

Beyond this arises the problem of what “research by design” might mean. If such a category did exist – and it may not – the fact of an existing category would tell us nothing of its contents. Unlike dragons, we know that the planet Jupiter exists. Like the edges of the map, however, we know relatively little about conditions on the surface of the planet. Even though the laws of nature mean that some facts must be known – gravity and pressure, for example – these facts tell us little about the myriad realities that may play out depending on specific factors.

As a probe, Frayling’s discussion was intended to open possibilities. Those who mistake it for a report mistake its potential value.

In one sense, however, Frayling misread Read. In adapting the surface structure of Read’s terms, he failed to realize a distinction that is implicit in Read’s project. This is the fact that education can be developed though the direct practice of an art. This is the case in socialization and modeling, in guild training, and it is the basis of apprenticeship (Friedman 1997: 55, 61-65; Byrne, and Sands 2002). In many situations, education and learning proceed by practicing an art or craft. One can also learn the art and craft of research by practicing research. Nevertheless, one does not undertake research simply by practicing the art or craft to which the research field is linked.

So far, the category of research by design has proven fruitless. Around the time that Frayling published his 1993 paper, Nigel Cross wrote the first of two editorials in Design Studies on the theme of research by design.

In his first editorial, Cross (1993: 226-7) points out the distinctions between practice and research and the value of connecting research to teaching and to practice.

In his second editorial, Cross notes how little progress had been made in research by design over the two years between 1993 and 1995. He writes that part of the problem involves the claim that “works of design are also works of research” (Cross 1995: 2).

Cross (1995: 3) states that the best examples of design research are: purposive, inquisitive, informed, methodical, and communicable. This requires articulation and shared knowledge within and across the field. This, again, requires articulate communication of explicit knowledge. In 1999, Cross addressed this issue again in a debate on research methods in design.

Looking back over the failed efforts of the past decade to produce valid examples of research by design, Cross (1999: unpaged) wrote, “. . . as I said in my Editorial in 1995, I still haven’t seen much strong evidence of the output from the ‘research for and through design’ quarters. Less of the special pleading and more of the valid, demonstrable research output might help.”

While the phrase “research by design” has been widely used by many people, it has not been defined. I suspect, in fact, that those who use the phrase have not bothered to read either Frayling’s (1993) paper or Read’s (1944, 1974) book. Instead, they adopt a misunderstood term for its sound
bite quality, linking it to an ill-defined series of notions that equate tacit knowledge with design knowledge, proposing tacit knowledge and design practice as a new form of theorizing.

While these problems are relatively inconsequential outside our field, it is important to understand that they exist if we are to develop a foundation for theory construction in design research. This is why I have given them so much thought.

Again, I want to be clear on the many values of tacit knowledge. Tacit knowledge is central to all human activity, and the background of embodied individual and social knowledge provides offers the existential foundation of all activities, including intellectual inquiry. The only issue I raise here is that tacit knowledge and reflective practice are not the basis of research and theorizing. This is not to say, however, that there are no relations between those different categories of construct.

While ancient science was hypothetical and deductive, it offered no way to select among theories. While the river civilizations of Mesopotamia, Sumeria, Egypt, and China made great advances in practical knowledge, administrative routine, and professional practice in many fields, they had nothing in the way of scientific theory. Explanations were traditional and practical or mythic (Lloyd 1970: 1-23; Cromer 1993: throughout).

Thales proposed the first scientific theory when he suggested that the earth was once an ocean. While he could not test his theory, what made it scientific as contrasted with mythic was the fact that Thales proposed a natural explanation rather than a story of divine action.

Greek mathematics offered another foundation for science, and the Pythagoreans and Euclid built theories that are still used today. Again, however, there were no tests. Mathematical and geometrical theories are entirely axiomatic, and they can be tested by deduction and logic. While empirical inquiry found a few early champions in such medieval scholars as Robert Grosseteste and Roger Bacon, it was not until Francis Bacon (1999, 2000) published *The New Organon* in 1620 that a philosophy of science was articulated requiring a foundation in empirical observation.

At the same time, observation linked with inventive theorizing accounted for the great advances of Copernicus, Galileo, Newton and many more. The tradition of empirical inquiry lies beneath two great activities in design: design science and reflective practice. These meet in research traditions of many kinds, including those traditions anchored in social science and critical inquiry.

Because this paper does not describe a philosophy of science, I will not explain how or why this is so, and I will not develop an argument for any specific research tradition or the kinds of theory construction on which a tradition must be established. I merely point to the fact that explicit and articulate statements are the basis of all theoretical activities, all theorizing, and all theory construction.

This true of interpretive and hermeneutical traditions, psychological, historical, and sociological traditions, and it is as true of these as of quantitative research in chemistry, descriptive biology or research engineering, logistics, and axiomatic mathematics. The languages are different. However, only explicit articulation permits us to contrast theories and to share them. Only explicit articulation allows us to test, consider or reflect on the theories we develop. For this reason, the misguided effort to link the reflective practice of design to design knowledge, and the misguided effort to propose tacit knowledge or direct making as a method of theory construction must inevitably be dead ends.

All knowledge, all science, all practice relies on a rich cycle of knowledge management that moves from tacit knowledge to explicit and back again. So far, design with its craft tradition has relied far more on tacit knowledge. It is now time to consider the explicit ways in which design theory can be
built – and to recognize that without a body of theory-based knowledge, the design profession will not be prepared to meet the challenges that face designers in today’s complex world.

Future directions
The goal of this paper has been to examine criteria, approaches, and methods for theory construction in design research. To do this, I began with a foundation of definitions, using these to build a range of applicable concepts.

There is not enough room in one paper to go beyond the general consideration of methods to a specific description of how to develop theory and build specific theories. This remains to be done in a future paper.

Many avenues deserve exploration in the future. These include linking theory building to the perspectives of design science, proposing models of theory construction from other perspectives, generating theory from the practice of leading contemporary designers, and developing such basic tools as a bibliography of resources for theory construction and developing theoretical imagination and sensitivity.

Theory-rich design can be playful as well as disciplined. Theory-based design can be as playful and artistic as craft-based design, but only theory-based design is suited to the large-scale social and economic needs of the industrial age.

This systemic, theory-driven approach offers a level of robust understanding that becomes one foundation of effective practice. To reach from knowing to doing requires practice. To reach from doing to knowing requires the articulation and critical inquiry that leads a practitioner to reflective insight. W. Edwards Deming’s experience in the applied industrial setting and the direct clinical setting confirms the value of theory to practice.

“Experience alone, without theory, teaches . . . nothing about what to do to improve quality and competitive position, nor how to do it” writes Deming (1986: 19) in his critique of contemporary manufacturing. “If experience alone would be a teacher, then one may well ask why are we in this predicament? Experience will answer a question, and a question comes from theory.”

It is not experience, but our interpretation and understanding of experience that leads to knowledge. Knowledge emerges from critical inquiry. Systematic or scientific knowledge arises from the theories that allow us to question and learn from the world around us. One of the attributes that distinguish the practice of a profession from the practice of an art is systematic knowledge.

As artists, we serve ourselves or we serve an internalized vision. This internalized vision is essentially a facet of the self. In the professions, we serve others. In exploring the dimensions of design as service, Nelson and Stolterman (2000) distinguish it from art and science both. My view is that art and science each contributes to design. The paradigm of service unites them.

To serve successfully demands an ability to cause change toward desired goals. This, in turn, involves the ability to discern desirable goals and to create predictable – or reasonable – changes to reach them. Theory is a tool that allows us to conceptualize and realize this aspect of design. Research is the collection of methods that enable us to use the tool.

Some designers assert that theory-based design, with its emphasis on profound knowledge and intellectual achievement, robs design of its artistic depth. I disagree. I believe that a study of design
based on profound knowledge embraces the empirical world of people and problems in a deeper way than purely self-generated artistry can do.

The physicist Richard Feynman once argued for the imaginative power and beauty of science. He did not argue against the other arts. Rather, he stated that understanding how things work and why adds another dimension to beauty.

“Poets say science takes away from the beauty of the stars – mere globs of gas atoms. I, too, can see the stars on a desert night and feel them. But do I see less or more? The vastness of the heavens stretches my imagination – stuck on this little carousel, my little eye can catch one-million-year-old light. A vast pattern – of which I am part… What is the pattern, or the meaning, or the why? It does not do harm to the mystery to know a little about it. For far more marvelous is the truth than any artists of the past imagined it. Why do poets of the present not speak of it? What men are poets who can speak of Jupiter if he were a man, but if he is an immense spinning sphere of methane must be silent?” (quoted in Gleick 1993: 373) Understanding how things work and why expands the powers of the human mind and soul.

However, I also argue for a theory-rich practice of design for an intensely practical reason. The world’s population recently exceeded six billion people for the first time. Many people in today’s world live under such constrained conditions that their needs for food, clothing, shelter, and material comfort are entirely unmet. For the rest, most needs can only be met by industrial production. Only when we are able to develop a comprehensive, sustainable industrial practice at cost-effective scale and scope will we be able to meet their needs. Beyond art, beyond poetry, beyond science, this is the purpose of design. Design will never achieve this purpose until it rests on all three legs of science. To do this, design practice – and design research – requires theory.
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An innovative approach to the aesthetic design

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Abstract

As the aesthetic aspect of a product is becoming more and more important in customers' decisions, there is an increasing need of tools able to express and preserve the styling intent during the product development cycle, while offering an interaction with the user much more adherent to his mentality. The European Project FIORES-II (Character Preservation and Modelling in Aesthetic and Engineering Design) is aimed at creating innovative CAD tools capable to capture and preserve the product aesthetic character and make it accessible in a multi criteria approach for styling and engineering design optimisation. In order to explore the possible relationships between emotional character and product shape, an extensive analysis has been carried out, thanks to the collaboration of industrial designers in the automotive field, such as BMW, Pininfarina, Saab, and in household supplies field, such as Alessi and Eiger. In this paper, the main outcome and the innovative design functionality defined on the basis of the results of the above mentioned research will be presented.
An innovative approach to the aesthetic design

Introduction
Styling is a creative activity where the designer’s goal is to define a product that evokes a certain emotion while satisfying the imposed constraints. Therefore, a better understanding of human reactions can allow an easier satisfaction of market wishes and tastes. On the other hand, the complete design of new products requires multidisciplinary expertise and consequently it results from the collaboration of several actors. It is then clear that the formalization of the design intent underlying the product specification may improve the communication quality among the involved actors, who can belong to different departments in the same company, e.g. styling and engineering, or to external suppliers. In addition the formalization of the relationships between shape and aesthetic character included in a computer system may help designers to achieve their goal more directly. In fact, even if the introduction of digital tools in the styling workflow in the last twenty years has significantly shortened the development time and costs, some critical issues have still to be faced and overcome to move towards an ideal optimised digital design process, in which the design intent is automatically communicated and preserved throughout all the process phases.

When designers create shapes with digital techniques often the available tools for model definition and manipulation restrict the way in which a shape can be modelled: they often have to concentrate too much on how to use the system to obtain what they have in mind. To make the modelling process more intuitive, the interaction should be performed through a direct control over the three-dimensional space in the same way a pencil dominates the two-dimensional space. In fact, an easy interaction requires functionalities simulating the traditional method of stylists’ work. The current limitations are mainly due to the fact that the modelling activity is mostly based on low-level geometric elements. Often it is necessary to have a full understanding of the underlying surface representation to know which elements have to be changed to obtain the wished surface modifications. On the contrary the user would like to directly handle properties strictly linked with his design intent.

Based on these considerations, the European project FIORES-II (GRD1-1999-10785-Character Preservation and Modelling in Aesthetic and Engineering Design) (FIORES-II), aims at building innovative CAD tools more adhering to the creative user mentality and at improving the cooperation between the main actors involved in the product development process, by identifying the relationship between shape geometry and aesthetic character. The goal of this paper is to illustrate the project objectives and intermediate results. It is structured as follows: in the first part a survey of the main research works studying links between shape and aesthetics is given; part two describes the FIORES-II project objective and presents the results achieved until now. Conclusions can be found in part three.

Related works
Several researches have been carried out in order to identify the links between a product’s shape characteristic and its emotional message. These relationships have been analysed from different perspectives including perceptual psychology (Luh 1994), design and computer science (Wallace and Jakiela 1993, van Bremen et al. 1998, Hsiao and Wang 1998, Yoshimura and Yanagi 1998, Chen and Owen 1998).

Suggestions have been proposed for formalizing brand identity, possibly by means of archetypes (Smyth and Wallace 2000), or associating terms to a specific character. In literature, results of experiments are shown about the possibility of categorizing products in classes sharing some aesthetic character terminology (van Bremen et al. 1999, McDonagh 1999, Ishikara et al. et al.)
However, all these experiments are quite limited in the number of analysed objects and interviewed persons as well as in the results. No systematic and precise specification of a correspondence between product elements and emotional terms has ever been provided. Also the problem related to the use of terms has not been fully addressed: terms have the disadvantage of being subject to personal interpretation, mainly depending on cultural environment and personal experience, thus an agreement on a common language has to be found.

A formalization that could be processed by a computer program requires the identification of direct relationships between the geometric elements of an object and its aesthetic characters. Ideally, the mapping specifies those values of shape characteristics and parameters that correspond to the design model conforming to the intention. Van Bremen and his colleagues at Delft University (van Bremen et al. 1998) provided some examples of possible, but not tested, associations between aesthetic and shape parameters without proving an effective feasibility of the mapping process. They concluded that such an association is rather difficult and it is not a simple mapping, since the same aesthetic parameters can be associated to different shape parameters.

For the above reasons, it is not possible to give an absolute definition of an aesthetic character, but it is preferable to specify how to increase or decrease the object’s already given characters. In addition, it was shown that the choice of the aesthetic variable type depends on the product. Therefore, an effective system needs to incorporate subject dependency, possibly by introducing subject-specific relations or weighting functions.

**FIORES-II objectives**

The general objective of the FIORES-II project is to improve the working procedures and the computer aided tools adopted from designers for modelling product shapes. The new modelling tools should help CAS/CAD (Computer Aided Styling/Computer Aided Design) operators (in the following indicated as *surfacers*) to more easily attain a model with specific emotional characteristics according to the stylist’s intent and to preserve them during engineering optimisations. This implies to have tools able to preserve the aesthetic design intent during the required model modifications and able to extract the aesthetic character from CAD models and compare it to others and/or directly act on it.

The general objective can be achieved by the following intermediate results:

- a vocabulary for the aesthetic design;
- a mapping of styling character descriptions on geometric entities and properties objectively describable by computable and measurable parameters;
- methods (algorithms and s/w prototype) for the extraction of aesthetic shape properties;
- methods (algorithms and s/w prototype) to optimise the design with respect to aesthetic and geometric engineering requirements.

To find the relationships between geometrical elements of a product shape and its aesthetic characters is the key to innovate the modelling tools by enabling the specification of those values of shape characteristics and parameters that, once processed by a computer system, could compute the design model conforming to the original intention. In the following the activities carried out to achieve the above objectives, are illustrated.

**The language of aesthetic design**

To explore the possible relationships between product shape and aesthetic character, it is first necessary to identify a common language based on proper words and definitions used by designers in their daily activity, able to cover the description of aesthetic aspects beside the emotional
reactions of a generic observer. The analysis of the relation between terms describing aesthetic properties of lines and shapes, and terms describing emotions associated with geometric elements has been conducted through a three-steps process:

- identification of a vocabulary of terms actually used to describe shapes of industrial products (mainly car bodies and domestic appliances);
- verification of the usability of the vocabulary to properly identify the aesthetic and emotional character of product shapes;
- identification of terms adequately associating aesthetic and emotional character with specific lines or shapes.

First, a large set of internal documents, brochure and papers describing industrial products from an aesthetical point of view, has been supplied from the industrial partners. It allowed the collection of proper words and definitions currently used by the designers in their working activity, representing the first vocabulary. A refinement of the vocabulary has been achieved by processing the results of different kind of interviews, structured in order to collect a number of data as large as possible.

Different questionnaires have been organized via Web, mainly concerning the car industry and the domestic appliance; shapes suitable for the interviews have been carefully selected: complex enough to show the effects, simple enough to describe the shape and to relate properly to the vocabulary. In order to avoid influences derived by colours, only high-resolution black and white pictures have been used. Moreover, to be closer to the designer mentality, the project partners representing end-users selected those curves they considered important to provide the perceived product character.

In figure 1 an example of the addressed questions is illustrated.

**Figure 1:** A part of the Web Questionnaire concerning the automotive sector

The results of the questionnaires, mainly filled in by professional designers and students of design schools, were analysed with respect to the distribution of frequencies of choices (i.e. how adjectives
are distributed over product pictures) in order to describe and understand what such elements may have in common, and thus have some measure of their likeness and differences.

Once completed the analysis of questionnaire results, a series of interviews, personally conducted and video recorded, have been performed. The videotape support has been useful to fix the observer reactions to different aesthetic aspects, during the different phases of the interview. First designers have been interviewed with the main objective of verifying if:

- the previously identified terms are actually general and unequivocally understood;
- terms are associated to characteristic lines in a coherent and consistent way;
- designers use the same terms both to indicate designing lines and to indicate actions to be performed on these lines.

Finally they were asked to increase/decrease the object character in order to understand on which elements and how they currently act to achieve the wished character changes.

In this way, the design activities carried out by stylists and surfacers in different industrial fields have been deeply analysed and the language they use during the different phases of the product design cycle has been captured. It emerged that stylists use different languages when they speak with marketing people and when they work with surfacers at the definition of the 3D digital model, as it is summarized in figure 2.

**Figure 2:** Languages used by stylists in the different design phases
The language used when marketing people and stylists exchange data between themselves is composed by terms that are related to emotional values (e.g. *dynamic*, *aggressive*) and express somehow the objectives, i.e. the *character*, the final product has to hold. Within the project, this language has been defined as “*the language of the trends*” (*LTE*), as it has a contextual valence because it is conditioned by fashion, trends, agreeability, attractiveness and so on, which are recognisable and coherently understood only within specific cultural and temporal conditions.

On the other hand, during the creation and modification of the digital model stylists communicate how to achieve their aesthetic intent using a more detailed and restricted set of terms corresponding to shape properties. In this phase they provide instructions on which elements and properties have to be changed to enforce or change the character (e.g. making a curve a bit more *accelerated*, or decreasing the *tension* of a curve…) to fulfil marketing directives. Hence this latest set of terms constitutes what in the project has been indicated as the “*Language of trade*” (*LTA*) and represents the first link between low-level CAGD (Computer-Aided Geometric Design) descriptions and the high level character of a product. In other words, finding some link between emotional character and geometric shape features seems to be more easily reachable by understanding the procedures followed by designers for obtaining the desired character thus considering a two levels mapping: the first level links geometric properties with stylist terms, the second links these latest to the emotional character.

To identify the second association, FIORES-II is taking advantage of the “learning” capabilities of Case Based Reasoning (CBR) techniques (AI_CBR, CBR_WEB, Stahl 2001); a CBR system works by matching new problems to "cases" from a historical database and then adapting successful solutions from the past to current situations. In this context it deals with the necessary large amount of data required to ensure the validity and the flexibility of the association, taking also into account the subject dependency.
In figure 3, the structure used by CBR for deriving the association between the two identified languages is shown:

Figure 3: Schema of the geometry-related information handled by CBR

The user specifies which are the curves most important for the characterization of the product from the emotional point of view, i.e. the Characterising shape elements (CSE), and the main product characters in terms of LTE. CSE are the curves that are used by designers to evaluate the shape and that are normally modified for emphasizing the product character when drawing. They include those curves frequently indicated as character lines, which may correspond to important object sections, profiles or other construction and light lines (e.g. reflection and shadow lines (Hagen et al. 1995)).

The system automatically gives a description of each curve by vectors of LTA terms with the associated property values. Additional spatial and dimensional relationships can be specified by the user. The type and number of the characterising elements and of the mutual relationships are dependent of the product type. Additional context dependent information, such as producing company, target marked, product type, etc., is also included to restrict the evaluation to comparable objects.

The LTA terms represent the first link between geometry and the high level character of a product and end-users identify this language as the most important for improving their normal activities and communication. Therefore for the prototype development it has been decided to give the highest priority to the design functionality whose application produces the results that end-users expect in association with LTA terms.
Innovative modelling functionality for aesthetic design

The LTA includes all those terms that have been selected from the designers as being the most used for shape evaluation and modification request. Even if they correspond to the English translation of the terms commonly used in their native tongue, some harmonisation work has been needed to ensure a common understanding. These terms put in relation geometric properties with perception and are mainly inherited from the traditional prototype creation by clay modelling (Podhel 02). The following terms have been selected for the prototype development:

- Acceleration
- Crown
- Convexity
- Concavity
- Sharpness
- Softness
- Crispness
- Tension
- Lead in

In figure 4, some examples of the modifications on curves corresponding to some of the above terms are shown. In the picture, also the radius of curvature of the different curves is displayed in order to visualise the corresponding obtained effects.

![Figure 4: Examples of curve modification effects obtained by applying some of the selected modifiers.](image-url)
The objective is to develop modelling tools able to act on the aesthetic character of a shape and able to preserve it during the geometry modification. Thus it becomes possible to manipulate a product character by means of combination of modelling operators acting directly on specific properties of the CSE, instead of working on low level geometric elements not directly linked with the target property.

The development of modelling tools in correspondence to the LTA terms has a double motivation: on one hand to provide tools for modifying the shape in a direct mode, i.e. directly used by designers on the selected entities, and on the other hand to measure some shape properties to provide the interpretation of the object character. Due to their first usage, these modelling tools have been called *modifiers*.

The example in the figures 5 (produced by FIORES-II end-user group) shows the modifications applied to a ski-box to get bigger having a new character (*directional*) but at the same time preserving also the original one. The modifications are mainly applied to the character lines and propagated to the surfaces; they include scaling operations and curve adjustments in correspondence to the designer language terms. This didactic example must be considered when character lines are not generative curves but result from some evaluation (a silhouette line for instance), then it becomes more complex to achieve. In the example, the original ski-box (figure 5a) combines the characters *soft* and *stumpy* impressed by the character lines Line1 and Line2.
Figure 5: An example of application of modifiers to a skybox

In figure 5b is shown an intermediate ski-box obtained by stretching the proportions. The box has also a new character: it is far more slender. Simply scaling of the two character lines is not sufficient: it does not express a directional character and at the same time the stumpy/fat rear of the box has now been lost.

Figure 5c illustrates the skybox obtained by modifying the Lead-in on the part of Line 1 indicated by the window and by increasing Tension on the Line 2; in this way a character similar to the one of starting skybox (5a) has been achieved.

As seen from the above example, modifiers act on several geometrical properties of a given CSE at the same time. They can be considered as a semantic shape control. As previously said, it turned out that, in addition to their modification (relative) action, these operators could also represent meaningful tools for shape comparison purpose. This leads us to define an evaluation measure for each of them. By controlling their evaluated values it is possible to control the combination of the associated geometric properties and hence, by specifying their changes, to control the shape.
To achieve the above functionality, the following problems had to be solved for each considered modifier:

- Definition of its meaning from the designer point of view: what shape is the designer expecting when the modifier value changes for the considered entity? Which are the geometric properties that are affected by the modifier?
- Specification of the mathematical function producing the expected shape modification and the related domain of application, i.e. hypothesis / restrictions on the CSE in order to have the possibility of applying the modifier.
- Identification of the required parameters to be provided by the user or automatically specified by an algorithm in case of character preservation. This also includes the specification of which of them and how they can be used within the optimisation process.
- Evaluation of a measure of the modifier.

The above points have been treated and the software implementation is currently under development.

Several difficulties have been encountered, mainly related to getting a full comprehension of how stylists perceive shape and then to translating this into mathematical formalism. Even if some of the terms used have a direct mathematical counterpart, the meaning is not exactly the same; for example not all the curves in which the second order derivative increases are necessarily perceived as accelerating curves. Moreover, different shapes may be perceived as having the same property value. This means that several characteristics/variables contribute to a single property, thus requiring a further level of interpretation to give a formal description both of the property and of its measure. In addition, it is important to underline that the function measuring the property had to be continuous and derivable in order to control the optimisation process required when stylists are going to modify a shape by specifying a target aesthetic property.

The study has been restricted to planar curves; this is not a tough limitation because users typically prefer to act on curves having a specific meaning within the shape, what we indicated as CSEs are normally judged in a planar view (paper or CAD screen). Nevertheless, since the final aim is always to change the 3D model, the modification has to be propagated to the related surfaces. For doing this, the consortium has decided to use already existing technologies provided by the software developer partner, such as Global Shape Modelling (GSM) of thinkDesign™ (thinkDesign is copyright of think3, www.think3.com).

For the propagation of the change to the surface, the following aspects have to be kept into account and are now under consideration:

- How to preserve the CSEs’ semantic: e.g. if the CSE is a Silhouette computed (with some parameters) on an initial shape S, the modified one has then to be still a Silhouette.
- How to guarantee constraint compatibility and consistency, e.g. how to increase the concavity of a section in a view while putting more crown in an intersecting silhouette in another view.

Conclusions
In this paper, the objectives of the European Project FIORES-II and its preliminary results have been described. They include the identification of two languages actually used during the product development by stylists and of their mutual relationships. The first language (LTE) is used during the briefing and in general in the communication with marketing people and customers and is related to the cultural and emotional message the product has to communicate. The second language
(LTA), inherited from the clay modelling activities, is adopted in the communication with the CAS/CAD operators during the digital model creation and modification.

The studies conducted during the project confirm that neither the designer language nor the marketing language are consisting in a fixed mapping between concepts and objects and therefore the association between aesthetic character and geometric character cannot be considered as strictly fixed.

In the project particular emphasis has been devoted on the development of modelling tools corresponding to the second language, since they are considered as the basis for allowing:

- Direct shape modification (as shown in the example above) by a more semantic control than the one offered by classical methods.
- Specification of the aesthetic character in objective terms;
- Aesthetic character modification;
- Character preservation during the shape modifications

At present the theoretical specification of the tools is almost completed and the implementation of the software prototype is currently under development. The preliminary results confirm the validity of the approach not only from the point of view of user interest but also from a scientific perspective that can link different disciplines such as mathematics and perceptual psychology.

**Acknowledgements**

This work is supported by the European Commission under the GROWTH Programme within the Project FIORES II, *Character Preservation and Modelling in Aesthetic and Engineering Design*, G1RD-CT-2000-00037. The authors thank the Project partners for the provided material.
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‘One-on-One’: a pedagogic base for design instruction in the studio

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Abstract
Despite changes that computation introduces in the mode in which instruction is carried out in the design studio, we still rely heavily on the desk ‘crit’ in which an individual student converses with an instructor about the student’s work in progress, which is laid out before them. Despite the centrality of the desk crit to design education, no formal training is offered to instructors. Typically, they act only on the basis of their experience and intuition, and surprisingly few studies have centered on the details of the all-important student-instructor communication and its implications for the student’s learning process. In this paper, we report a few protocol studies of ‘one-on-one’ ‘crits’ in studios of a school of architecture and we show what we have learned from them. We propose that such studies are useful for the development of a pedagogic base for design instruction in the studio.
‘One-on-One’: a pedagogic base for design instruction in the studio

Competence in design praxis is acquired by doing, and nowhere is this learning by doing more universally institutionalized than in the design studios of schools of architecture. The studio is the heart of architectural design education, and probably of design education in general. It is a practicum where students carry out design assignment under the guidance of design instructors. Despite variations among schools the mode of instruction in the studio is surprisingly similar the world over. Typically, a group of one to two dozen students shares a territorial base (the studio) for the duration of the academic unit (e.g., a semester). They work in this space, individually or in small teams, on design assignments that are planned to attain specific curriculum goals. The group meets with the instructor(s) two or three times a week to review the work in progress. Some reviews are formal; others are less formal “pinups”; in those reviews other students as well as invited reviewers may take part, but for the most part students hold individual tutorial sessions with an instructor, usually at their desks. These sessions are called ‘desk crits’ (‘crit’ is short for critique), and because of their individual nature – usually one student and one instructor are involved – they are referred to as “one-on-one”.

A one-on-one session usually starts with the student presenting his or her work, or how it has evolved since the last time the instructor has seen it. Then a discussion of the work is led by the instructor, during which questions are asked and answered, examples given, principles and precedents evoked, alternatives suggested, problem areas pointed out, etc. Quite often sketching is also used during the discussion. This interactive session is where the student is expected to learn how to design, and to enhance his or her understanding of designing. Students are extremely sensitive to the nature of one-on-one sessions and respond to the instructor’s ‘style’ of teaching, which varies greatly from one instructor to another. Instructors, however, are normally skilled designers, but as concerns teaching – they are self-taught: no training for design instructors exists other than, sometimes, an apprenticeship on the fly, with an experienced instructor. The one-on-one session is based on communication between the two parties – instructor and student. However, it is the instructor who ‘gives’ the crit, and the student who ‘receives’ it. This turns the desk crit into a very sensitive setting with a powerful potential for personal growth, but also for distress and possible learning hindrance. It is therefore important, in our view, to look at what actually transpires in one-on-one studio desk crits.

The instructor-student interaction in the design studio was cogently described by Donald Schön (e.g., 1981, 1987), who highlighted successful versus unsuccessful cases: success or lack thereof are explained, according to Schön (1981) and Argyris (1981), primarily by the learning behavior of the student who ‘knows how to learn’ or suffers from ‘learning binds’. The teaching behavior of the instructor, however, is not analyzed in any depth. In fact, curiously little has been written about design instruction or design pedagogy; instead, instruction methodologies are sometimes attempted. In-depth classifications of the various types of institutional models have also been the subject of recent studies (Bar Eli 1998; Salama 1995). An exception is a study by Sachs (1999) who described and analyzed the common phenomenon of ‘stickness’ in the course of the design process, with great empathy for students who feel stuck and with insight into the forces that permit them to get unstuck and move forward with their designs. Likewise, Ochsner (2000) has written about the student-instructor relationship from the perspective of psychoanalysis. Lastly, Anthony (1991) has devoted years of research to the formal reviews in the studio, where juries critique the student’s work (usually upon its completion). This is an important and illuminating contribution to design education pedagogy, but it does not pertain to one-on-one desk crits.
We believe that it is time to pay increased attention to design instruction pedagogy. The one-on-one session in the studio is too precious, and potentially too hazardous, to continue to entrust it to untrained hands of trained designers. To this end this paper analyzes a small number of one-on-one sessions, based on protocols, in order to exemplify some of the issues that we think are pedagogically relevant. We conclude with an appeal to work towards training programs for design instructors.

A note on methodology
We do not wish to propose a comprehensive design instruction theory, nor do we have in mind a prescriptive ‘how to’ method. Design education theory and methodology, and curriculum issues, have been paid quite a lot of attention to in recent years (e.g., Bar Eli 1998; Belkis 2000; Boyer and Mitgang 1996; Cuff 1991; Porter and Kilbridge 1981; Salama 1995). In contrast our work is based on observing and documenting (video or audio taping) student-instructor interactions as they occur in the studio. Design sessions were observed and documented by students as part of their course assignments (see acknowledgements); the protocols we collected were consequently analyzed, using a variety of quantitative, and mostly qualitative methods. All the sessions were observed close to the middle of a term, and the studios in question were regular curricular components of the first, second, third and fourth year of undergraduate studies in the Faculty of Architecture and Town Planning at the Technion. Where we quote from the protocols, the quotes are translations (by the author) from the Hebrew.

Types of instruction and types of reasoning
We would like to isolate the desk crit, and address it independent of other studio-instruction factors such as goals, contents, or working method. Quayle (1985) lists six profiles of instructors, which we reduce to three:

Instructor as source of expertise/authority: The instructor knows something that the student is trying to learn; he or she is expected to transmit this knowledge and know-how to the student who, in turn, is expected to know how to extract it from the instructor.

Instructor as coach/facilitator: The student has potential abilities and tacit knowledge and the instructor is expected to help develop and maximize this potential through guidance and opportunities for the acquisition of experience. Schön (e.g., 1987), among others, insists on describing the design instructor as a coach.

Instructor as ‘buddy’: The instructor provides positive reinforcement and encouragement and helps in the socialization process into the professional community and its culture.

There are many overlaps among these profiles but only rarely can a single instructor perform all of these roles equally well. Consequently, we propose an even further reduction, one that has a practical bent: the role model, who excels in the practice of design, and the design educationist, whose expertise is teaching and training (Goldschmidt 1988). Obviously, here too overlaps exist (and are welcome); a student who enjoys a balanced exposure to both, with more or less overlaps, is likely to benefit from the complementary strengths they have to offer. This dualism requires elucidation.

What does the role model do? He or she usually comes to the studio with a fat pencil and during the crit, while describing or explaining something, often draws to show the student what is meant. It may be a well-known exemplar or precedent or a possible improvement on something the student has drawn, or a reformulation of the problem at hand by way of a negative example or a diagram of
The role model is a practitioner. He or she has worked on problems similar to the one the student is wrestling with, and has an inventory of numerous relevant cases stored in memory. He or she acts mainly by modeling designing and by providing examples. “This is what I did/would do in this case” or “in that project the solution was…. see what we can learn from it?” – are phrases the student is likely to hear from the role model. The role model teaches primarily by examples that assist the student in reasoning by similarity. He or she is definitely a source of authority, and normally does his/her best to also be a good coach.

The educationist must know a lot about design, and must certainly have at least some design experience, but is not necessarily based in practice: he or she is an academic who has become a professional teacher, whether formally trained as such or not (the latter is normally the case). The educationist is an experienced instructor, who can quickly identify students’ styles of thinking, their strengths and weaknesses. Whereas the role model teaches what he or she knows, the educationist tries to teach what the student needs to learn. He or she are often more methodical in their approach and they try to teach design methods to students; they may have well developed personal theories of design and its instruction. They invent exercises that are believed to help clarify specific issues, and they often suggest sets of design principles to students. If we were to reduce their work into one type of instruction, we would say that the educationist provides rules for design novices to reason by. The educationist is a coach by definition, but he or she may also be a source of authority. It is not unusual for coaches, especially young ones, to also be ‘buddies’.

This pair of descriptions evokes the two types of reasoning that cognitive science claims is used by both children and adults: rule-based reasoning and similarity-based reasoning. In yesteryears, it was believed that there is a clear hierarchy whereby similarity-based reasoning is inferior to rule-based reasoning, and typical mostly of young children. In recent years the primacy of rule-based reasoning is no longer universally accepted as an absolute truth, and researchers are interested in the relationship between the two modes of reasoning: rule based and similarity based, in both children and adults (Sloman and Rips 1998). According to Sloman (1996) we are endowed with two independent (but interacting) cognitive systems, each dedicated to one mode of reasoning: one associative and similarity-based, the other symbolic and rule-based. Other researchers have advanced the view that if indeed there are two systems of reasoning, they are equally important to processes of problem-solving and learning (i.e., Gentner and Medina 1998).

Our protocols include examples of instruction by both ‘role model’ and ‘educationist’ types of teachers and it is fascinating to see how they appeal to both kinds of reasoning, respectively. Let us look at a segment from a protocol taped in a first-year studio, where a short exercise was conducted in which a dwelling unit was to be designed. The instructor refers to cubes the student has generated to compose the dwelling unit with, to introduce principles of repetition and unity in design:

“...when you start looking at your cubes, where one cube represents built [area] and the other represents a garden, represents a void, then once again it is easy to repeat a little the same sort of... That is, if you succeed in creating something of this scale that is close enough to that scale, of an exterior room... That is, to succeed in creating the same type of joints.”

In contrast, a fourth year instructor models for a team of three students who are designing a School of Architecture in a college campus near a lake:

“...since you have a slope toward the lake, it could be possible to give some opening; if I draw the ground line [draws], it could be possible to open... that is, we have the urban courtyard of the campus that is connected to the upper courtyard and here [draws] we go down...”
The instructor draws a section that illustrates a possible solution to a specific design question, thereby creating a model, or an example. Her students are expected to learn from this example how the slope in the site can benefit their design. She acts as a role model. The mode of instruction here is different than the one employed by the first year instructor, who coaches his student by trying to show her that the different partial design problems she encounters should not receive independent ad hoc solutions, but rather that she must learn to look for overall principles that will lend her design coherence. In this case the principle is repetition: indoor and outdoor spaces of the same scale, joints of the same type.

### Teaching – learning asymmetry

Every elementary schools teacher knows something that design instructors are sometimes very surprised to discover: that what one (thinks that one) teaches is not necessarily what the learner learns. In other words, in a teacher-learner interaction there may well be a discrepancy between messages sent by one who teaches and messages received by one who learns. We refer to this phenomenon as a teaching-learning asymmetry. Design instructors rarely try to verify that the student is in a position to understand their comments exactly as they are intended: design crits, as captured on tape, are often solid long monologues by instructors with a minimal participation of the student in the ‘discussion.’ The following little study illustrates our point.

A desk crit in a first year studio was taped and transcribed. The transcription – or protocol – was consequently given to both the student and the instructor (at the end of the three-week design exercise). Each of them was asked to mark phrases (their own phrases and those by their counterpart) that they thought influenced the subsequent development of the project.

<table>
<thead>
<tr>
<th>Influential phrases</th>
<th>Instructor’s phrases</th>
<th>Student’s phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marked by instructor</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Marked by student</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>Overlap (marked by both)</td>
<td>(8)</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 1: Influential phrases in protocol of first year studio crit

The count, as given in Table 1, shows that most of the influential phrases were by the instructor. This is not surprising because in a first year studio both parties are likely to rely on the teacher as the leading partner in the instructional process. However, the interesting information in this Table is the small number of influential phrases that were marked by both student and instructor: 9 out of a total of 44 influential phrases, or 20%. Of the 9 phrases, only one is by the student. In other words, only a small part of what the instructor thought were very important messages he had sent were perceived as such by the student. On the other hand - we would like to emphasize the other side of this coin as well - only a fraction of what the student thought was important, at least in her contribution to the conversation, was noted by the instructor as significant. If the unacknowledged influential phrases by the student (in her view) contained questions, puzzlement or alternative ideas that had better been attended to – the instructor failed to realize their potential magnitude.

### One-way communication

Crits vary widely in the extent to which the discussion is a true dialogue between the instructor and the student. Some students are more outspoken than others, of course, but the good coach appears to know how to engage the student in a conversation. The student’s involvement is crucial to his or her learning in terms of understanding and remembering the points raised, reflecting on them and developing an independent position, and maintaining a high motivation to continue to develop the
work. When two-way communication is replaced by one-way communication, in which the student is mostly silent, something may be wrong, but many instructors are not sensitized to a possible learning bind to which their behavior may be a contributing factor. Let us look at two examples.

In the first case the setting is a second year studio where the instructor’s teaching behavior is guided by a firm design education theory she subscribes to. Towards the end of a long crit during which she speaks almost all of the time, she tells the student that she would like to see more detailed studies of his ‘leading ideas’, and various types of specific drawings and models. The following is a vignette from the final exchange between them:

I: Look, until the end of the term…
S: You simply get out of me
I: Get what out of you?
S: Get out of me
I: What?
S: Lots of blood, sweat, and tears [in Hebrew – an idiomatic phrase meaning: experiencing hard work, difficulties and frustration on the way to an achievement]
I: Out of everybody, not just you
S: I am not used to working like this
I: You are not used to it? But you will [get used to it]; this is our profession…

The student is obviously frustrated; he thinks he had done enough preliminary work, and he wants to move on to the final design phase. He sees the instructor’s requests as a negative assessment of his progress, and finally he cannot help himself and explodes with a complaint. The instructor, definitely an educationist, is neither shocked nor puzzled; she sticks with her way of doing things and does not find it necessary to ask the student, at the end, how is he used to work. She therefore misses the opportunity to show him what he can gain from complying with her request. The student does not understand why he is asked to undertake certain assignments, and the chances of his benefiting from this work are therefore quite slim.

The second case unfolds in a third year studio where a pair of students who work together on a housing project receive two crits, from two studio instructors, in two consecutive studio meetings. The first crit proceeds with both students participating actively. The protocol can be divided into three parts that roughly correspond to predominant types of phrases by the instructor: a) first, the students present and explain their work and the instructor asks clarification questions and comments on design in general. b) second, particulars of the design are discussed. c) in the third phase more general comments on design are offered, but they appear along with proposals and directions for the development of the project. No negative assessments are voiced, and in the last part of the crit a number of positive assessments are clearly pronounced.

In the second crit, which is longer, one of the students stops participating after a short while and remains a passive listener. The instructor’s phrases in the protocol can be divided into four parts with the following characteristics: a) in the first part, after hearing the students’ presentation and explanations, the instructor shifts among some clarification questions, proposals for development, and negative assessment. b) second, more clarification questions are asked and some general development ideas are offered. c) then comes a long phase of more clarification questions. d) finally, general and particular directions for development are laid out. Negative statements are frequently made throughout the crit, and some positive assessments are offered in the final phase.
A couple of weeks later the students were presented with the protocols and were asked to mark those phrases by the instructor that they thought had or will, at a later phase, have influence on the development of the project. The results are shown in Table 2.

<table>
<thead>
<tr>
<th>First crit (17 blocks of 2 phrases)</th>
<th>Second crit (20 blocks of 5 phrases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have not been influential</td>
<td>Will not be influential</td>
</tr>
<tr>
<td>Have not been influential</td>
<td>Will not be influential</td>
</tr>
<tr>
<td>Student 1</td>
<td>0</td>
</tr>
<tr>
<td>Student 2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: Influential phrases in protocols of third year studio crits

The difference between the students’ reaction to the two crits is obvious (and is accentuated by the discrepancy between the sizes of blocks of phrases in the first and second crit). The first crit is perceived as helpful: very few of the instructor’s comments are believed to have no influence on their work. The second crit elicits a much higher proportion of comments that are not believed to be helpful; the instructor appears to have failed to encourage trust in the students who are not very open to her commentary and suggestions. There appear to be two reasons for this state of affairs: first, the large number of negative statements, which must have discouraged the students. Second, the apparent lack of structure in this crit, where the instructor made proposals before she had fully acquainted herself with the work, was also problematic for the students. When asked in a later debriefing about his lack of participation in this session, the second student said: “She [instructor] didn’t seem interested in what I had to say.” No wonder that under these circumstances the students had trouble ‘suspending disbelief’ in the second crit, while the first crit posed no such problem.

In conclusion

Protocols of one-on-one desk crits are useful because they give us a glimpse into the fineries of this crucial locus of design education. We have chosen to concentrate on but a small number of episodes that raise a few of the many important issues that we think should be explored. A further step in this study, which we have only initiated in an informal way, is presenting the instructors with the protocols, and with our analyses, for their comments. We have done this, for example, with the instructor of the second crit referred to in the last section. The instructor was stunned – she could hardly believe the facts and claimed that this is not at all typical of her mode of teaching. We are quite willing to believe her, but one such session is sufficient to point to problems that may impair suspension of disbelief.

Today, computational technology is beginning to change the nature of the crit in the studio. The student uses the computer to present his work (using PowerPoint or similar software), and the discussion that follows takes place without the traditional spread-out of documents on the desk. It is difficult to remember or return to specific ‘small’ points and even more difficult to act on them with overlaid sketches, for example. Computation has done wonders to enhance the level of presentation in the studio and elsewhere, but we postulate that in terms of instructional value, the paper and pencil desk crit has advantages that no computational technique can emulate. It is therefore of great interest to conduct in-depth explorations of this age-old tradition in order to ameliorate it and maximize its advantages.

We think that extended studies of the sort we have begun to conduct can potentially provide rich data on design pedagogy that may be useful in training design instructors. Such training, which is
non-existent at present, could, in our view, be an important contribution to the advancement of design education everywhere.

Acknowledgments
The research reported in this paper was supported by the fund for the promotion of research at the Technion. The author wishes to thank students who participated in the *Cognitive Aspects of Architectural Design* seminar at the Technion in the last two years, and in particular Hila Nadav, Michal Daum, Adi Massarwa, Keren Har’el, Eyal Hendel, Dani Tatsa, Keren Goldschmidt, Elinor Aljam, Eran Ben-Dov, Eugene Drobskoy, Sanny Goldman and Noa Sar’el. Their work has informed this paper and their fresh ideas have enriched my thinking.
References


The designer as strategist: response from MA alumni

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Abstract

The underlying ambition behind the Brunel programme was to generate new kinds of design professional who understood the contextual dimension of design work, and are able to respond to these wider revolutionary changes and contribute hugely to the development of new concepts and products within organisations. They also respond to the demand for closer ties between design and its social and industrial context by taking up roles as integrators and catalysts for innovation and change.

Graduates from Brunel have been accepted into manufacturing and service companies as well as design consultancies. They are valued because they have crossed the tribal divide, they speak something of the new language of management, they have adequate structural understanding of institutions and corporate affairs, and they have been taught to be good flexible team workers. They do not, however, abandon their platform of design skills, or their understanding of creative processes. These abilities become transformed.

The author’s research output to date has focused mainly on an investigation of the value of academic and industry partnership. This paper is part of a series looking at the nature of both programmes - collaboration with industry and the career paths of graduates. It will focus on responses from 1999/2000 Brunel alumni and constitute an analysis of learning outcomes and in particular, new skills of the MA graduates now retained in quite different organisations.
The designer as strategist: response from MA alumni

Introduction
The last two decades have seen astonishing revolutionary changes which have an impact upon the work of designers. The most obvious revolutions have taken place in the development of new materials, in advanced manufacturing technology, and in information technology. There have also been parallel shifts in organisational thought, and in the generation of wider more acute social and economic perspectives. At one level enterprise management is now much more concerned with creativity, vision, team working and empowerment, and at another level global conditions are perceived as more chaotic and complex. The former is in many ways a response to the latter. Because the world is more complex and difficult to understand then new organisational perceptions, models and tools are needed.

After many years of promotion by government and design institutions, most companies are now aware of the enhanced value that design can bring to their organizations. Management personnel know that design is vital in innovation strategy but may struggle to integrate it successfully in their businesses. How company personnel are selected for design-related decision-making is still a subject attracting much scrutiny and deliberation. Enterprises expect innovation from designers without being overly explicit about their concerns and requirements. For their part, average designers very often lack skills to describe basic kinds of innovation or how much difference they might make once achieved.

Design, in all disciplines, is now acknowledged as a valuable resource. Designers, now in positions of increased influence towards their clients and consumers, may not be using this influence effectively enough. Designers need to know more and take on more challenges. Exclusion from major design decision-making processes in client companies need not be a permanent state of affairs (Gornick 2001).

UK design schools have responded to some of the technical developments, (for instance through CAD, IT, electronic media and the use of experimental materials) but the wider revolutions have had little impact in undergraduate design education. In the UK there are now a number of post-graduate courses which in various ways are attempts to change the mainstream culture of design education and respond to these wider issues. There is a shift to analytical and contextual work which has an important influence on changing design graduate career paths. Beyond that, individual MA programs have differences in emphasis - components in the new MAs are similar but the aims vary.

The Brunel programme
The first formal manifestation of the new contextual MAs occurred at the RCA in 1989-91. The author constructed and taught that RCA course with David Walker from the Open University. It may be viewed as a comprehensive pilot scheme for the Brunel Masters programme that followed.

At Brunel, the MA Design, Strategy and Innovation programme was unique in that it sought to place design graduates in the heartland of enterprise as high up the organisational ladder as possible in order to influence the integration of design more effectively. The author’s intention, as founder director of the Brunel MA DSI course from 1993 to 2001, was to place graduates of this programme directly into manufacturing and service companies in roles equal in status to middle or senior management. The key focus was on industry-based research projects. The Brunel programme continues to grow well but with less emphasis now on these industry-focused objectives.
The underlying ambition behind the Brunel programme was to generate new kinds of design professional who understood the contextual dimension of design work, and are able to respond to these wider revolutionary changes and contribute hugely to the development of new concepts and products within organisations. They also respond to the demand for closer ties between design and its social and industrial context by taking up roles as integrators and catalysts for innovation and change.

Graduates from Brunel have been accepted into manufacturing and service companies as well as design consultancies. They are valued because they have crossed the tribal divide, they speak something of the new language of management, they have adequate structural understanding of institutions and corporate affairs, and they have been taught to be good flexible team workers. They do not, however, abandon their platform of design skills, or their understanding of creative processes. These abilities become transformed (Walker and Gornick 1996).

The author’s research output to date has focused mainly on an investigation of the value of academic and industry partnership. This paper is part of a series looking at the nature of both programmes’ collaboration with industry and the career paths of graduates. It will focus on response from 1999/2000 Brunel alumni and constitute an analysis of learning outcomes and in particular, new skills of the MA graduates now retained in quite different organisations. The graduates entered their employment after completing the programme and it is their qualitative response to issues relating their training to their career trajectories that will form the basis of this study.

**Designer as strategist**

This paper begins with the basic premise that in the new millennium design is only half-fulfilling its promise. Designers have qualities that enable them to do far more than design. As a result of long term, and ultimately successful promotion by government, design institutions and finally media, designers have reached a stage of recognition they have long aspired to, but a level which does not do justice to their range of thinking or inventiveness. For the most part designers are not grasping the opportunities now open to them.

There is much discussion in design circles currently on the need for design to adopt more strategic arguments, but also considerable confusion as to what strategic thinking for designers might actually entail. Strategic thinking in organisations is concerned with setting appropriate goals and creating pathways for future decision-making. With their innate starting position of posing the question “what if?” designers are in key positions to help to push management ideas forward. They can produce models, prototypes and drawings to show in visual terms what their ideas entail and they can champion their proposals persuasively with visually enhanced presentations.

Unfortunately there are two main obstacles at present that inhibit most designers from adopting this route. In the first place, designers are not trained at undergraduate level to take up these tasks in organisations, their basic education has unspoken parameters which concentrate on the project in hand and clients’ given brief.

Secondly, there is natural divergence between inventive, free-ranging creative designers and rationalist and analytical management personnel. The continual tension and potential conflict require resolution. Only a few designers have purposefully gained sufficient knowledge of the real world to be able to sustain arguments coherently. Here we have a conundrum. Managers now know about the “What” and the “Why” of design but they are still unsure of the “How”. Designers are now in an enhanced position to lead and yet they have been constrained by their education into thinking that strategic activity is not part of their range of responsibility.
And yet, if we look at the ideal characteristics of people required to manage the many scenarios of organisational change, according to management gurus Harvey-Jones (1994) and Handy (1995) the skills they prescribe bear a remarkably strong resemblance to those inherent in experienced design activity - the ability to conceptualise, supply prototypes quickly and offer an enhanced understanding of the consumer/user. Couple this with the fact that working patterns in most areas have changed significantly as a result of new technology and new management systems and it would appear that more experienced design-trained graduates need to take the leap into strategic positions both in industrial companies and design consultancies. Only a few so far have adopted these new roles.

The idea behind the RCA and Brunel programmes was to take design-trained graduates with work experience and to expose them to a range of new contextual thinking that would mirror economic and business issues and all the concerns of current enterprise activity. The aim was to present students with new options for a range of careers that, at the time, fell under the banner of design management. The unique proposition of the curriculum was formal industry-based research projects that would be assessed and credited with equal status to output in academic theory. The intention was to generate people who would become boundary crossers by broadening student perspectives and enlarging the range of their working roles. We were totally transparent about the programme’s aims. Students understood that they would be learning new languages in order to engage in a totally different quality of dialogue.

**Left and right sides of the brain**

Designers have fundamentally different ways of thinking that is by taking lateral leaps and making barely rational metaphors and associations. They work through tangible detailed modelling and prototypes. There is an understandable tension between design and management in organizations and design is seen to represent the forces of creativity and management represents the forces of control. The one seems to resist the other but both creativity and control are necessary. Mutual trust and respect are needed. Design management principles are necessary to hold the two sides together, and to seek rapport between people who have a lot to offer each other, although they think differently. Good communication and interpersonal skills are a major component of the programme philosophy. Both RCA and Brunel programmes emphasised group projects which provided students with an immediate immersion into both the trials and benefits of team activity and the tangible experience of working directly in industrial companies.

**Knowledge and learning**

The theme of this study is the communication juxtaposition between the individual, the team and the organisation as a whole. Stacey’s (2000) work on strategic management and organisational dynamics emphasises the importance of narrative, conversation and learning from one’s own experience as the major ways of gaining understanding and knowledge of strategy in organisations. He encourages students to reflect upon the usefulness of their own experiences in future activity. Pfeffer and Sutton (1999) analyse companies overcoming barriers to turning performance knowledge into organisational actions and maintain that taking action in a prescribed setting and confronting problems makes learning more efficient as it is grounded in real experience.

Stacey (2000) says: “When we talk about communications we try to explain complex human processes in language taken from a mixture of cognitive psychology and psychoanalysis. Both of these psychologies start from the position of the autonomous individual. For the former, group and society are simply formed by individuals who are then influenced by what they have formed. In the latter, group and society play a much more important role in that the individual mind is structured by the clash between individual drives and social prohibition”. There is another way of thinking...
about human nature to be found in sociology, social constructionism, and in something like group analytic theory. From this perspective, the individual is social through and through to the core. The individual mind and social relations are simply two different perspectives on the same phenomenon. Motivation and energy for relating arise in relating.

These days there is much discussion about the “learning organisation” and “knowledge creating company”. This is partly driven by new technology wherein no single individual can keep up to date with all the recent developments and partly by looser styles of open management. The underlying ambition behind the Brunel program was to generate new kinds of design professional who are able to respond to the demand for closer ties between design and industry by taking up roles as integrators and catalysts for innovation and change. The significance of bringing received wisdom and point of application together is described by Binney and Williams (1997) who point out: “Learning, in the sense of an increasing capacity to do things, does not take place in the classroom or in a workshop or even on a company ‘awayday’. It happens as people ‘do’ as they interact with others and reflect on their experience. Learning comes from bringing thinking and doing together”.

Making connections
Graduates from Brunel are accepted into industry and valued because they have crossed the tribal divide, they speak something of the new language of management, they have adequate structural understanding of institutions and corporate affairs, and they have been taught to be good flexible team workers. They do not, however, abandon their platform of design skills, or their understanding of creative processes. Rather they bring these abilities and insights to the company, but now newly expressed and embodied in a form and language that managers can readily understand. The response from UK industrial companies has been swift and positive. Many company contacts have written to praise the work of the students and to support the direction of the program (Walker and Gornick 1996).

The curriculum was not an easy process to follow; it demanded much from students. Stacey (2000) argues that there is a recognized struggle in each human to retain personal freedom, to take leaps into the unknown and at the same time to seek the reassurance of familiar landscapes and systems. Stacey describes it as “the paradoxical human need to fuse into a group and yet remain an individual”. Dialogue is where two parties exchange views about paradoxical situations, each having the intention of modifying their position in the light of the views and evidence presented by the other. Each participant is open to being influenced by the other. Argument is simply stating positions without any intention of moving. Dialogue is thus the required process for intelligent reasoning.

Conversational life cannot develop according to an overall blueprint since no one has the power to determine what others will talk about all the time. Creativity, innovation and learning are all transformations of organising themes as they reproduce themselves. Stacey concludes that the key to this transformation is diversity. “The fundamental requirement for transformation is non-average, deviant, maverick or eccentric behaviour on the part of the entities comprising a system”.

Monitoring and evaluation
In shaping the new Brunel curriculum with my colleague David Walker from the OU it became apparent that constant monitoring and evaluation would be required. There were 3 reasons for this. First, major components of the programme were formal industry-based research exercises for students. In sequence, the first of these was a student team design management audit of a selected company and the second, an individual student internship in a company either already known to the
programme or newly selected by the student. These industry-based exercises involved complex organization by the author with industrial companies who were involved in continual change and an increasingly volatile economic climate. As there was a formal student assessment by credited report and presentation, these projects had to be monitored closely. Secondly, programme material and references could never be static but had to reflect constantly changing economic and business environments. Finally, these programmes were undertaken as an experiment in design education. This evaluation process started in earnest when the programme started at Brunel in 1994. It had to be proved that the idea was sound and where modifications were required. Feedback from both industrial partners and graduates of the programme was paramount.

Over the 12 year period of directing these programmes the author has observed certain emergent patterns in graduate outcomes. Some were to be expected and others evolved from specific elements in the curriculum. It had been decided early in programme planning that there would be a limit on a yearly intake of up to 15 students in order to allow for maximum student/tutor interface and a continual opportunity for students to discuss and present their ideas both formally and informally. We wanted all voices to be heard in discussion. As a result of this decision the group dynamic in each yearly intake became very pronounced.

Advancing into new areas of strategic thinking and relating new material to their own career potential was a steep learning curve for students. A high diver learns his or her skill in the swimming pool by tackling successively higher levels of diving boards. It is a frightening process and challenging at the same time. At each stage something new is learned about the individual’s skills and capabilities and especially, their courage quotient. It is evident that support of peer group members going through the same exercises at the same time is a key factor in successful knowledge gain and strong motivation for achievement (Gornick and Inns 2000).

The students in year 1999/2000 formed a particularly strong group. Their comments on the year’s teaching and learning throws some light on the levels of their adoption of the new language.

Structure and curriculum of the course as a whole:

TG: (Graduate employed by Oyster Digital Design consultancy) The curriculum of the course exceeded my expectations. On reflection and due to the emergence of new technologies and digital industries in the past year, I feel that there should be much more emphasis on new economy businesses, systems and practices. Apart from this, the curriculum was a broad, introduction to the scope of design management. The theory work served as excellent material and tools to equip us in the real world!

JD: (Graduate is partner in strategic consultancy, Engine) Overall course structure and curriculum is excellent and would seem to cover all the relevant/most pertinent issues, allowing students the opportunity to specialize in their particular areas of interest. Audit and internship programmers are vital, allows specific elements of taught course to be implemented in practice. The industry links proved to be an excellent way of gaining employment, and experiences provide intellectual ‘food’ for the final dissertation.

DT: (Graduate is Innovation Scouting and Planning Manager at Orange) In the curriculum of the MADSI course, one module feeds into another and so when it comes to ‘practice’ during the audit, students are well prepared. Don’t change the structure.

SC: (Graduate is employed by l’Oreal, France) The structure of the course is fine but very intense for one year. It would be advisable to make sure that anyone interested in doing the course knows in
advance. The curriculum is very interesting. The nature of the course is great, very fulfilling, with a good mix of lecturers.

Relationship between theoretical and practical elements, particularly the value of the practical:

TG: The group audit project served as a good introduction to the application of our newly taught design management and strategic skills within a commercial context. Lessons learned from the first 3 months were put to test in an environment that was wholly welcoming of our work (HSBC being the case study). This led to a productive 4 weeks where students were able to test theories, explore new ways of working and develop techniques taught. The support of working amongst a team further enhanced the opportunity and our confidence to explore our new roles and skills.

The second practical exercise; the internship period, took this process of student development towards employment one step further. The internship period (in Oyster consultancy) again served as an excellent period to exercise new skills, but also test the water and discover particular attributes. It provided excellent opportunities to make contacts in industry and extended relationships with the host companies. This was a tough period but valuable.

AF: (Graduate employed by Oyster Digital Design consultancy) The internship period is very important to employment. My time at IBM serves as a real door-opener to potential employers, and the experience of the audit is something that sounds very impressive during interviews. I originally started the course because I was fed up free-lancing and I wanted a new direction to take my design skills into industry. The course has provided me with an excellent springboard to take me into industry.

SC: It is very valuable to apply the theory when doing the internship.

CT: (Graduate is Head of Product development at Innovata, a medical device manufacturing company) One of the great strengths of the course is this new cognitive view (which) is put to the test through the use of design audit and internship, both of which I thoroughly enjoyed.

DT: Moving from academic theory to practice is salutary. Creating ideas in the university context is easy; implementing them in practice is very difficult. Two weeks after I arrived to start my internship at Orange, the person who took me on left to start another job. I had convinced him that my research into a fuzzy, intangible area would be useful for the company, and his exit meant I had to find my way without a champion for a while. By learning new languages and ways of communicating, I managed to make a diffuse area more focused, more understandable.

The holistic outlook and strategic content of the Brunel master’s program enabled me to consider the audience whenever I speak in the company. Marketers and engineers don't talk together easily; people with an industrial design background can encourage communication. So I changed my language, established a role, and brought more people in for what we call ‘innovation scouting’, which functions internally for related products and planning and externally for new ideas and new technology. The most important aspect of corporate life, I have found, is personal relationships and networking.

Learning outcomes
TG: Learning outcomes led to a confidence and clarity to be able to apply design and not just to produce it; to consider elements of design management that cover a spectrum of meanings; to explore new areas of design outside the area of our own specializations; to work alongside a spectrum of design practitioners within the group, gaining a better picture of the real potential for
design and design management; to make contacts in business on a senior level; and the confidence to write reports and conduct presentations.

AF: The over-riding thing about the course that made it special for me is what you can learn from your peers. The lectures opened our minds to different ways of seeing things, and this was taken further by discussions with my classmates.

DT: The thing that brings the course alive is the mix of people on it and the different experiences they bring. I believe our year was very fortunate to have a range of people who all had similar aspirations about how design can be used strategically and yet had a varied background. This aspect is helped through the recruitment of students who have work experiences that they can bring as well as more general life experiences. This is not to say that recruits should not come straight from university, but they should be very strong candidates if they do.

JD: Overall, I’m convinced that this kind of curriculum should be taught before any BA course, but that gets us into a whole debate about the British design education system.

Deliverables ie. Employment potential:

TG: Employee potential has been highly fertile from this year’s MADSI. This is the result of a combination of the excellence of the course and the teaching, but also the enthusiasm and connectivity of an excellent set of students. This connectivity and enthusiasm should be wholly encouraged.

AF: I am delighted with the choice of course I made; I have numerous different skills that I feel I could use to obtain employment. I have a good job and I have learned lots.

JD: Deliverables (if anything) should be slightly more project based, I think this might provide better employment potential; the highly strategic nature of the course may I think possibly scare some employers and make students appear ‘over-qualified’.

DT: I got exactly what I wanted out of the course, which is surprising, considering that I didn’t know what that was. My objective was a change in career direction. The course doesn’t just open your mind; it turns it inside out. I firmly believe that I would have been unable to secure the position I now hold had it not been for the learning I have gone through over the last year.

CT: Fundamentally the MADSI course stimulated me to consider design at new levels and with greater breadth. This stimulus was complimented with the tools to inquire and think both strategically and in an innovative way. I now have the confidence to comment on, and manage, design within industry.

Conclusions
In examining the relationship between the individual student and his or her peer group, it is evident that the course made its intentions transparent. Graduates for the most part, although agreeing with the philosophy of the course and aware of the outline curriculum, found the theoretical material new and challenging. The formal team-based audit was a successful exercise in terms of an initial foray into the corporate world. The individual student internship was a more complex undertaking and stretched student interpersonal and diplomatic skills.
The value of the industry-based research activity is seen as an important departure for this type of post-graduate programme enabling graduates to experience at first hand the problems and dilemmas that occur regularly in modern enterprises subject to continual change. The students were encouraged to function equally well as individuals or in groups either as leaders or members of the team. In discovering new roles for themselves and at the same time recognizing new facets of their own personalities. In the year 1999/2000 the peer group reinforced their emergent new personal knowledge.

The standard of teaching and particularly the wide range of tutors’ expertise was welcomed. Experienced students appreciate differences of opinion in lectures. They have a better opportunity to understand where they stand personally in the spectrum of taught theory. Graduate response reveals that informal discussions in the group evidently played an important part in further analyzing and reinforcing taught theory. In the collective memory of the graduates surveyed, the information retained as a result of informal discussions was vital in developing individual knowledge resources.

The change in graduate perceptions, knowledge and language opens doorways to career options hitherto unexplored. There have been indications that their new skills are not always readily understood, especially by human resource departments that have established formulae to follow. A design-based graduate would be seen as being a designer, rather than a design strategist. Graduates, however, have entered organizations and have been employed as a result of their ability to invent a new role specifically for their host organization.

It is to be expected that resistance may be encountered in many spheres, in education, but much less so industry. It is essential to find champions in organizations to support students undertaking these research-based projects. In each team audit, and two took place each year with teams of around 7 students in each, a company liaison was appointed to monitor students’ progress with course director. In the individual student internship this role was not covered in each instance, hence the history of DT at Orange.

**Final note**
The programmes at RCA and Brunel started out, essentially, as an experiment. They challenged the orthodoxy of design education. There was bound to be some resistance to the ethos and ideas. It was one thing for the author and colleagues to argue the case and quite another to expose graduates to the conflicting opinions. They have risen to the challenge well. There is continual communication between staff and alumni, and a strong solidarity. Career patterns continue to be monitored. Alumni are always considerate of recent graduates and make every effort to help them whenever possible. There are two MADSI alumni currently teaching in the Design Department at Runnymede, one is a lecturer on the current MADSI course.
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Product charisma

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Abstract

Consumers are attracted by product designs that feel “alive” and that contain surprise elements. Meaningful product attributes are an important way to differentiate a product from the competitor’s products. Companies in mature markets, especially, have a competitive advantage when they succeed in integrating this “emotional value” or “experience” into the product design.

This paper presents a classification of the various messages that a product can convey. The different product messages are visualised by means of a schema in which three groups of messages are distinguished. These three groups consist of messages about the product itself, about the company and about the product user.

The product messages are described in detail and illustrated with recent examples of meaningful product designs.

The classification of the different product messages is a synthesis based on findings from literature. In a next research stage this classification and the development process of products with “emotional value” will be analysed in further detail.
Product charisma

During the last decades, industrial product design has moved from a “rational” approach to a more “psychological” approach in which meaningful messages in design have gained importance. A product can, for example, contain status symbols or look “friendly” to work with. The right messages or emotional values in a product contribute to its attractiveness and influence the buyer’s decision.

The main objective of this article is to present an overview of possible messages in a product. In the overview, three groups of messages are distinguished. These groups consist of messages about the product itself, about the company, and about the product user. These product messages are described in detail, visualised in three diagrams and illustrated with recent examples of meaningful product designs.

More competition, more messages
Several people in the design field (Eger, 1991; Luh, 1994; Marzano, 2000; McDonagh-Philp et al., 2000) have emphasized the importance of “emotional benefits” produced by the messages in the product. This emotional benefit can be a competitive advantage. According to Marzano (2000), head of Philips Corporate Design, companies no longer have to satisfy people’s functional needs, but have to provide them with ways to stimulate their senses and intellect. Philips Corporate Design aims to design “meaningful objects that support people in their daily tasks, express values they believe in, and stimulate their emotions and creativity”. The integration of this “emotional experience” in the product design is used to differentiate the product from competing products with the same functionality.

The Italian company Alessi produces tableware and other domestic products. Some of its products have an expressive and non-conventional product design. In Westerlaken (1999) Alberto Alessi, the Chief Executive of Alessi, remarks that a product has to fulfil its function, but that its emotional function is becoming more important. McDonagh-Philp et al. (2000) summarize this same phenomenon as follows: “In the design research stages, emphasis is changing from “hard” functionality to “soft” values in product design”.

Different terminologies are used to describe the soft qualities of a product. McDonagh-Philp et al. (2000) use the term “emotional domain”, “soft design” or “soft functions” in product design. Durgee (1999) calls this “product soul”. Bürdek and Gros (2000) and Steffen (2000) use the terms “product language” and “symbolic function”. Marzano (2000) uses the term “product experience”, which is close to the terminology “added emotional value”, “emotional fit” or “product emotions” used by Desmet, Overbeeke and Tax (2001). For an overview of these different terminologies see figure 1.
Terminology for Meaningful Product Design

<table>
<thead>
<tr>
<th>Termination</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional domain, soft design, soft functions</td>
<td>McDonagh-Philp &amp; Lebbon (2000): Loughborough University &amp; Royal College of Art Muller (1997): Delft University of Technology</td>
</tr>
<tr>
<td>Emotional function</td>
<td>Westerlaken (1999): Alessi</td>
</tr>
<tr>
<td>Added emotional value, emotional fit, emotional product experience, product emotions</td>
<td>Desmet, Overbeeke &amp; Tax (2001): Delft University of Technology</td>
</tr>
</tbody>
</table>

Figure 1: Terminologies to describe product messages.

There is a relationship between these different terms. The above terminologies look at the phenomenon at three different levels. The first level indicates the existence of communicative product qualities. At this level we find: soft design, emotional function, symbolic function, emotional domain and product language.

The existence of this phenomenon leads to a product with: meaning, identity, character, soul, symbolic value, added emotional value, pleasurable benefits etc. This is the second level.

Products with the above qualities cause a reaction on the level of the product user. They might bring about an emotional benefit, product experience, product appeal, product charisma or product attraction.

The terminology “emotional value” or “emotional benefit” will be used in the following text. A product will be considered to have appeal or charisma because of its mix of functional and emotional value.

**History: The growing importance of emotional product value**
The movement from product design based on functionality towards product design with an accent on communicative product aspects has been gradual.

In 1896, the American architect Louis Sullivan published an essay in which he stated: “form follows function”. He referred to the appearance of the buildings he was designing and the influence of the building’s function on its shape. The same design philosophy "form follows function" was used extensively thereafter in product design and architecture, persisting until around 1980.
**Functional product styling**

In the period 1919 – 1933, the influential German “Bauhaus” movement used a “functional” product styling. The Bauhaus aimed to adapt the product’s design to the industrial possibilities of that period. This philosophy of “design for industry” and the concept of “form follows function” resulted in a minimalist product styling based on geometrical shapes and few decorations. The product was said to look modern because a machine made it. Few products designed in the Bauhaus period were taken into production (the Bauhaus period from 1919-1933 was very short), but some of the Bauhaus products, such as the table lamp by K. Jucker and W. Wagenfeld, show the force of the “form follows function” principle. For example, the table lamp by K. Jucker and W. Wagenfeld is still in production 70 years after its creation. (See figure 2). After the Second World War, many design schools in Europe were based on the Bauhaus principles of functionality.

Figure 2: The Bauhaus table lamp, by K. Jucker and W. Wagenfeld in 1923-1924 (Droste, 1990).

**Decorative product styling**

Streamlining or aerodynamic product styling became very popular in the United States around the period 1935-1955. With American streamlining, decorative (non-functional) elements were added to the design of consumer goods. See for example the streamlined car design in figure 3. In the 1930’s, the French product designer Raymond Loewy said, "La laideur se vend mal", in other words, that ugly looking products are difficult to sell. Raymond Loewy expressed the need for decorative elements in product design and used this product styling to promote his services as a product designer in the United States. He was one of the pioneers in the United States to use aerodynamic product styling.

Streamlined styling was first used for the design of aerodynamic products such as cars and trains. This was useful to lower petrol consumption. Later, streamlining became a meaningful symbol, which signified modernism and technical progress in society. When this style was applied to static products, such as a refrigerator, commercial success was instantaneous.
Meaningful product styling
The United States was ahead of Europe in applying decorative styles such as streamlining. European design remained dominated by the rational concept of “form follows function” for a long time. In Europe, the real break from the functionalist approach in product design came with the designs from the Memphis group (Bürdek, 1996). From 1981, the Italian design group Memphis created furniture and decorative products, such as lamps and vases. The Memphis designs are expressive, often provocative and cheerful.

The bookcase designed by Ettore Sottsass (figure 4) is an example of early work in the Memphis design style. It reveals an anti-functionalist attitude through its use of colour, decoration and experimentation with form and surface (Woodham, 1997).

The interest in the Memphis designs showed the need for change and the increasing interest in meaningful product aspects. The practical, rational aspect of product design no longer fulfilled all needs and did not dominate the product’s shape any more.

The Memphis products received a lot of attention and international companies such as Philips and Sony were influenced by this design philosophy. Many companies in consumer goods started to pay more attention to these expressive product qualities.
Theoretical background of the emotional product function

In the 1960's, the French philosophers Barthes and Baudrillard started to analyse the socio-psychological meaning of products. Barthes argued in his book “Mythologies” (1957) that objects and images not only signify their basic function, but also carry a "meta"-meaning. He discussed the socio-psychological function of objects and referred to the science of signs (semiology) that is based in linguistics (Julier, 1993). The analysis of the sociologist Baudrillard was based on semiology as well. In his book “Le systeme des objets” (1969), he describes the link between social life and symbols in products (de Noblet, 1993).

Around 1975, the theory of product language was developed at the Offenbacher Hochschule für Gestaltung. In the Offenbacher theory of product language the “product functionality” is distinguished from “the product language”. Among the product’s language aspects we can distinguish “message” aspects and “aesthetic” aspects (Bürdek, 1996; Steffen, 2000).

In the Offenbacher theory of product language the message (or sign function) gives meaning to the product and is considered as the content of this product language. The aesthetic function is considered as the grammar or the structure of this product language (figure 5).

Figure 5: Basic structure of Product Language by the Offenbacher Hochschule für Gestaltung.

In the following diagram a figure is developed that is based on this structure. A slightly different vocabulary has been chosen and the “product meaning” is developed in more detail.
Product meaning in more detail
In the following text the “product meaning” is divided into different types of messages that can be communicated by the product. In this renewed diagram, the product meaning is divided into three main groups of messages: “messages” about the product itself, about its user and about the company (see figure 6).

Figure 6: Summary of different messages we might find in a product.

Published remarks from designers and research from different sources (Steffen, 2000; Durgee, 1999; Kälviäinen, 2000; Marzano 2000; Fayolle 2000; Fishman 1999) have been used to obtain this further understanding of the different messages in a product.

In the following three sections we will first look at three major groups of product messages. In the first place the messages about the product itself, secondly, about its user and thirdly, about the company. Each group is developed in detail.

Messages about the product
*Messages about the product provide information about the product itself*. Information about the product is divided into three subgroups: product information, place in time & culture, and affective signs. For an overview see figure 7.
The group *product information* can contain messages about the product’s “working principle” (how, where, and when to use the product). Innovative elements in the product’s design (“novelty and surprise”) are also included in this category. This message group basically explains the product’s function and its elements of newness.

The second group of messages in a product’s design (place in *culture and time*) can contain “historical” styling elements, be part of a “styling movement” or be the expression of a “cultural identity”. This group of messages places a product in its historical or cultural context.

The third group of messages is called *affective signs*. Affective signs might concern the “artistic feel” of the product, its “craft qualities”, its “human characteristics” or the use of symbols related to “nature”. This group brings a product closer to its user, because the product feels more “human” than “industrial”.

Figure 7: Signs about the products, its place in time & culture and affection.
Messages about the product: product information
Messages that give information about the product contribute to a better understanding of the product. In the following sections we will look at symbols related to:

- The product's working principle
- The product’s quality
- The product’s newness and surprise elements.

Working principle
Messages concerning the product’s usage give information about what the product does (identification of its function). The design can express as well how to use it and when to use it (for instance, under festive or daily circumstances).

Quality
A product can be designed as well to give an indication about its performance and quality. A product’s design can accentuate the product’s performance because product styling can be used to make a product look faster or even more powerful (for example, in car designs).

Novelty, originality or surprise
Styling elements can be used to ensure that distinctive, original qualities are noticed within the first moments of decisive contact with the product. Surprise conjured up by the product gives a product an attractive character (Durgee, 1999; Kälviäinen, 2000).

Now we will look at the second detailed group within the theme “messages about the product”. This detailed group places the product in its cultural context and time frame.

Messages about the product: place in time & culture
Specific forms or colours give a product a cultural or temporal signification. Historical symbols show “our roots” (Durgee, 1999) or give us a “sense of belonging” (Kälviäinen, 2000). Styling trends gives us “identifying marks” (Starck in Bommel, 1997). Symbols concerning time & culture are related to:

- Historical value
- Styling movements
- Cultural values

Historical value
Many products on the market are based on old designs and obtain their appeal from their association with earlier times. Archetypal shapes make a product easily recognisable and give a re-assuring value because “they make us feel the roots of our identity” (Durgee, 1999).

The popularity of antique products demonstrates the importance of traditional shapes as well as authentic values. An aspect that is specifically important in antique products is the “life the product had before”. Products that rate highly in terms of soul “look like they have been through a lot”, and that “they would have many stories to tell”. They seem to be “attached to another life” (Durgee, 1999). The past has a special symbolic meaning, because tradition is a metaphor for high quality (Kälviäinen, 2000).
Styling movements
Often it is possible to recognize the period in which a product was designed. The choice of materials and shapes determines if a product fits in its period. A sixties’ design has different styling from a product designed in the nineties. This gives the product a modern or old-fashioned look. The French designer Philippe Starck remarks that he tries to work with semantics as a tool. What he does has to be sometimes in line and sometimes in conflict with society. In any case, it has to give “identifying marks”. Every period has its colour (Bommel, 1997). Kälviäinen (2000) explains that we need such references because “the connection between history, contemporary time and the future gives us a sense of belonging”.

Cultural symbols
A German style or French look can contribute to the charm and attraction of a product. An example in car design is the more “solid” look of the “German” Volkswagen and the “expressive” look of the “French” Peugeot 206. Additionally, appreciation of colours is not the same in every geographic region; a “wrong” colour can lead to the rejection of a well-designed product.

Apart from the two previous message groups “product information” and “time & culture” we will now look at a third group concerning “affective signs”. Affective symbols are currently very present in products. For an overview, see figure 7.

Messages about the product: affective signs
Affective products have a friendly presence or create user “affinity” (Fayolle, 2000). Different ways exist to create affective products, for example a touch of luxury or craft quality in a product’s design can make a product appealing.

Craft qualities “make the product unique” and show its “warm human side” (Kälviäinen, 2000). Craft qualities even bring a touch of human warmth to product design. A product can have a lively character and somehow look like a new friend. Affective symbols may include signs about nature too. This can be reassuring or poetic for humans in an industrialised world.

In the following text we will look at symbols related to:
- Dreams, artistic feel, luxury
- Craft qualities and product uniqueness
- Human characteristics
- Nature

Dreams, artistic feel and luxury
According to Alberto Alessi, the Italian producer of expressive domestic objects, art is lacking in many products and “Objects have to make you dream” (Westerlaken, 1999). Elements such as dreams, hope for a better future or the illusion of luxury have always been important in products. Design movements such as the Art Nouveau or the Art Deco demonstrate this. Elements of dreams, hope and luxury can be found in the decorative elements of the Art Deco period. At a time of great American economic depression, architects designed buildings that contained the illusions of luxury with decorations that make you dream (of rich cultures of the past). Products that contain decorations or that feel artistic are special. Such products take time to appreciate (Durgee, 1999).

Craft qualities and product uniqueness
Hand-made quality adds personality to a product. Hand-made products give the feeling that there is a person behind the product (Durgee, 1999). The knowledge of the touch of the human hand makes the product more valuable than a machine-made one. It does not feel like a cold industrial product.
Apart from this human “warm” side, a hand-made product can be used in the search for individuality. The marks of tools and the involvement of the crafts person make a product unique. Hand-made production means produced in small quantities. This contributes to the special character of the product and in its turn to the uniqueness of its user (Kälviäinen, 2000). Even imperfections in a mass-produced product can make a product unique and therefore personal and valuable. For example, a specific noise in a car makes this car different from other cars and therefore recognisable and personal.

**Human characteristics**

In current product design, the human shape is often present in a simplified and abstract form. Products can be attributed with human characteristics so that humans feel closer to them. We can distinguish designs that are based on the shape of the “human body” and designs that conjure up associations with “human emotions”. The Amora ketchup bottle refers to a body shape in a direct and simple way and was designed to appeal to children. See figure 8.

![Image of Amora Bottle designed by Barre & Associés (Barré B., Lepage F., 2001).](image)

Within Philips, research is developing in the area of emotional product experience and communicative needs. Stefano Marzano, the managing director of Philips Design (450 designers worldwide), is managing several research projects on future design concepts. Different disciplines such as social sciences, cultural behaviour, and production technology work together in these projects (Bürdek et al, 2000). Marzano (2000) explains that the “anthropomorphic” form of the Philips web cam creates a friendlier relationship with its user. This was found to be an important characteristic of the camera that helps to take away the “big brother is watching you feeling”. See figure 9.
According to the IDSA, the Industrial Designers Society of America, animation and softness are present in this “playful new creature”. Philips Corporate Design received the ISDA 1999 Gold Industrial Design Award for the design of this web-cam.

Durgee (1999) argues that the object of marketing is to give a product a personality or a soul, or in other words: “to make it come alive”. This was exactly what happened when the French design agency Barré & Associés designed a new children toothbrush for Signal. The product feels rather “lively” as it is standing up and has a body and a head (Barré et al., 2001).

The Apple iMac and iBook give the feeling of a product that is alive too. These computers have a light that blinks on and off when the computer is in its standby mode. People have described it as breathing and beating: “The iBook breathes” (Fishman, 1999). Humour and enjoyment can be integrated into a product on purpose. Jonathan Ive, the designer of the Apple iMac describes that the team aims to design products that people enjoy (Fishman, 1999).
Apple gave its most recent iMac with a flat screen, launched in January 2002, liveliness too. The new iMac with a flat screen can be adjusted at different angles. This time this was not based on human characteristics, but on nature. Steve Jobs says about this computer: “Instead of looking like the old iMac, it looks like a sunflower”.

Nature symbols
Many elements in the Art Nouveau movement were based on romantic flower patterns. Animal shapes can be found in the more recent movement of Bio-design, used considerably in automotive design between 1980 and 1990. Durgee (1999) found that elements in the product showing close connections with nature and natural forces contribute to the personality, or what he calls “high soul”, of the product. Not only the shape of the product, but also the materials can create a “feeling” for the product. An organic material such as wood is perceived as a warm and “living” material. Inorganic materials such as marble, glass or metal are perceived as cold, hard, industrial and “dead” materials. Natural materials have distinctive smells and sounds and simply refer to nature. While we live in busy cities, we may try to bring back our past connection with nature by using natural materials and shapes in our products (Kälviäinen, 2000).

In the previous section the theme “messages about the product in detail was developed in detail. Now we will look at the second important theme “messages about the product”. See figure 6 for the overview.

Messages about the user: being the same or different
A product user can choose to be “the same” or, on the other hand to be “different” from others and he / she can use a product to communicate this. The product’s design can communicate the user’s “personal characteristics” such as “age”, “gender” (female or male) and / or “personality”. For example, a car might be imagined to be fast and its owner can also be imagined as having the same quality. This means that the styling of the car is used to communicate a supposed personal characteristic of its user.
A product can express social characteristics too. For example the product can provide “status” or demonstrate the success its owner has in life, it can reflect its user’s “ambitions or beliefs” and the person’s “lifestyle”.

Figure 12: Messages about the product user in the product’s design.

**Messages about the company**
The third major theme to discuss is “messages about the company” (see figure 6). Messages about the company demonstrate the company’s values. Some of the company’s intrinsic values might become visible through its products. For example, Apple Computer, whose slogan is “Think different”, distinguished itself from competition by being the first company to sell coloured computers in a very friendly and different design (Thibault, 1999; Redhead, 1998). All competitors’ products had beige or grey colours and a technical product shape. This different approach was a success. The Apple iMac was launched in August 1998 and in the first year 2 million iMacs were sold (Fishman, 1999).
Swatch and Bang & Olufsen are two other examples of companies with a clearly recognisable style. In some cases the designer has an expressive personal style and the companies demand this “design signature” in its product. Examples are the watches designed by Mendini or Haring for the art collection of the Swatch watches (Hayak et al. 1991).

![Swatch designed by Keith Haring in 1985](Edwards, 1998)

Figure 14: Swatch designed by Keith Haring in 1985 (Edwards, 1998).

**Future research**

As shown in the previous text, products can contain a variety of messages. In this article the objective was to obtain a detailed overview of these meaningful messages in a product’s design. The three diagrams in this article (figure 7, 12 and 13) summarise the variety of communicative signs we might find in a product.

It is important to obtain a good understanding of this facet of a product’s design, because today, meaningful symbols are an important way to differentiate a product from the competitor’s products. Consumers are attracted by product designs that feel “alive” and that contain a surprise element. When competition grows, improving the product’s emotional quality becomes essential for a company.

This theoretical synthesis needs to be compared with the design practice and the development process of products with “personality” needs to be analysed in further detail too. It is not only important to know what kinds of messages are integrated in a product’s design, but also to analyse the methods used in design-oriented companies to obtain a product with “added emotional value”.

![Diagram of communicative signs in a product](Company's Style: Intrinsic Values, Brand Image, Corporate Design; Designer's Style: Messages about The Company)
Different variables in the company culture, the R&D resources and the development process are expected to influence the creation of products with added emotional value. A competitive environment is expected to stimulate this process as well. Future case study research is therefore planned in companies producing competitive consumer goods with a very strong design orientation.
References


A method for designing and analyzing interaction design at earlier phases of the design process - use of the scenario, performance, and description format

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Abstract

In this study, we explored a set of methodologies that can be used at earlier phases of the design process, for designing and analyzing interaction design. Our methodology features a prototyping method that adopts performance technique, an observation method using video from the view of a user and a view that includes the system as a whole, and a method for describing interaction scenarios. Our method aimed to use the scenario and performance as techniques for communicating new design concepts and sharing experiences between designers and users, and to promote interaction between the user community and the design team. We enacted two case studies regarding the adaptation of the methodology. In one case a designer role-played a user, and in another case real users enacted the performances. We evaluated and confirmed the effectiveness of the methodology through these practices.
A method for designing and analyzing interaction design at earlier phases of the design process - use of the scenario, performance, and description format

Introduction
The user's experiences are shaped via interaction among users, artifacts, information, and environments in the interaction sphere. In order to enhance the user's experiences, it is important to capture the user's needs in their appropriate context from the viewpoint of interaction design at earlier phases of design development. In current design processes, interactions are described using various methods. At the planning and designing phase, the interaction styles and scenarios are represented with using certain design methods such as idea sketches, storyboards, text stories, and flow charts. At the analysis phase, interaction sequences are observed and analyzed by means of usability evaluation methods, for example - video analysis and protocol analysis.

Two major problems are involved in these current processes:

1. We cannot directly compare the interaction designed in the design phase with the interaction captured in the analysis phase, because different methods are used for representing the interaction in each phase.

2. The target systems are analyzed in the context of their use, after functional prototypes are made. However, at this point it is too late to address the essential interaction design requirements and problems. Due to these problems, sufficient design in the context of use cannot be achieved with the participation of the user.

Research objectives
For performing user-centered interaction design, we think it is effective to create a description method that can be used for both design and analysis. If such a method is established, we can compare the interaction scenarios considered by the designer or planner, with interaction sequences the user actually acted. This also enables design teams to compare scenarios made by several persons, and to reuse whole or part of scenarios created in other projects.

On the other hand, it is also important to create a method that enables us to simulate artifacts-in-use (Bannon and Bodker 1996) in the real users' contexts at an earlier phase before functional prototypes can be made. We think the possibility of creating such a method exists in prior studies concerning performance such as "Informance" (Burns et al. 1994), "Experience Prototyping" (Buchenau and Fulton 2000), and the playful design approaches (Brandt et al. 2000a/b).

Based on such recognition, we explore and propose a method that uses an enhanced scenario-based design and prototyping method involving performance. Our methodology consists of:

1. A description formats for representing the interaction scenario, which can be used for design and analysis.

2. A method for prototyping the experiences of target artifacts at earlier phases of the design process, using the scenario and playing performance technique.

3. An observation method using video that captures the user's personal views and the system views.
4. A method of analyzing interaction based on comparing designed interaction and observed interaction.

**Procedure**
Our methodology has four basic phases, preparation of scenario, activation of performance, observation of performance, and analysis of interaction.

**Preparing scenario**
The scenario is a sequence of users’ activity in their context of use. Studies about target users, their work process and practices are used for designing scenarios.

**Description format**
In this research, a description format for representing the interaction scenario is introduced. Figure 1 shows a sample of the format. The format contains columns for scenes, situations, users’ activities, interaction elements, and design points. This format is basically the same as that created in our prior study for the description of observed interaction (Hasuike et al. 2001).
We consider it important to compare scenarios generated by designers with those generated by other designers or planners, and even to compare a prepared scenario and the observed sequence. This format enables us to do so. Besides, observed sequences can be used as base scenario for the

---

**Figure 1: Fragments of a scenario for case 1 described in the format**

<table>
<thead>
<tr>
<th>Scene</th>
<th>Situation/ Event</th>
<th>User Activity</th>
<th>Sub-Activity</th>
<th>User</th>
<th>Target Artifact</th>
<th>Others/ Environments</th>
<th>Design Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a Train</td>
<td>A little crowded. Cannot sit down.</td>
<td>He is standing beside a door.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>He takes out the electronic pad from his bag.</td>
<td>Holds</td>
<td>A bag</td>
<td>How to hold?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>He turns the power on.</td>
<td>Pushes the button.</td>
<td>Push</td>
<td>Provide Power Switch</td>
<td>A bag</td>
<td>How to turn on?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>He views electronic documents copied from his PC.</td>
<td>Display Documents</td>
<td>Draw</td>
<td>Memo</td>
<td>How to scroll pages?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>He accesses to the database in the intranet, and downloads documents.</td>
<td>Touch</td>
<td>Display Information</td>
<td>Key? Button? How to operate? How to download?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>He takes memos something picked up from a document.</td>
<td>Draw</td>
<td>Display Information</td>
<td>Memo</td>
<td>With a pen? Where is the pen? How to draw?</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Receives e-mails</td>
<td>Hear View</td>
<td>Indicate e-mails exist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>He browses the mails.</td>
<td>View</td>
<td>Display Mails</td>
<td>How to represent contents?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some seats become available.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| In a Train             | (On a seat)      | He sits down. | Seat | A bag | How to hold? |                       |              |
|                        |                  | He reads a newspaper (data). | Display Information | How to represent? How to get the newspaper | |                       |              |
next design and the performance. We consider it is effective to create this scenario and performance cycles.

**Acting performance**

**Roles**

Three roles are involved in the execution of a performance: a performance director, actor(s), and observer(s). A performance director navigates the performance based on a scenario, suggests appropriate situations to the actor, and answers questions from actors. Actors neither see the scenario nor are cognizant of its details; they recognize the situation via dialogue with the director, and reorganize their activity along with the progress of the performance. Some dialogue takes place between the director and actors while executing the performance. These include an explanation of the situation, suggestions regarding the activity, and questions regarding the functionality of target artifacts, for example. The observer records these dialogues as well as the performance.

**Environments and props**

Performances should take place in real environments in which there may be some unexpected occurrences. These occurrences can be resources for grasping subconscious problems and requirements in the actual context of use.

There are two types of props for the performance: prototypes of target artifacts, and real artifacts existing in the use environment. We think it is important to observe how the actors act, which props they choose, and how they appropriately use the target artifacts and others in each situation. For this reason, it is basically better that the director doesn't designate to the actor which tool to use for each activity. However, in some situations, the director may have to suggest using the new artifact (prototype) rather than the existing real artifact.

**Scenario and performance**

Prepared scenarios are used as the bases for the performance. However, these scenarios are only a resource for the performance. They will be modified, detailed, and even re-created through the dialogues between the director and actors in the performance. We think it is important to modify and re-create scenarios interactively during the performance, based on the action and dialogue among the director, actor(s), and other design team members (product planners, designers, engineers and so on). This can make up forms of collaborative design work and user-participatory design (Kuhn 1996), for understanding work contexts, user requirements, and generating design ideas.

**Observation of the performance**

Observations of the performances are recorded in three ways as follows:

1. Video and audio records from the personal view of a participant captured by CCD camera located on the head of the actor

2. Video and audio records from the system view of the situation captured by observers via a hand-held video camera

3. Observation notes taken by the observers (researchers and designers)

The framework of this observation method is shown in Figure 2. This method is based on our prior study concerning an analysis of interaction design (Hasuike et al. 2001).
Analyzing interaction

Observation records are to be resources for understanding problems in the context of use, and generating design ideas. It is useful to simply review and share the recorded video/audio and notes. However, we propose more advanced use of the records. In our method, information gathered from the video, audio, and the observation notes are integrated in the format shown in Figure 2. This format was created for analyzing interaction design (Hasuike et al. 2001), in order to describe the observed information. Figure 3 shows a sample of the format. The format contains scenes, places, situations, and users' activities. Users’ views and system view captured from video are placed next to these descriptions. The dialogue protocols of the director and actors, and analysis notes are then added in the last field. This format is basically the same as the format for scenario description described above. Thus, we can compare the scenario with the records described in this format.
<table>
<thead>
<tr>
<th>Index</th>
<th>Scene</th>
<th>Situation/Event</th>
<th>User Activity</th>
<th>System View</th>
<th>Personal View</th>
<th>...</th>
<th>Director</th>
<th>Actor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>Waiting for a train at Platform</td>
<td>A train comes in.</td>
<td>He gets on the Train</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In a Train (Beside a door)</td>
<td>He stands beside a door.</td>
<td>He takes out the electronic pad from his bag by his right hand.</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td></td>
<td>&quot;Hard to open.&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>He holds and operates the e-pad by his right hand.</td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
<td></td>
<td>&quot;Too difficult to operate while hanging on to a strap.&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>He hangs on to a strap by his left hand.</td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td></td>
<td>&quot;Too difficult to push a button while hanging on to a strap.&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;Can operate if I can hold it on upper side.&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;Something such as jog-dial is suitable than the button&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;Can hold only the body?&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;Heavy for holding by one hand.&quot;</td>
<td>&quot;OK. Easy to hold if without the cover.&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;The center button is easy to push, but others are difficult to do, because I lose balances.&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&quot;Do you needs something such as a strap to hold?&quot;</td>
<td>&quot;Yes. I want such strap as that of a video camera.&quot;</td>
</tr>
</tbody>
</table>

Figure 3: Fragments of the analysis sheet for case 1 described in the format
Case studies
We conducted two case studies as adoption of our methodology. Table 1 shows the summary of these studies.

<table>
<thead>
<tr>
<th>Type of Task</th>
<th>Case Study 1</th>
<th>Case Study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Sales Work</td>
<td>Housework</td>
</tr>
<tr>
<td></td>
<td>Office, Street, Station, Train, Customer's Office</td>
<td>Living Room and Kitchen at Home</td>
</tr>
<tr>
<td>Target User</td>
<td>Sales Person</td>
<td>Family, Homemaker</td>
</tr>
<tr>
<td>Actor</td>
<td>A Designer</td>
<td>Three Homemakers</td>
</tr>
<tr>
<td>Prototype</td>
<td>Non-functional Mockup for Office Use</td>
<td>Non-functional Mockup for Home Use</td>
</tr>
</tbody>
</table>
| Source for the Base Scenario | Results of Former Ethnographic Study | 1. Results of Preliminary Web-based Questionnaire  
|              |              | 2. Outcome of Group Interview and Brainstorming with the Actors |

Table 1: Summary of two case studies

Sample artifact
We assume a new sample artifact, which is a kind of PDA (personal digital assistant) that adopts the technology of electronic reusable paper. This future artifact is expected to replace some of the current paper/electronic documents and the tools used to handle these documents. The artifact’s basic specifications and features had been already defined by the product planners and the designers. There were two types of non-functional design mock-ups, and the performances were enacted using these prototypes.

Types of participation
We established two types of participation as cases in the process.

1. The designer(s) act as a real user(s).
2. Real users act as themselves.

In the former case, the designer "actors" role-play as users. This is similar to the attempt of "Informance" (Burns et al. 1994). This case is considered collaborative design work performed by...
the design team. In the latter case, the user "actors" role-play as themselves. This case is considered a user-participatory design in its early design phase.

Case study 1
Task and scenario
In this case, we establish sales work as a sample of business scene, and conduct a performance. We used the results of an ethnographic study regarding mobile sales work done by people in our company (Tamaru et al. 2002) for creating a scenario. This ethnographic study uses the self-photo method. The results are represented in several analysis sheets and the interaction map (see Figure 4). We described a scenario of sales work by thinking about what types of activities the electronic paper system can support. Figure 1 shows fragments of the scenario written in our interaction scenario format.

Figure 4: The interaction map created in the ethnographic study

This scenario includes a series of tasks involved in the presentation of a product to a customer, at the customer's office. This scenario begins with the preparation of materials, for a sales presentation at the salesperson's desk in his office. After that, he reconfirms a appointment with his customer, puts the paper/electronic documents into his tools and a business briefcase, adds his schedule to his team's bulletin board, leaves the office, walks toward the railway station, gets a newspaper (data) from a vending machine in the station, reads the electronic documents while standing in a train, gets...
off the train and walks to his customer's office, confirms the route to the building, attends the meeting with a customer, makes the presentation in the conference room, goes back to his office, and sorts out the documents at his desk. During these sequences, the salesperson performs certain communications; he receives and sends some e-mail, he accesses the intranet of his company, and he talks with a colleague on the telephone.

**Participant and props**
The actor was a designer who had not participated in designing the system. He had a mockup of the target artifact, a cellular phone with e-mail capability, notes, pens, a bag, paper documents, and some electronic documents stored in the target artifact. In addition, certain artifacts were present in the environment. For example, there was a desktop PC in his office, paper documents were on his desk and in paper files, electronic documents were in the PC, there was a bulletin board in his office, there was a vending machine at the station, there were straps in the train, there was a projector and a whiteboard in the conference room, and there were other pieces of furniture or other facilities in each environment.

**Procedure**
After the director explained the outline of the target work, the actor began to enact the performance. The director suggested situations like these: "Now, you just got an e-mail from your colleague in the office, how would you become aware of that here?", "If your system’s battery became low, how would you know the situation?", "How would you present the document in the system to your customer? How would you scroll pages?". The actor then responded these questions in his performance and explanations. The actor sometimes put questions to the director. These included questions regarding the supposed situation, regarding the features of the artifacts, and regarding the functions and operational methods of the artifacts. In view of this dialogue, the scenario was modified and re-created interactively.

The performance and dialogue with the director were recorded using two video cameras from personal view and system view, and using the notes taken by observers.

**Results and analysis**
Observed data were described into the format. Figure 3 shows the fragments of the interaction analysis sheet of the performed sequence. They are compared to the original scenario, and the differences point out problems in the context. Many problems became tangible through the analysis, and many ideas were generated through the performance and the dialogue. The following are fragments:

- Sales persons want to sort the documents and add memos by the system before the presentation.
- Operations by touch are easy and suitable than that by scrolling keys, for selecting and sorting the electronic documents, especially in case user can hold it by a hand, and operate it by another hand.
- User has to hold and operate the artifact by one hand, while hanging on to a strap in a train. However, current design is not suitable both in weight balance and in the layout of the keys for one-handed holding and operation. In this scene, operations only by keys should be prepared.
- Current cover design is not comfortable for taking the artifact in and out of a business briefcase.
- The system should prepare a mode for face-to-face presentation, and prepare a one-touch button for rotating screen.

- The system should have additional control methods for presentation, which must not interfere with the audiences viewing the contents in the screen. One method is to have a remote control device for presentation mode.

- It is key point how the artifact works together with other artifacts in users’ contexts, PCs, information vending machines, cellular phones, electronic white boards, video projectors, and so on. There are some overlapping features, and may be possibility for smart collaborative work.

Case study 2

Task and scenario
In this case, we established housework as a sample of domestic scene, and conducted a performance. We submitted preliminary questionnaires regarding the home use of the target system to unspecified persons on the Intranet via a web-based system, and used the results to create a scenario. This scenario contains scenes such as this: a homemaker gets a recipe while watching a cooking program on TV, she takes an order for foods, she receives a circular notice of the neighborhood association.

Participants
Three participants acted in the performance. They were all homemakers.

Procedure
In this case, the sessions were conducted in the living room of the house of one of three participants. First, the designer explained the outline of the artifact using the mockup to the three participants gathered in the room. After that, the director conducted a group interview and discussion session. In this session, they discussed the everyday life and work of the participants. Then they discussed about how the target artifacts can support these tasks.

The prepared scenario was used as a reference for these discussions. As a result of the discussion, four new scenarios were generated. The first was a sequence for checking mails, faxes, messages of answering machine, and adding memos to the schedules. The second was a sequence for taking an order for foods, for dinner. The third was a sequence for cooking in the kitchen while viewing recipes and other documents. The fourth was a sequence for writing and contributing an article to a magazine. Performances were conducted using these new generated scenarios. After the director confirmed the outline of the target work, the actor began to act each performance. The director suggests situations like these: "Now, you just came home. You are at the entrance, what do you do at first?"

The performance and dialogue were recorded using two video cameras from personal view and system view, and with notes taken by observers. Each actor had a small CCD camera attached to her head when she acted the performance.

Results and analysis
Observed data were described into the format. Figure 5 shows the fragments of the interaction analysis sheet of the performed sequence. They are compared to the original scenario, and the differences point out problems in the context. Many problems became tangible through the analysis,
and many ideas were generated through the performance and the dialogue. The following are fragments:

- The management of a family’s schedule is an important and complex task, and the system should support them.

- The system should handle memos and messages via mail, fax, and answering machine from the children’s schools, from the father’s company, from the local community, and so on.

- The system could be touched by wet hands or by hands covered with powders from kitchen work.

- The system should be resistant to splashes of water and oil from the kitchen.

- The system should easily vary the direction of the monitor at the kitchen counter, allowing it to be seen from the kitchen side and from the dining room side.

- The system should easily be carried from room to room without concerns regarding the power plug.
<table>
<thead>
<tr>
<th>Index</th>
<th>Scene/Event</th>
<th>Situation/Event</th>
<th>User Activity</th>
<th>System View</th>
<th>Personal View</th>
<th>Director</th>
<th>Actor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>In the living room</td>
<td>She carries the e-pad to the kitchen counter.</td>
<td></td>
<td></td>
<td></td>
<td>&quot;Where would you set the such communicators?&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In the living room</td>
<td>She places the e-pad on the kitchen counter.</td>
<td></td>
<td></td>
<td></td>
<td>A: &quot;Here. Changes the direction to the Living room or the kitchen according to the situation.&quot; B: &quot;May be same in my home.&quot; B: &quot;I will changes the direction to the kitchen while cooking.&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In the kitchen</td>
<td>She views the lamp of the e-pad, which sees suppose as to be at the top of it.</td>
<td></td>
<td></td>
<td></td>
<td>&quot;OK. Please changes the direction.&quot; B: &quot;If the lamp is on, I will see the display.&quot;</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5: Fragments of the analysis sheet for case 2 described in the format**
Analyzing difference
In the two case studies, we could successfully observe many differences between the designed interaction scenario and acted performances, using the method. We consider that these differences can be divided into three levels:

1. Differences in scenario level
2. Differences in function and modality level
3. Differences in representation level

The first, there are some differences between the prepared scenario and sequence of acted performance. Prepared scenario has some activities that is not suitable for real contexts. These parts are re-created through the dialogue between actors and the director. This can be a resource for re-thinking about concepts of the artifact, target scenes, works, basic features, and users. The second, there are some modification or requests in some part of prepared scenario. This can be resource for re-thinking about basic interaction style, and about applied technologies for the features and functions. The third, there are some modifications or requests for quality of each design details. This can be a resource for re-thinking about details of design details and qualities. These three levels of differences can be useful resources for the next design steps.

Discussion
We carried out two types of case studies regarding the adaptation of this methodology. Through these two case studies, we try two types of participation for the process. In one case a designer role-played a user, and in another case real users enacted the performances.

In the first case, a designer simulated a user and acted a performance. The designer actor said in the reflection interview after the performance, “In a scene, I couldn't enough perform the role, because I could not image actual user's objectives and its background on the situation.” This shows that the experience of the performance gave the participants an awareness of what he does not know about target users. This awareness will promote the design team to study more about target users and their work practices.

In the other case, actual user acted performances. Through this, the design team could share the context of use with actual users. The user actors performed the prototype of the experience, and participated in generating ideas as well as in finding problems. In the dialogue with the director, participants made many ideas and suggestion for the design. We consider we could develop a form of positive user participation in the design generation.

Conclusion
In this paper, we have proposed a methodology for early phases of the design process. This featured a prototyping method that adopts performance technique, an observation method using video from the view of a user and a view that includes the system as a whole, and a method for describing interaction scenarios. Through two case studies, we confirmed our methodology is effective for understanding user requirements and generating ideas of interaction design. From these experiences, we think we could develop a form of collaborative design, and that of user-participatory design, for the interaction design. By using this method, designers and users can take into account the user's unconscious characteristics and requirements, forming a basis of cooperation toward better design.

Though we have applied our method to only two cases, we have to study more cases and improve the methodology. For making the scenario and performance cycles, it is necessary to study more formal description of the scenario on the format. It is also important to study how to incorporate
this methodology into the whole design process for user-oriented design approach, and how to use it in combination with other design methods such as ethnographic field work, questionnaires, the usability evaluation methods.
References


(Brandt et al. 2000a) Brandt, Eva and Grunnet, Camilla, 2000, Design as a Play with Props that Make up or Design Requirements, Workshop on translating children's answers into design requirements: Opportunities and limitations, Athens, March, 2000.


Design, risk and new product development

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Abstract

Research that attempts to view prior investment in design as calculable risk is potentially important within an increasingly competitive new product development environment. An important aspect of such research was to identify investment in design as part of the financial and cultural risk within firms, in particular, the identification of critical decision points and their associated risks. Business success may now be related to a degree of risk involved in new product development decisions.

The research described is currently being undertaken for the Design Council. Survey and analytical techniques have been used to elicit critical decision points in the development of selected Millennium Products. The primary selection (of 92) was based on an analysis of the design and technical innovation evident in currently available products. Secondary selection (of 16) was based on company responses to a short questionnaire. The final selection (of 6) represents the types of risk evaluation employed by each of these case studies. Detailed, illustrated case studies structure and describe informal and formal techniques. Research methods include the use of semi-structured interviews based on the NPD process supplemented by literature provided by each company. These were analysed with the aid of the qualitative tool NUD*IST (content analysis followed by secondary theory building analysis processes). Web based materials aimed at SMEs will be delivered via the Centre for Product Design Information (CPDI) located in the Birmingham Centre for Design Research, Birmingham Institute of Art and Design, University of Central England.
Design, risk and new product development

Introduction
This paper describes research undertaken by Birmingham Institute of Art and Design, University of Central England with the support of the Design Council Innovation Fund. Through the study of a number of small and medium sized enterprises (SMEs), the work explores the various risks encountered in innovating new products.

This research should be particularly useful to small and medium-sized companies. It is hoped that the experiences of others will help them recognise their areas of risk and to identify ways of supporting design and product development processes (see: Horne-Martin and Jerrard, 2002).

It has often been found that companies fail to invest in design, despite numerous government invitations, due to their perceptions of the downside risk. Indeed even when companies do invest in design they often tend to be risk averse and therefore much of the opportunity and market potential can be lost through such a position. Within the UK the situation is made more difficult with the continual development of new products designed and developed specifically for European consumption resulting in a rising import tide.

Although there has been a great deal of research in other disciplines (eg., Financial Services) with regard to the management of risk, research so far indicates that there is little to enable design professionals and companies to understand risk in decisions about design in a rigorous and objective manner.

Harrison (1987) defined a decision as “a moment in an ongoing process of evaluating alternatives for meeting an objective”. Product innovation and development is characterised by a number of critical decision points. Risk can be described as making a choice at these critical decision points with degrees of uncertainty. The New Product Development process (NPD) moves from one domain of decisions to another and may be represented by a flow, with critical decision points appearing at intervals. A decision is ‘a specific commitment to action’, the moment of choice.

Risk, therefore, concerns the possibility of failure or loss in a variety of areas. Often, there are formal situations where risks are discussed against management-based ‘rule of thumb’ criteria. How people as well as processes may be at risk in product development is the focal point of this work.

The project
Earlier work (see: Jerrard, Newport, and Truman, 1999) has shown that researchers have, in recent years, developed a range of experimental models in the field of NPD. From this, it seemed particularly appropriate to consider these issues, as design seems to be a good business risk in a time of conspicuous consumption but where considerable government-backed effort is still required to try to influence SMEs. The potential to establish knowledge about where design decisions find confidence and authority could be determined by a focused study of SMEs, involving a quantitative survey and qualitative review of a specific sector.

A search of existing publications has influenced the selection process for the case-study companies. In particular the development of NPD illustrations useable by other companies seemed most useful. Therefore, identifying a product similar to their own or of particular interest will be the way in which companies could make use of the detailed findings. This would be represented in the printed form up to a level of detail. The linked web pages, however, will have the potential to separate...
information levels and points of access. An initial literature search showed risk case study material might be classified as:

- Quantitative risk management
- Strategic risk management
- Risk analysis

Additionally, the literature search showed that there are numerous factors that come into the equation in relation to assessing risk when making decisions:

- How to evaluate the ‘decision’ contributions to potential product performance in the market place.
- The fact that decisions on design are often qualitative - and the knowledge and information about success (ie., decision-based contributions to new product development) is often anecdotal and often related to organisational culture, eg., with the development of the Dyson vacuum cleaner.
- Some companies learn from past decision-making, which they use as a benchmark for future decision-making.
- Design is frequently not viewed as something central to the product rather a marginal element and assessed as such.
- Organisations are at different levels of maturity in terms of their use and understanding of design decisions.
- There are a number of levels of decision making around design, which involve risk assessment between a strategy and a project
- SMEs in particular are risk averse and yet need to improve their assessment of risk to build their confidence in decision-making. This is emphasised by numerous government initiatives to encourage them to invest in design and innovate to improve competitive advantage.
- SME internal culture or management style is rarely formally linked to the quality of new product development.

From the work carried out the initial plan was to consider decision points that were identified as being non-financial, partly financial or wholly financial. Further sub-headings were applied at the company interview stage. The identification of development processes for new products showed that there are specific ‘domains’ where linked decisions are made. Both formal and informal decision-making appears to be important in assessing risk.

Relevance to design
The extensive literature covering the Management of Risk (for example: Reeb, Kwok and Baek, 1998) normally does not include the management of design or indeed relate to a typical environment of new product development, the SME. There are however some interesting exceptions, notably in: Roy & Potter (1991) and Bruce, Potter & Roy (1995). Day-to-day risk is traditionally linked to design investment but has never really been quantified in a detailed way. This may be due to a variety of factors including the relatively imprecise nature of both consumer
response and quality of designer performance in relation to new product development. Also, related benchmarks often only refer to the totality of product innovation focusing on idea to market. Reported management creativity is largely anecdotal, and is usually based on intuition and management will. Accordingly, such issues in management are viewed as being more socially/culturally based than business based (see: Lohmann, 1998).

The issues surrounding the potential of design are also well known, particularly where a company may calculate reinvestment from an in-house benchmark (see: Couger, 1998) or from an established simulation (see: Vose and Scott, 1998). The culture of design is viewed sometimes as a key element (see: Cawood, 1998) but more often as an associated or even marginal issue. Investment in design within SMEs involves comparisons with other areas of financial investment, potentially providing potent intelligence. Creativity likewise appears to be measured against other work cultures that are in its immediate vicinity (see: Paper, 1998). Literature to support design investment risk may appear in government documents (eg., the Design Council) or via consultancy (eg., Business Link) although little is published demonstrating reasons for initial design investment. Knowledge of design may be grounded only in personal experience with a lack of accessible benchmarks, particularly in understanding the company’s ‘risk culture’. A number of central questions apply concerning the potential recognition of procedures and benefits of risk management in design:

- Is it possible to map the considerable literature based in management of risk in general management to the design function?

- Is it more appropriate to establish design as an integrated feature where risk is a shared between decision ‘locations’? That is, establish design investment for the first time to be financially and culturally based, thereby providing expectation that two ‘types’ of investment may be concurrently required.

- Can an investment tool be developed from research, which combines financial and cultural analysis?

Clearly quantitative measures may be best applied to regular project ventures; design projects may be seen as more singular and by their nature intrinsically experimental.

**Influencing design**

Research that attempts to view prior investment in design as calculable risk is potentially important within an increasingly competitive new product development environment. The operation of design within SMEs however is often singular and so the opportunity to import appropriate best practice is often limited. Business success may now be related to a degree of risk involved in non-incremental new product development decisions.

There has been a great deal of research directed at describing the design process and the management of new product development. The time is particularly appropriate to consider the integrating potential of risk management techniques within knowledge of the design process.

Those involved in product development are familiar with group as well as individual risk assessment processes. Personal experience of conscious risk-taking and whether or not the risk is subsequently confirmed by events is the base line for collaborative and overt risk assessment, but both rely on the accuracy of the environmental model against which the risk is assessed.
Design in product development attempts to make overt the complex and implicit potential relationships between client, user, market, supplier and manufacturer. The risks involve all of these relationships as well as those evolving from project planning. Incremental product development (IPD) limits what is unknown by taking small and easily identifiable risks. Therefore IPD appears to be commercially safer than NPD, but this may be at some considerable opportunity cost. It will not provide major shifts in customer perceptions or consequent major changes in market performance.

New Product Development does not accrete around what little is certain, as in the case of incremental product development, but aims to introduce new material, component or manufacturing technology, or bring about changes in function, appearance or product architecture. For the market to perceive that a product is innovative, it must be near the boundaries of acceptable change in technology, performance or taste.

The risks involved in environmental change are as unpredictable for IPD as they are for NPD but environmental change is perhaps more difficult for smaller companies to monitor. The nature of innovative products is that they embody clear advantages for the customer. The difficulty for innovators is predicting whether the new product will be viable, available and acceptable and therefore proved to be innovative.

**Methodology**

The research used a formal 13-stage framework for NPD (Cooper and Kleinschmidt, 1986). The companies did not necessarily follow this generic framework, but it helped in clarifying the different stages of product development including the location and frequency of important risk-taking decisions. It also enabled comparisons to be made between the companies.

Survey and analytical techniques were used to elicit critical decision points in the development of selected Millennium Products. The Design Council Innovation Fund, stimulation for the development of innovative products and the promotion of the effective use of design provided most of the project resources. The selection of Millenium Product companies seemed appropriate from a database of 92 companies. These companies were asked to complete a simple questionnaire; from the responses 12 companies were chosen for in-depth structured interviews. The companies were chosen on agreed criteria, for evidence of technological and applied innovation, such as:

- Product function (what the product does).
- Appearance (what the product looks like).
- Product architecture (the way the components are articulated or put together).
- Material technology (one or more of the materials from which the product is made).
- Component technology (one or more of the components that are used to make the product).
- Manufacturing technology (the way one or more of the components are made, or the method of assembly).
- The Market

For each area, a scaled assessment scored thus:

- Well known / usual / always done / no innovation.
- Not well known / relatively unusual / rarely done / no innovation.
- New / minor change / never done before / minor innovation / relatively insignificant.
- New / medium change / never done before / medium innovation / significant.
- Radical / major change / never done before / major innovation / highly significant.
Finally, a selection of six companies represented different types of risk within their informal and formal design management techniques. Semi-structured interviews based on the NPD process were supplemented by company literature. Content analysis was followed by secondary theory-building process.

The six case-study firms described in the results of the project (see: Horne-Martin, Jerrard, 2002) fall within three types described by Gore et al (1992):

- **Specialists – which produce a limited product range for specific customers.**
  1) Starlight Therapy Tables – ‘Massage Table’, a light-weight health product.
  2) Turnwright Ltd. – ‘Community Bed’, a hospital bed for the home.

- **Jobbers – which produce a wider range of products for few customers**
  3) Iain Sinclair Design – the ‘Eon Torch’, a small flat personal light source.

- **Marketers – which produce their own design and products for a wide customer base.**
  4) V&A Marketing Ltd. – the ‘Anywayup Cup’, an innovative toddlers training cup.
  5) Bisque Ltd. – the ‘Hot Springs’ spiral radiator.
  6) Ozonex Ltd. – the ‘Ozone Hygenic Toothbrush’, a new shape brush with innovative qualities.

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Fig. 1: Starlight Therapy Tables ‘Massage Table’

Fig. 2: Turnwright Ltd ‘Community Bed’

Fig. 3: Iain Sinclair Design ‘Eon Torch’

Fig. 4: V&A Marketing Ltd. ‘Anywayup Cup’
The main critical decision point found to be common within all case studies is the commitment decision, that is, the decision to proceed from the initial stages of development to further product development. This is supported by Gore et al (1992) when discussing issues about strategic decision-making.

Discussion
The work has found that neither formal quantitative nor qualitative risk management methodologies on their own sufficiently address the uncertainties of product development. However, the different experiences of the case studies were found to be useful in addressing risk issues and minimising or reducing uncertainties. In essence, resolving risk issues requires decisions to be made and some of these critical decision points were identified in examining these six case studies.

As Jerrard et al (1999) describe,

“new product innovation is considered mostly in terms of technological innovation, but whereas new technology does not necessarily have to be part of design innovation, most new technologies cannot be implemented without it. Innovative design however, still seems to contain more market risk than innovative technology.”

They develop the subject by stating that:

“risk is mostly associated with management decisions about new designs or new technologies made without appropriate information on continuous contextual change.”

Risk can probably be better managed when decision makers are aware of the potential outcomes of their actions.

Risk tended to be described by the companies’ managers in personal experience terms during product development. They learned from their processes and found alternatives that would reduce or minimise their risks. There is a tendency to view NPD as a linear process with critical decision points logically spaced in along the way. However, they did not necessarily know that decisions had been taken until later in the process. As a general rule, and as expected, financial risks tend to be the major concern closely followed by personal risks. Design risks were usually related to technical issues, safety and copyrights. An interesting risk identified by several of the companies occurred from the success of the product in launch and lack of preparation for the rate of production expected. The table below illustrates the main areas of risk identified by the case studies:
### Type of risks

<table>
<thead>
<tr>
<th>Type</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Risk of money loss</td>
</tr>
<tr>
<td>Personal</td>
<td>Reputation&lt;br&gt;Loss of personal finances, e.g., savings, house mortgages, etc&lt;br&gt;Disruption of personal circumstances, e.g., family arguments</td>
</tr>
<tr>
<td>Design</td>
<td>Design integrity</td>
</tr>
<tr>
<td>Sales</td>
<td>The demand exceeded expectations</td>
</tr>
</tbody>
</table>

### Minimising risks

The case studies identified specific areas of product development where risks can be either minimised or reduced. Some arose from the companies after going through their development processes and getting them to reflect on past experience, others were considered essential pre-requisites for product innovation. The generic process for NPD may be identified thus:

<table>
<thead>
<tr>
<th>Feasibility study</th>
<th>A thorough feasibility study including market research and technical issues.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing and promotion</td>
<td>Allow enough budget for marketing and promoting the product – ensuring that the entire budget is not spent on product development.</td>
</tr>
<tr>
<td>Technical testing</td>
<td>Technical and safety testing to protect the company from future legal complications.</td>
</tr>
<tr>
<td>Pilot production</td>
<td>Making sure the manufacturing processes will support future production.</td>
</tr>
<tr>
<td>Sharing risks</td>
<td>Sharing marketing and advertising risks with distributors.</td>
</tr>
<tr>
<td>Gradual growth</td>
<td>Making sure the company grows gradually to allow adjustments and reorganisation.</td>
</tr>
<tr>
<td>Market testing</td>
<td>Checking the target market before full production starts.</td>
</tr>
<tr>
<td>Time</td>
<td>Allowing enough time from conception to launch – it always takes longer than anticipated.</td>
</tr>
</tbody>
</table>

All companies examined were managed in a personalised way by their owners, a characteristic of small independent firms. The organisational structure of the small firms tended to be simple and characterised by a high degree of informal interaction between the management and the employees. The financial resources of the owner had a strong effect on decision-making because this was usually the only or main source of capital. The availability of finance is often mentioned as one of the most substantial problems they had to overcome.

An important part of the RISK project is the dissemination of its results to other SMEs, in order that they may benefit from its findings. To this end, the RISK project was devised in association with, and links to, the Centre for Product Design Information (CPDI).

CPDI provides an Internet-based information resource specifically targeted at SMEs including materials; processes; legislation relating to design; human factors and ergonomics; a directory of
suppliers and consultancies; case studies; design theory, incorporating management processes and
techniques, and a library focusing on new design research. Chiefly, CPDI aims to improve SMEs’
product development processes and reduce their risk of innovation, resulting in an increase in their
competitive status, sales and profitability.

The RISK project is included on the site as a full document in the library area. Additionally, it is
available as linked sections from both the case studies and design theory sections. This also allows
users to link through to other related areas such as brainstorming, marketing strategy and new

technologies.

CPDI was part-funded by the European Union European Regional Development Fund and was
established in November 1999 in Birmingham Institute of Art and Design, building on the work of
the Birmingham Centre for Design Research.

Research outcomes summary

• Published case studies for use by SMEs and others identified by the Design Council and by
CPDI. Case studies and risk evaluation techniques will additionally be available on the
CPDI web site.

• New product development maps for each of the case studies identifying the critical decision
points during the process and the risks associated with these decisions.

• Detail on specific critical decision points in new product development, particularly relating
to formal and informal procedures.

• Particular insights into risk calculation within design management and finance and a
transferable tool to operate within general management is planned to be accessible to
companies looking for best practice.

Future directions

The aim of this research is not to give a solution to all the problems of risk in NPD but to provide a
useful transferable tool to enable companies in equivalent or related sectors to design and develop
new products with the minimum of risks. Also, the reflection involved in planning the NPD
process, should provide specific and unique insights into critical decision points. The results have
given rise to a number of future research questions, including:

• How applicable are these SME case studies to risk and design strategy in medium-sized
companies?

• Is the kind of learning and commitment observed here applicable to a wider range of
organisations?

• Can the techniques be used to identify NPD processes in much more complex
environments?


Centre for Product Design website: [http://www.biad.uce.ac.uk/research/projects/CPDI/cpdi.html](http://www.biad.uce.ac.uk/research/projects/CPDI/cpdi.html)
References


Folding, blending and implicate order: reconceptualisation in design education

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Abstract

In this paper we consider some of the rich body of work of the mathematician, quantum physicist and thinker David Bohm. Bohm’s ideas have both direct and tangential relevance to design. We review Bohm’s notions of implicate and explicate order as metaphors for the totality of design and the relationship of its parts. There are parallels with initial inception and then realisation through the subsequent stages of design. If one starts with Bohm’s position that the universe has an implicate order, then design is one way of unfolding that order to make it explicate. Design ideas are enfolded around us at all times; the processes of design merely unfold them to the world in an understandable manner. We also explore Bohm’s notions of folding and blending and look at their links with invention, innovation and renovation. Folding and blending are ideas that are comparatively easy to accommodate and provide alternative conceptual access to the complex field of design.
Folding, blending and implicate order: reconceptualisation in design education

We are critical of the process model of design prevalent in formal education in the United Kingdom and elsewhere. It treats design as a problem solving exercise where a potential 'solution' is specified and an 'outcome' is achieved through a cycle of making, testing and refining. In this form the model is flat, discrete, sequential, periodic, atomistic and prescriptive. Above all, it belongs to a mechanistic age (Howe, Dillon & Smith 1999).

In a decade of work with undergraduates studying technological education, we have explored a number of different ways of looking at the design model. We see the process as fluid, sometimes chaotic, often complex and frequently involving a large element of uncertainty. We have looked for metaphors, analogies and alternative frameworks for design in non-linearity, fuzzy logic, and loose ‘theories of everything’. With our students, we studied, amongst others, the works of Stephen Hawking, James Gleick, Peter Coveney, Roger Highfield, Peter Eisenman, Charles Jencks, Gilles Deleuze, Werner Heisenberg and, especially, David Bohm. All these writers say things that in some way resonate with our perspectives on design.

We looked in detail at the works of David Bohm, not with the intention of trying to get to grips with quantum physics, the main thrust of his work, but as a means of extending our thinking about an alternative, non-mechanistic approach to design. Bohm researched theoretical physics and philosophy and held posts at Berkeley, Princeton, São Paolo, Haifa and Birkbeck, London. He had a special interest in creativity and made a significant contribution to the debate about the relationship between art and science.

What attracted us was Bohm’s views on holism, something that we believe is integral to design. We share his concern at the kind of thought that treats things as inherently divided, disconnected, and broken up into yet smaller constituent parts, where each part is considered to be essentially independent and self-existent (Bohm 1980). Bohm regarded the then prevalent scientific view as typical of the ‘old physics’ of a mechanistic order, the principal feature of which is that the world is seen as constituted of entities which are outside of each other in the sense that they exist independently in different regions of space (and time) and interact through forces that do not bring about any change in their essential natures (Bohm 1980). The analysis of the world into independently existent parts does not work very well in modern physics. Both in relativity theory and quantum theory, notions implying the undivided wholeness of the universe provide a much more orderly way of considering the general nature of reality (Bohm 1980). This mirrored our unease at the old physics thinking that had led to a design model that we were obliged to introduce to our students. Like Bohm, we were looking for a new, non-fragmentary world-view.

Bohm developed a vision of an ongoing, evolving universe characterised by a considerable amount of probability and a high degree of uncertainty. Earlier work in the quantum area had provided insights into the notion of uncertainty. Heisenberg, in 1927, had formulated his ‘uncertainty principle’ after conducting measurements of the movement of electrons and concluding that these involved considerable ambiguity. There were ‘grey’, flexible considerations to accommodate, rather than purely ‘black and white’ ones. Bohm’s investigations led him to believe that totally unseen, unobserved, sub-quantum forces were causing the apparent strange behaviour of sub-atomic particles. These forces were likely to be characteristic of a deeper dimension of reality that he called the ‘implicate order’.
Within the implicate order all is contained, all is enfolded into everything, all is folded into itself. The implicate order provides an image, a kind of metaphor, for intuitively understanding the implication of wholeness (Bohm 1987). The implicate order is an enfolded entity. For Bohm, the hologram is a good analogy: the entire object is contained in each region of itself, enfolded as a pattern of waves, which can then be unfolded by shining light through it (Bohm 1998). When the implicate order is unfolded it becomes an explicate order. Our genes contain encoded information (an implicate order) about how our ancestors solved the problems of survival. The Human Genome Project is enabling us to read the code, to make it explicate.

We can use this idea in turn as an analogy for design. Perhaps, as Bohm postulated, all is enfolded and what is needed is a process of ‘unfoldment’. Landscapes are a record of human enterprise, of how through the ages we have used the land in different ways to extract a living. Each successive generation, through imagining, modelling, making, modifying and manipulating, has restructured its environment through design. Restructuring is formalised through the mastery of practical skills and the development of crafts, initially these were associated with agriculture, later with manufacture, culminating in the emergence of guilds and professions associated with engineering, construction, architecture and related disciplines (Dillon 1993). The landscape is a totality. The processes that have formed it are enfolded. When we work in the landscape we begin to unfold the order and understand the processes involved. The order becomes explicate and we have a cultural context for what we do and make (Howe & Dillon 2001).

So we might view the design object as ever present (in latent form) all the while there are people to think about it; it is merely waiting to be brought into a physical state. This has an interesting parallel with the ideological thinking of Walter Benjamin (1892-1940). Benjamin understood human creativity to be embodied in the products of human labour. As well as being material artefacts, products represent the social relationships out of which they arise (Smith 2001: 43). The realisation of a design object is a result of engagement in unfolding processes, both material and cultural, rather than the search for a solution to a problem.

The ‘problem’ has been our problem. Within the educational context, if there is not a real problem to be solved then one has to be made before design can take place. Design is seen as a problem-solving exercise and we are not the only ones to be perplexed by it (see, for example, Poyner (1998: 15) who describes a poster designed by a student as not solving a communication problem so much as presenting the viewer with a communication problem to solve). As a discipline in education, design has arisen from a scientific paradigm. The idea of folding offers an opportunity to make a break with the old paradigm. There is a ring of non-linearity and optimism. Here is a possibility that does not have a set routine or a feel of prescription about it.

There is another aspect of Bohm’s writing that can be applied to design to enable us to look in a new way at what has up to now been thought of as a sequential matter. This is the notion of ‘non-locality’. It means that when a force acts on particles it tends to influence all of them and this influence does not decay or fall off with distance. It implies an instantaneous connection between distant events (and, incidentally, appears to violate the basic principle of relativity, that no signal can travel faster than light) (Bohm & Peat 1987).

This is of great interest. Whereas we might accept that separate elements of the design process can be described, we find it difficult to accept that there is a specific direction, a set order and sequence for engaging in the individual aspects. Can it be said absolutely that design starts with a ‘brief’, goes on to a ‘specification’, then to ‘research’, then to ‘planning’ and so on in a prescriptive, linear way? Surely, different parts of the sequence operate consecutively and often there are periods when it is necessary to backtrack, to make sideways movements and revisit areas to revise and reform.
either ideas or structures? The existing model has the tendency to keep the designer moving in one
direction towards the completion of the task. With the new approach however, it is possible to
visualise several things going on concurrently. Concurrent engineering has accommodated this
notion, particularly at the production phase so that the pace of production can be increased. Here is
a means of conceptualising the various processes of design operating together, rather like the
unfolding of a flower. As a flower unfolds from bud to full bloom, all its parts unfold together
rather than one at a time; the petals reveal themselves in unison, the colour is unveiled and the
stamens move in keeping with the overall motion.

Other notions that are compatible with enfolding and unfolding and that serve as analogies for
design come from Gilles Deleuze (1997). He reformulated Leibniz’s philosophical work on the fold
as it was experienced in Baroque times. He put forward the idea that within the fold there is the
possibility of the co-presence of an infinite and the finite and there is also the possibility of the
limited and the unlimited. As the fold unfolds it opens up further folds, which in being unfolded
reveal further folds. What this means is that there can be no real beginning, and, usually, no real
end. The complex fold recasts the nature of inside and outside. Yet within the movement there are
real states. Static actual existence is not precluded; rather, it is to be thought of as an interruption to
or an eruption out of movement (Benjamin 2000; see also Doel 2000).

Designers do not operate on one project at a time to the exclusion of other emerging creative
thoughts. They do not engage on a task in isolation but accept that each separate task has within it
the potential for yet another development, like the sets of wooden Russian dolls where as one is
opened yet another is revealed. As the designer works on one enterprise a new series of possibilities
open up to be explored. This is part of the excitement and intrigue of design.

The notion of continuity between inside and outside is a comfortable one: the designer being
engaged on the task, as the inside, with the overall influence of outside constraints of necessity
impacting upon thought and action. Then again the idea of a continual movement taking place
provides yet another point of similarity. There is an implication of lateral movement, not of
standing still and basking in the glory of what has been designed and realised, but rather a desire to
drive on again. The movement is ever present, nurturing itself to invest in the next revelation. The
creation of one design object is a perturbation in the movement that leads irrevocably toward further
design. All these factors allow us to explore new ways of how design might be presented in a more
creative form.

Indeed, the notion of creativity is closely tied to the notion of design and both are in turn linked to
notions of invention, innovation and renovation. Invention is concerned with assembling,
organising and structuring ideas, thoughts and materials to bring into being something new. Like
design, it may be regarded as a folding and unfolding activity. All the constituent parts used and
incorporated in an invention tend to remain intact and with their own integrity. It is this composite
togetherness of separate parts that allows us to see it as a folded entity. Invention gives us a
smooth and heterogeneous sensation, not a homogeneous or fragmented object. These are the
characteristics of folding. The parallels with folding in a culinary context are strong (Cunningham

However this is not the same for innovation. Innovation and invention are closely related but they
do have important differences too. Innovation might much better be termed a blending activity.
Innovation, unlike invention, starts from something in existence and then adds something else to it
to reveal a new thing. This new realisation is an integrated mixture or compound of the constituent
parts. To blend, according to the Oxford English Dictionary is to mix together, to form a
harmonious compound, to become one, for one thing to pass imperceptibly into another. In essence
a blend is something that consists of separate parts mixed into one another. Folding, as we have seen, is where the separate constituents retain their own integrity within the mixture. This in no way suggests that innovation is inferior to invention; it simply means that they are different and their processes should not be confused. It is almost needless to add that culinary comment has been made on blending too. Also it is worth bearing in mind that folding, theoretically at least, may be reversed so that the separate parts making the mix can be returned to their original states. With blending this is not the case, for once the blended mixture is constituted all the separate parts become as one and cannot be undone. It may be inferred that blended activities are not likely to possess the same flexibility or potential for creative development.

The general area of blending also has its own theory. There is a considerable body of work predominantly arising from the studies of Fauconnier (1997). Whilst nearly all this work is concerned with conceptual blending, it does suggest some possible application in areas such as design too. The notion of blending helps us with a further distinction, between innovation and renovation. When we do things in new ways we can legitimately call it innovation. Renovation is doing more efficiently or effectively the things we could previously do. Most change is incremental and involves a good deal of renovation, of re-visited well-tried approaches and improving on them. Renovation is an on-going process where decisions are made at the individual level with limited external interference. The day-to-day adjustments that people make to their practice to refine it and fine-tune it to the available resources. We renovate to bring things up to date. There is no need to renovate something that works well, unless it is for reasons of fashion (Dillon 2000). With innovation and renovation we are looking at degrees of blending.

Edward O. Wilson, the sociobiologist, now argues that there is a fundamental unity or ‘consilience’ to all knowledge. Everything in our world is organised in terms of a small number of fundamental natural laws that comprise the particles underlying every branch of learning says Wilson, and all learning is thus ultimately connected (Wilson 1998). We are interested in helping students connect ideas, abstractions and procedures as they engage in their design work. Whereas there will be elements of their work which demand the most exacting standards of precision and quality, they are not working in a world of absolutes. Reconceptualising design in more holistic terms will help students understand the context of their work and help them find their own consilience.

The reconceptualisation of design proposed in this paper requires a corresponding movement in educational thinking and practice if it is to be fully realised. That such a movement is happening is evident, for example, from a series of international conferences on ‘thinking’. The series was started ten years ago by a group of visionary scholars dedicated to the notion that something radical needs to be done to help people develop their thinking powers beyond current capabilities. Emphasis in the early conferences was on intelligence and thinking. In recent years the scope has broadened to include creativity. This year, in Harrogate, United Kingdom, the conference took in wisdom and intuition, qualities that hitherto have been shunned by most educationalists. Our reconceptualisation has much in common with intuitive thinking. Claxton (1997) defines intuition as the emergence of a sense of direction without a clear rationale, a kicking of the unconscious. We now have the notion of the ‘intuitive practitioner’ (Atkinson & Claxton 2000). We might expect such a practitioner to be receptive to an implicate order and willing to let ideas unfold rather than have them constrained within a pre-defined framework.
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Accessed 7/00.


Comparison between communication instruments for people with speech impediments and the efficiency of GUI environments

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Abstract

Communication is a basic desire for all humankind, and it is believed that no special groups should suffer from a cultural lag in communication. This study focuses on special groups like people with an acoustic disturbance, and those with a normal sense of hearing who are able only to communicate through sign and finger languages. Among the major difficulties encountered during communication, there were individual differences in the understanding of texts and in the expressive method of gestures. To solve these basic problems, this study largely consisted of three stages. Firstly, the illustrations used in the sign and finger language textbooks of the Seon-hee Seoul National School for the Deaf (SNSD), as representative of schools for handicapped children in Korea, were redesigned into different illustrations that incorporated a high level of perceptiveness. Secondly, new sign language textbooks were made by studying and applying the effects of line width and length, as well as the number of pictures, on the degree of perceptiveness in communication for developed sign and finger languages. Thirdly, a language output mode was created to focus on programs with high generality, centering on developed textbooks and various prototypes of sign and finger languages. The difference in perception, among other things, will be measured in consideration of the speed of sign language, the shape of characters and the emotional aspect. This new textbook for the deaf is planned to be released all around the world, although the study of its effects may require the whole lifetime of the researcher. However, in consideration of those people who have difficulty in satisfying the basic interactive desire of humans and are socially isolated in their capacity for communication, this study is worthy of great expectations for the future.
Comparison between communication instruments for people with speech impediments and the efficiency of GUI environments

Aims and backgrounds of study
This study counts people with a speech impediment as its focus group, among other special groups, and is positioned to examine those who can only marginally share in various cultural benefits compared to people with a normal sense of hearing. Such hearing-impaired individuals have difficulties in communicating smoothly with those possessing a normal sense of hearing, as impacting a variety of cultural, educational and communicational avenues of expression due to the physical handicap. Besides which, communication between isolated groups is being developed from a different angle. It is natural that the dream of smooth communication is difficult to realize without first solving economic, cultural and social problems, as well as basic physical problems. Efforts to communicate via simple but various ways of language expression, however, were the motivating power behind this study. The results of interviews showed that such individuals could not communicate smoothly due to often heavy reliance upon a personal vernacular of familiar expressions and secret languages, though they might have received special education.

A quite interesting fact discovered during this study is that everyone tries to perceive things and convey a message - the basic desire of humans - by learning a language. The only difference between people with normal sense of hearing and those with an acoustic disturbance is that the former use a universal and typical way of expression called language (among various methods), while the latter utilize their own ways of communication via sign and finger languages.

One thing that drew my attention is that the deaf use a mobile phone, ironically, as a viable means of communication in Korea. They access it not on an audible level, but for the use of short message service (SMS) functions. Though there are some cases of the deaf communicating by use of a touch pad, as often shown in some soap operas, such a reality would be possible only for those cases who acquired their handicap later in life.

In an interview with students from the SNSD located in Chongro-gu, Seoul, conducted two summers ago, it was found that most students with a speech impediment have a complex disorder, as stemming from the major causes of cerebral infantile paralysis, brain dysfunction and learning disabilities. Thus the individual difference in gestures generates the appearance of dialects. With the encouragement of the principal, the focus of study over the last two years was on developing a systematic sign system.

This work was as hard as that experienced by King Sejong – the creator of the Korean alphabet. Though the research and development haven’t been finished yet, it was not until this study was facilitated that I realized such individuals would be much better able to constitute their own community if the work was conducted at an advanced and particular level. Simply put, they should be making textbooks with a distinct linguistic virtue relevant to their community, rather than merely accepting the simple level of expressing a language through illustrations.

After visiting SNSD, it was found that there was a great difference of communication ability from the educational aspect between those with a normal sense of hearing and the disabled. The deaf were communicating with each other in a variety of methods of expression. The miscommunication caused by these various modes of expression is likely to pose a great barrier in life between the disabled and other people. Communication among people with a normal sense of hearing has gone
smoothly even in different regions, as they learnt and practiced the relative definitions of expression, forms of expression, and correct textbook pronunciation in classes held in their mother tongue. As mentioned above, even people with a normal body and sense of hearing can effect various kinds of idiosyncratic changes in expression.

As mentioned above, the aims of this study are to search for new communication methods among those isolated by their physical handicaps, and to suggest a prototype of future design for a discursive framework. The intent is to establish a communication system, develop relevant instruments and implement a global communication system, on the road to constructing a communication system for people with a speech impediment and positioning the future models of design.

Changes in communication
Changes in communication, including the essential meaning, “to convey a message”, are in constant progress with the development of media. C. E. Shannon & W. Weaver, in an information and communication engineering module conceived about 40 years ago, said that: “The mathematically and precisely formulated model refers to a graphic formula for explaining human communication activities, starting from a technologically processed and physically prescribed signal set, and such keywords have been used as sender, receiver, code, sign, channel, redundancy, noise, encoding, and the like.”
In other words, it is a view which follows the model of behavioral psychology, the ‘stimulus-
response’ mechanism that information is transmitted along a certain path from a sender to a receiver
through the activity of communication. If the message of a sender is encoded and transmitted to a
receiver, the sender and the receiver have the same information and as a result, an effect that evokes
the same thoughts, behaviors and attitudes is expected.

**Changes in the concepts of a sender and a receiver**
The nature of the main body of communication has been changed. The active party that exercises
controlling power over information access, communication and use in cyber space has undergone
vast transformation. In other words, a receiver in the existing communication model has little
control over transmitted information, except for a partial right to determine chosen access. As he or
she is passive in the problem of when, why, from whom and what kind of information they will
receive, there exists a deliberating organ who puts pre- and post-censorship on information content,
time and intention in the name of public welfare.

In this structure, an information receiver in an era of multiplex communication is no more than an
information consumer. Nevertheless the Internet created an active information user, not a passive
information consumer. Users have full control over the content, time, intention and objects of
information to transmit, as well as the ability to actively select the information to be consumed
themselves. They are not receivers but information users, and act as creative main bodies in
generating the contents and formats of media via active intervention and participation.

**Internet communication service**
Web users have come to enjoy much greater power than any other users of media, in that they can
search for the services and information they want. Moreover, they are able to instantly give
comments and opinions on the received information, or ask for the explanation and apology of a
content provider. In this relationship, a user may have the experience of being transformed from a
simple receiver to a provider by voluntarily modifying and editing information data on his or her
own computer, as well as providing their own information on the Internet. As the concept of a
receiver has been changed into that of a user in the S->M->C->R->I model of basic analysis for
communication, and the user is able to simultaneously play the role of a sender, it is no longer
possible to describe communication in cyber space with existing models. Interactive
communication has been realized as escaping from the limits of one-way communication, and in the
field of design, interactive expression that induces other people to respond by presenting an
imperfect or ambiguous meaning rather than providing a perfect meaning has been increased.

**Etymological meanings of sign language**
Sign language goes back to the Age of Homo Sapiens in primitive times. In the era when human
intelligence was unspecialized, man used ‘gestures’ as the primary medium of communication.
On the other hand, modern humans surf the web among new currents of informatization. As shown
above, the trends of communication change continuously. The new flow of informatization suggests
both a wide range of thought and a chance to innovate knowledge.

Diverse communication environments caused changes within communication modes not only in
general social environments, but also for people with a speech impediment. With these changes, a
new educational medium of communication was expected for special groups who had difficulty in
accessing various types of information. The first use of sign language in a school was in Lette, the
school for the deaf in Paris, France (1760). In Korea, sign language first began to be used 80 years
ago.
A person with an acoustic disturbance is someone who cannot hear sounds in a meaningful manner, and one who cannot grasp the meaning of sonic messages even when exposed to dissonant or high decibel sounds.

As the result of an interview, a congenial subject with impediments due to cerebral oxygen deficiency in the placenta or parental diseases (10%), and subjects with acquired handicaps due to diseases like the measles, meningitis, diphtheria, etc., as well as stemming from the side effects of streptomycin or an accident (90%) are considered to be suffering from the cause of an acoustic disturbance.

**Problems in sign language**

Sign language is a language invented by the deaf, so that the hearing-impaired may understand things and communicate. Still the method has a variety of problems as follows: It is a presentative means of expression. It is pictorial, and thus, cannot accurately express the nuances of emotion. Moreover, due to the limited expression of sign language the whole expressive nature of a language is not possible. As a single facial expression or gesture can constitute the subject of a dialogue, the accurate division of motions is the most important thing in communication.

**Communication system design**

This study largely consists of three stages. Firstly, the illustrations used in the sign language textbook for handicapped (acoustic disturbance) middle school students, as designed by the Ministry of Education, was reformatted into different illustrations featuring a high level of perceptiveness. Secondly, the efficiency of communication was inspected through comparison between existing and developed types. Thirdly, hardware instruments were developed with a design module to highlight a high degree of perceptiveness, as a software system was suggested. This software will be a key element in solving the problem of generality. In the future, the function of application would be included in this word processor with high generality, in order to develop a module for the disabled. There is intent to make a demonstrative inspection centering on this module pack, and to treat the disabled through new perceptive communication.

![Conceptual framework](image)

**Fig 3: Conceptual framework**

**Finger language design**

Arabic numerals were designed with illustrations in the sign language textbook for handicapped (acoustic disturbance) middle school students, as designed by the Ministry of Education. The illustrations are simplified examples. Currently, a design module to express a variety of languages is under development.

It is intended to estimate the perceptiveness of both those with a normal sense of hearing and the deaf, using line width and various speeds of animated images for sign language textbooks under
development. These will focus on the deaf, and are concerned with a high perceptiveness for the movement of things. This will be a key element in building a harmonious community between those with normal sense of hearing and the deaf.

![GUI environment of PDAs](image)

**Fig 4: Finger language design**

**GUI environment of PDAs**
Figure 4, 5, 6 is the GUI environment of PDAs that is gaining wide popularity. The displayed pictures are those activated through a sign language translation mode. There are finger language expressions geared to symbolize simple numbers, and a sign language display structured to add fresh fuel to the future development of a functional module. The size of display under development will be greater than previously existing models, and in the inner part of the terminal functions to give every kind of educational effect through various language expressions are under consideration.
Interpretation of finger language test data

In this study, a test was conducted of SNSD teachers and students that focused on the finger language developed by prior research. The goal in the first sampling survey was to ascertain if communication is possible between those with a normal sense of hearing, and deaf subjects who are able to use finger language.

The field survey was conducted with students of the SNSD located in Chongro-gu, Seoul in April 23, 2002. The questionnaire was made up of 11 items, and all items except three involved the student making a guess at numbers with finger language. Knowing that there are many students with acquired cerebral infantile paralysis, the use of letters was avoided.

The intent was to measure the degrees of perceptiveness and errors within the developed finger language. Centering on this result, the visual definition of characters in prototypes for a secondary model of developed sign language is to be made.
For this survey, a total of 141 SNSD students were tested (including 39 from 9 elementary classes, 50 from 6 secondary and 52 from 8 higher classes), as well as a total of 53 faculty members among the staff of 97 (including the principal and 2 assistant principals, 65 teachers and 32 clerical staff members).

There were several test types of finger language under consideration. The A-type had three items: the first featured nine icons at nine by twelve millimeters in numerical order, the second was of nine icons without order, and the third has 18 icons in random order.

The B-type had five icons of 15mm wide and 20mm long, while the C-type had 18 icons in random order of 15mm wide and 18mm long. In the D-type, the largest test group to be completed involved 26 icons at six by eighteen millimeters. Two samples tested in the E-type for application to mobile communication environments had six icons each, for the writing of numbers 6mm wide and 8mm long. This test was carried out during 15 minutes per class, and the entered numbers were simply combined into a total.

Some quite interesting facts were found. Though it may be regarded as natural, students in higher education had the highest level of perceptiveness. This boils down to the fact that perceptiveness is...
related to studies conducted up to the present. Girls in higher education were lower than boys at 93.93%, while girls in secondary education at 93.25% also showed a difference from boys. Boys in elementary education marked a high degree of 81.57%, and female teachers at 96.19% had a higher perceptiveness than male teachers.

There also existed a difference between the deaf at 90.12% and teachers at 96.04% in the classified total, which may be considered as due to differences in their relative positions as learners and teachers rather than stemming from their handicaps.

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<th>Q3</th>
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**Fig 9: Totalization of the disabled students**

In addition, seeing from the classified total among a series of eight items, simple arrangement questions showed the highest percentage at about 97.73%. Question 2 where the order was changed made a difference from Q1, and Q3 with a larger size showed a lower degree at 89.25%, while Q4 with many small lines marked a rather high percentage at 91.29%. The Q8 as applied to mobile communication showed quite a good effect at 91.60%

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<td>93.05</td>
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**Fig 10: Classified total**

**Comprehensive analysis according to the classified total**

In conclusion, this study identified - as expected - that a physical handicap doesn’t always translate to a low intellectual ability. Though this kind of comprehensive analysis may be possible by allowing people with normal sense of hearing and the disabled to concurrently take an identical test at the same place, consideration should also be made in the future for those disabled who are isolated from other people in communication. Such subjects marked quite a high percentage in the total points, possibly resulting from the fact that questions which require the simple writing of numbers were included in the questionnaire, considering their brain damage and other physical handicaps. However, people with a normal sense of hearing were tested with the same questionnaire, and therefore it is thought that much consideration should be given from now on to the user interface design of a display screen.

The pictogram of finger language developed in this study, as centering on issues of comprehensive analysis, resulted in high perceptiveness in both those with a speech impediment and those with a
normal sense of hearing. Though there was a difference in relative intellectual ability, this problem is expected to be solved by the supply of various contents in future curriculums.

With the results of the new finger design, another interactive interface design should be applied to future prototypes for the experimental verification of new sign language designs. From now on, the interesting and exciting treatment of intellectual ability is to be expected via image-oriented characters and gestures extrapolating from the already developed precepts of existing sign language.

**Conclusion**

As a result of this study, it was found what effects the appearance of new sounds have on the communication course of images combined with a message, as centering on the comparative examination of communication courses for both people with a normal sense of hearing and a special group (the deaf).

A much more appealing alternative will be created if new instruments are introduced and more advanced application software is developed, by continuously observing and analyzing the variable factors of human psychology and solving certain problems. When the availability of this alternative is estimated by focusing on isolated groups, the desired sign and finger language systems will be completed as a result. After this, relative applications may be developed on the level of language treatment.

Several sign systems tested on the basis of this study proved that though some errors in communication between those with a normal sense of hearing and the deaf were displayed, the one group perceived signs based on their own intellectual abilities while the other has developed idiosyncratic methodologies based on individual organ sense adaptation. Therefore, it was found that a physical handicap is not always connected directly to low perceptiveness.

The expectation may be possible for a new concept of treatment with specialized instruments for the disabled. Furthermore, it may not be just a dream to envision the creation of contents predicated upon even minor treatment, as using yet to be developed various application software. As most disabled people are unwilling to learn sign and finger languages, the development and supply of interesting contents should be a prerequisite.

Based on the results of this study, the aims of future studies will be to build a harmonious community for both those with a normal sense of hearing and the deaf, by developing an advanced module and sign system and creating new instruments.

This study proved that there are few problems in communication between the disabled and those with a normal sense of hearing. It is expected that instruments for the disabled should be developed on a more practical level. Those interested in this study for the benefit of deaf individuals all around the world are always welcome to send an email to the researcher. <kmjanggo@kookmin.ac.kr>
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Common ground - a product or a process?

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Abstract

What does the Common Ground metaphor mean: solid rock, fertile soil, or swampy lowlands? Are we mapping the terrain or are we just constructing it because it would be comfortable to have one? We are in a historical moment, 40 years after the first conference on design methods, initiating the short “design science decade”, when other disciplines realize the fragile, fluid, historical character of their “grounds”.

On the lists and in conferences there are fierce debates, yet mainly concerning details of the respective positions. On the other hand ambitious perspectives are proclaimed, without being rooted in the community. Contributions reveal little reference to each other. Researchers rarely seem to take into account positions outside the material that supports their own views. Struggles for definition power seem to be going on, somewhere between evidence and eloquence. Maybe this is due to the imperative: “publish or perish”; at least here we have university level.

The paper presents a 4-step sequence of debate in a theory building process. This sample is then reframed twice, describing it as an evolutionary process and integrating it in a wider perspective of changing modes of knowledge production. Implications for design are discussed. My further intention is to initiate a novel form of debate, which might contribute to the communicative creation of Common Ground. The project “the basic PARADOX” poses the most fundamental question: are there foundations of design? The new imperative in academic design culture might be: “participate or perish”.
Common ground - a product or a process?

... dedicated to the White Knight, defender of Old-European scholarship

Step 1: A new position
In two papers (Jonas 1999, 2000) I formulate my position regarding design foundations. The first describes design theory as “a floating network of chunks of ideas”, without fixed epistemological core, acting in the interface region between shifting reference spheres: the contextual and the artefactual. Some deliberately provocative consequences from this view are, e.g. that there is no progress in design, or, that design is amoral, and has to be, in order to fulfil its function.

The second paper argues that design is acting in the “swamp”, which is a provisional metaphor for the hybrid mix of the natural, the human, the social, the divine, which cannot provide foundations but only entry points to the field. Design has no foundations because design itself is the basic human activity. Foundations might be emerging patterns in the swamp.

In order to relate design to science I argue that science is also acting in this swamp (in their case called laboratory), but that science is obliged to purify and de-contextualize the facts constructed there in order to protect its mythical image of being closer to the truth than other ways of knowledge creation. And I ask whether design should follow this problematic path.

The following relates this to two other positions. Steps 2 and 3 describe a “struggle” over my view, leading to a kind of stabilization of essential parts. Step 4 takes up a new idea and tries to develop it within the context of my framework.

Step 2: Struggle with Ken
Friedman (2001) took a critical look at the papers mentioned. The following is an imaginary dialogue, i.e. I reply to his critique, concentrating on the questions of overall style and the issues of progress and foundations.

Fig. 1: Alice and the Red Queen (Carroll 1996: 151).
K.F.:
“… These papers outline problems and issues without defining them. Opening the problem space allows us to reflect. Closing the problem space through robust definitions allows us to begin the search for solutions.”

W.J.:
The basic problems mentioned cannot be defined in a manner you would accept; definitions are not available. The concept of interface clearly refers to Simon and Alexander and their notions of design as interface discipline. “Robust” definitions might kill the problem before the search for solutions has even started. The idea that the problem space has to be closed in order to proceed towards solutions is inappropriate. Since the early 1970s we could know that in ill-defined, wicked problem situations problems and solutions evolve in a parallel process. If at all, the problem can be stated when a solution is achieved. And then the solution is the problem! I am convinced that this is true for design problems as well as for design theory problems.

K.F.:
“The growth of design knowledge, the steady history of improvements in design practice, the dramatic development of design research, and the gradual development of design teaching, all indicate progress.

Progress is not uniform. Comprehensive progress is impossible. Nevertheless, there is relatively wide agreement in our field that we are meeting Bunge’s (1999: 227) definition of progress as a ‘process of improvement in some regard and to some degree’ in all four areas of design.

The state of physics in 1895 offers a good comparison for our field. Because we are a different kind of field, we cannot hope to make the fundamental progress that physics has made over the past 100 years. Even so, we can hope to grow if we focus on a progressive research program.

Progress in research and in practice depends on prior art. This is another way of stating that progress requires foundations. If there is progress – and there is – there must be foundation(s).

There is progress in design. QED: design has foundations.”

W.J.:
I love circular arguments. But the circle cannot be traced back to some explicit axiomatic “foundation”. The concept of progress you are presenting appears to be rather modest. In my old-fashioned view progress comprises (1) an increase in scientific “truth” (there is progress e.g. in physics; but in design?), (2) an improvement of the human condition, the claim that Galilei and Bacon stated for science (there is progress in many fields; but through design?), and, (3) the utopian claim of enlightenment thinking: better human beings (no progress here). But I do not accuse design for not showing much progress in this sense, because, as I argued, design is the agency of bridging the gap, the interface. There is no reference point for defining progress, but merely fit or non-fit. Is Mac OS X a design progress compared with OS 9, or just an increase in functional complexity?

Parallels with physics or even mathematics seem inappropriate. Maybe there are parallels to the situation of the Design Methods Movement some 40 years ago: an exponential growth in rigidity … and then a collapse with important insights: that there are designerly ways of knowing, that design problems are mostly ill-defined, embedded, situated, etc.

I do not reject systematic inquiry. A culture of inquiry is evolving, which must not necessarily be the same as, e.g., in the social sciences. Refreshing and inspired designerly ways of inquiry are possible (Dunne and Raby 2001).
**Step 3: Re-stabilization**

Towards the end, after some 12,000 words, there is a considerable shift towards consensus, starting with the issue of *reasoned argument*.

**K.F.:**

“The arguments against the concept of foundations are intuitionist in nature. … … It is possible to ask for reasoned argument from evidence without locating design in the context of science.

While I have argued that SOME forms of design practice, design research, and design education are – and should be – treated as forms of science, this is not the case for all forms of design practice, research, or education. In contrast, ALL design activity requires reasoned thought. Ideas, issues, and inspiration often begin with intuition. This is the context of discovery. They must finally end in reason. This is the context of justification.”

**W.J.:**

I support the quest for reasoned arguments from evidence. But your article reveals no evidence regarding design foundations. Evidence cannot be replaced by eloquence. Regarding design, which, by metaphorical definition, acts at the “wavefront” between the actual and the new, it seems absurd to come up with the rigid and overcome logical positivist dualism of context of discovery vs. context of justification. Even in the “hard” experimental sciences there is a continuous multi-level path of re-construction from the experiment (or observation in situ) to the mathematical formulation of a “fact” (finished act).

We are still in a metaphorical stage. The design paradigm is trial & error, plus some analytic and projective tools, called methods, plus some mysterious human capacity called creativity (or chance?), plus some normative guidelines called style or fashion (or ideology). The same is true for the evolving artefact of design theory, which is located in the interface region between its evolving subject matter (design) and its evolving contexts (the reservoir of available theories). The Darwinian view, the use of basic systemic and evolutionary concepts, might be promising to transfer swampy metaphors into solid models.

**K.F.:**

“In the strict sense of Bunge’s definition, it may not be possible to establish an epistemological foundation for design. …

In arguing for foundations, therefore I do not assert the existence (of) a stable anchor for all design knowledge. Rather, I point to foundations (in) three senses. One is the historical sense. The next is the philosophical sense of a basis in goals and purposes. The third involves the multiple senses of the kinds of knowledge, theory, and practice that different forms of design and design research may engage.

If it is the case that design is a hybrid field – and the evidence suggests that it is – then design can occupy several states at any one time, while serving as a forum of different kinds of activities. While some of these activities must obviously be at variance with one another, variance does not mean contradiction. There is no reason that design cannot take several shapes, permitting several kinds of approaches.”

**W.J.:**

So we are very close to each other. No problem with these types of “foundations”. Main parts of my argument are stabilized, even the network of “chunks of ideas” seems rehabilitated. There is the
encouragement to proceed in the outlined direction. What remains is an uncomfortable feeling with your attitude of “knowing better”.

K.F.:
“In some ways, we clearly disagree. I call for clarity and explicit description. Jonas seems to believe that metaphor best describes the qualities of (celebrates?) the hybrid swamp. If it were impossible to describe the wetlands, the science of biology could not exist. The science of complexity and the concept of complex adaptive systems allow us to describe a hybrid swampy environment without reducing its richness. This requires greater and more explicit descriptions, not less.”

W.J.:
Blodermann! This is exactly what I am arguing for. Nevertheless I acknowledge the shift from physics to biology.

Step 4: Fresh memes from Dick
In order to develop the theory I will borrow from Buchanan (2001: 67–84). In stating, that “We tend to dismiss the way human beings have formed their beliefs in response to the natural and human environment” he explicitly introduces an evolutionary concept. His “ecology of culture” could well be compared to my “swamp”.

In developing our paths of thinking, we depend upon the philosophical assumptions that stand behind our basic beliefs, the contingency of which is not made explicit, however. Mostly they rest in a pre-conscious state of mind. In order to render them more explicit Buchanan identifies or invents four “generative principles” as generators for the various, sometimes incompatible, patterns of design theorizing today. His scheme shows two dimensions: the phenomenal processes (A) and the ontic conditions (B), each with two typical faces, so that a nice cross-scheme is showing up, an example of theory as design:

A: Phenomenal.
The underlying assumption is “that design is best understood by our experience of it …”

A1: Experience and environment.
The focus lies “on the problems that human beings encounter in their environment. ... It seeks to identify and integrate multiple causes of design rather than reducing it to a single cause. ...”. The four Aristotelian causes are showing up.

A2: Agent.
The focus lies on “the agent who performs an action. Design is shaped by the actions that human beings take in creating and projecting meaning into the world. ...This existential, operational approach is exemplary in its key features. It looks for successful examples of design practice in the past or present for models that may guide future ventures in designing. ...”

B: Ontic.
The underlying assumption is that there are “‘real and ultimate’ conditions that determine design in human experience ...”.

B1: Underlying forces.
The focus lies on “underlying natural forces and material reality. ... The paradigm of design is engineering, since engineering is closest to the natural conditions that are the ‘real and ultimate’ conditions of human life. ... This approach looks to the conditions that have shaped the past and seeks to project the trends of fundamental forces and movements into the future ...”.
B2: Transcendent ideas.
The focus lies on “ideas and ideals that transcend the necessities and contingencies of physical or material culture and the limitations of individual, personal experience. … This vision … is always oriented toward an ideal of beauty, truth, or justice that transcends and permeates the world of human experience, giving structure to meaning and values. …”.

Thus an explanatory structure for the chaotic image of design theory building is offered. The scheme as a whole reveals a strong Platonic appearance, which Buchanan only attributes to principle B2. It seems to float in an eternal realm of ideas, producing the puzzling variety of the phenomenal world of design theories. But where does it come from? Can it be integrated into the knowledge production process?

The answer is contained in the scheme itself. Buchanan - between the lines - seems to be in favour of principle A1: Experience and environment. Humans’ experiences lead to personal attitudes, preferences, styles. In consequence, theories of how the world (or design) works will come up, according to those preferences. Buchanan’s four principles are one of these emerging theories, which, in turn, through their dissemination (Design Issues is an effective replicator) influence personal attitudes, preferences, and styles in the community, and which shape the further conditions of our experiences.

To sum up: Generative principle A1 seems to be a bit “more basic” than the rest, because it contains the other ones plus itself. This shows the fractal character and self-reference of design theory, and, this is important, allows to integrate the “Buchanan meme” into the wider process of knowledge generation.

Reframing 1: A Darwinian view – evolutionary discourse
Steps 1-4 can be interpreted as Darwinian mechanism of (1) mutation – (2) selection – (3) re-stabilization and retention – and so forth: (1) Jonas introduces a new concept, which might be called a mutation, creative act, intentional provocation, or whatever an observer might prefer. – (2) Friedman acts as a selective environment, contesting the proposition. – (3) The chunk of ideas survives in this “struggle for life”, the interaction of the system (Jonas’ ideas) and the context (Friedman’s critique). The concept is re-stabilized. – (1’) A new appealing chunk of ideas appears which Jonas tries to integrate into his concept. – (2’) Someone might act as a selective mechanism, and so forth. In contrast to a genetic process in biology this mechanism is a memetic process. The “chunks of ideas” that are transferred might be considered as memes or memplexes (Dawkins 1976, Blackmore 1999).

The basis of our learning processes, which are the epistemological core of design, can be considered as biological, grounded in the need of organisms to survive in an environment. The aim cannot be true representation but (re-) construction for the purpose of appropriate (re-) action. According to Aristotle the recognizability of the world must rely on the fact that there is a kind of similarity between the “particles” of the world and those in our senses. The history of biological evolution indeed suggests certain similarities of the way the material world is structured and the way we think of the world. Evolutionary epistemologists (Campbell 1974) argue that the Kantian transcendental apriori has to be replaced by the assumption of an evolutionary fit between the objects and the subject of recognition.

The evolutionary model of knowledge production presents a spiral scheme of learning / innovation with structural identity from the molecular to the cognitive and cultural level (Riedl 2000). The basic structure, described in concepts of the uppermost level, is a circle of trial (expectation) and
experience (success or failure, confirmation or refutation), of action and reflection. Starting with passed cases, the circle consists of an inductive / heuristic semi-circle with purposeful learning from experience, leading to hypotheses and theories and prognoses about how the world works, and a deductive / logical semi-circle with the confirmation or refutation of theories due to new cases, etc.

Only very recently in the cultural evolution this general scheme was subdivided into the ratiomorphous systems of recognition and the rational systems of explanation / understanding, with its most extreme form: the logical positivist dualism of “context of discovery” vs. “context of justification”.

<table>
<thead>
<tr>
<th>Recognition (Erkennen)</th>
<th>Explanation (Erklären / Verstehen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- fitness, “truth” means strong design</td>
<td>- “truth” means correct causal relations</td>
</tr>
<tr>
<td>- prognosis is projection</td>
<td>- prognosis is forecasting</td>
</tr>
<tr>
<td>- networks, many causes</td>
<td>- linear cause – effect relations</td>
</tr>
<tr>
<td>- simultaneous (simul hoc)</td>
<td>- sequential (propter hoc)</td>
</tr>
<tr>
<td>- 4 Aristotelian causes considered</td>
<td>- only causa efficiens considered</td>
</tr>
<tr>
<td>- only local validity, context is crucial</td>
<td>- global validity claimed, context excluded</td>
</tr>
<tr>
<td>- allows no experiments, mostly irreversible</td>
<td>- relies on experiments, mostly reversible</td>
</tr>
<tr>
<td>- correspondence org. or artefact / milieu</td>
<td>- coherence inside a system</td>
</tr>
<tr>
<td>- reaches into high complexity</td>
<td>- reduces complexity</td>
</tr>
<tr>
<td>- is labelled “pre-scientific”</td>
<td>- is labelled “scientific”</td>
</tr>
</tbody>
</table>

Table 1: Erkennen vs. Erklären (Riedl 2000: 53 – 55).

While the ratiomorphous process of recognition has a high potential in dealing with complex, evolving phenomena, it is not very useful for causal explanations, and vice versa. But this “dilemma” is not inherent in the nature of knowledge production, but rather a consequence of the dualistic concept, which we have imposed on the process. The path from recognition to explanation is continuous and circular, sometimes with dead ends. Our language is too poor, or, too much locked in the “black&white” tradition, to express the beautiful shades of “grey” between the poles. In design the primary criterion of “truth” might be consensus in a community. The crucial question is whether design really needs the purified notion of explanation.

We can refer to Cross (2001):

“The underlying axiom of this discipline is that there are forms of knowledge special to the awareness and ability of a designer, independent of the different professional domains of design practice.”

Concepts of evolutionary innovation suggest similarities between the way the design process works and the way we theorize about design. These special “forms of knowledge” are the basic cycle of innovation and learning as described above. They are unspecific, because they are the formerly universal competence of humans dealing with their environment.

Reframing 2: Changes in society and knowledge production

Basically humans are “universal dilettantes”. The functional differentiation of societies de-valuated this trans-competence. Design professionalizes the competence of “universal dilettantism”; the human poietic drive is compensated by Do-It-Yourself industries. High modernity believed in planning, predictability, progress, and in the inexorable “scientization of society”. The 3rd quarter of the 20th century saw the peak of professionalization, the deficits of which have been described sufficiently (e.g. Schön 1983).
Since the 1970s we experience severe transformations in society and in the patterns of knowledge production, characterized, in a positive notion, as “knowledge society” (Bell 1973), or, more negative, as “risk society” (Beck 1986). Seen from a temporal distance, Nowotny et.al. (2001) characterize it as a shift from “Mode-1” to “Mode-2 society”. The interfaces between state, markets, culture are increasingly blurred. The relatively autonomous spaces these systems occupied, were products of the modern differentiatation, as was science. The scheme of functional differentiatation is dissolving in parts. The new program of the French CNRS reveals this shift from traditional disciplines to interdisciplinary problem fields. Moreover, the CNRS introduces the institution of “citizens' conferences” (Frankfurter Allgemeine Zeitung 26.03.2002). In Mode-2 society a new relation of society and science is showing up which might be labelled the “socialization of science”, or, the shift from Mode-1 to Mode-2 knowledge production. Science and society become transgressive, i.e. not only that science can speak to society (it always could), but rather that society speaks back to science. Innovation is the centrepiece of a new contract between science and society. It is mainly because of its success, that science has come under more pressure to deliver effective solutions to a wide range of increasingly complex problems. Thus science is being drawn into the production of contextualized knowledge.

**Contextualization** happens
- through the shift from a “segregation” to an “integration” model (discipline focus → problem focus, or, science → research),
- through the increase in uncertainty and more variation and selective retention through “success” that accompanies it (a Darwinian mechanism),
- through greater awareness of the place of “people” in our knowledge (actively involved in the production, conceptualised as either objects of research and / or as addressees of ensuing policies),

*Mode-2 knowledge production* implies that
- the separation of basic and applied research is blurred (e.g. quantum computers),
- the separation of natural and artificial, of science (what is) and design (what could be) becomes fuzzy (e.g. genetic design),
- the distinction of facts and values becomes a problem,
- the context of application is extended towards a context of implication,
- the focus changes from reliable to socially robust knowledge,
- the concept of “context of discovery” vs. “context of justification” becomes obsolete,

The “hard” epistemic core of autonomous self-referential science, which scientists have struggled to articulate and to defend, is weakening. The core is not empty but crowded and heterogeneous, which is not some sudden paradigm-shift from science to non-science, or from universal standards of objectivity to locally determined relativism, but the latest stage in a process of adjustment to an increasingly complex reality. Maybe the situation can be characterized as an uncoupling of modernization from modernity. The processes of innovation are separated from the values on which they were once assumed to rely. We have another paradox here: on the one hand, apparently, an alarming decline in science’s ability and authority to define and explain the natural world; on the other hand an unprecedented increase in its power to manipulate that world.

A “third way”, a more nuanced and sociologically sensitive epistemology is needed which incorporates the “soft” individual, social and cultural visions as well as the “hard” body of its knowledge. Science moves into the *agora* (Nowotny et. al. 2001: 201):

“... Science is no longer outside, either as a cognitive or quasi-religious authority or as an autonomous entity with its special access to the reality of nature. ...”.
Conclusion: Design as a non-modern discipline - science approaches design

Design, as a product of modernity, comes into being as a mediating interface between the making and the use of artefacts. Functional differentiation of societies is the paradox foundation of design; paradox, because, at the same time, design, as a cheeky “un-discipline”, rejects this separation, permanently meddling in everything. In this sense it is orthogonal to the traditional strategies of modernisation. Recently I formulated three theses regarding design (Jonas 2001), which can be related to science and the concepts of Mode-2 society and Mode-2 knowledge production.

(1) Design must fit.
This refers to the interface concept of design. The growing contextualization of scientific practice shifts the emphasis from internal coherence of its findings towards fitness with respect to its contexts.

(2) Design never ends.
This refers to design as a projective discipline, trying to transfer existing situations into preferred ones. Once the problem is solved, the solution becomes the nucleus of a new problem. The new scientific criterion of social robustness requires permanent feedback with its context in the agora. Scientific problems are never solved (Carroll 1996: 151, 152):

“…’Now! Now’ cried the Queen. ‘Faster! Faster!’ And they went so fast that at last they seemed to skim through the air, hardly touching the ground with their feet, till suddenly, just as Alice was getting quite exhausted, they stopped, and she found herself sitting on the ground, breathless and giddy.

The Queen propped her up against a tree, and said kindly, ‘You may rest a little, now.’

Alice looked round her in great surprise. ‘Why, I do believe we’ve been under this tree the whole time! Everything’s just as it was!’

‘Of course it is’, said the Queen. ‘What would you have it?’

‘Well, in our country’, said Alice, still panting a little, ‘you’d generally get somewhere else – if you ran very fast for a long time as we’ve been doing.’

‘A slow sort of country!’ said the Queen. ‘Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that! …”

(3) Design is a special art.
Design does not have to be ashamed of its pre-rational relics. There are mysterious aspects in designing, whatever we name them: intuition, creativity, or insights. Heisenberg, comparing mental images with their final mathematical models, suggests a complementary view of knowledge production, even in the “very hard” sciences (Miller 1996: 319, 320):

"... And, of course, then you try to give this picture some definite form in words or in mathematical formula. Then what frequently happens later on is that the mathematical formulation of the ‘picture’ or the formulation of the ‘picture’ in words, turns out to be rather wrong. Still the experimental guesses are rather right, that is, the actual ‘picture’ which you had in mind was much better than the rationalization which you tried to put down in the publication. That is, of course, a quite normal situation, because the rationalization, as everyone knows, is always a later stage and not the first stage. ..."

Mode-2 science cannot be reduced to its weakening core of formal standards, but has to be recognized in its widening context. Scientific research practice is approaching designerly ways of acting and reasoning. Design has never been strictly modern in a Mode-1 sense, and the discipline should not struggle for modernity in a situation when science and society and other “Sciences of the
Artificial” (BJM 2001) are leaving important aspects of modernity behind. Design can be conceptualised as an agency of modernization (innovation), uncoupled from the ideals of modernity, situated between the established scientific and professional spaces and expert disciplines.

Wiener (1948) argued that the promising fields for the flourishing of science are those, which have been neglected between the accepted disciplines. Cybernetics was a product of concrete design problems. Further disciplines may emerge from those fertile nowhere-lands. But design itself will remain in the swamp, or, more precisely, design will remain the swamp, where the potential paths of meaning can grow; or the not-yet-wired brain, where the axons search their connections: hypothetical, explorative, speculative …

Schön’s (1983) epistemology of reflective practice should be transferred to the process of building theory / foundations in design. Common Ground is an evolving processual concept, not a system of standards.

Appendix: the agora [http://www.thebasicparadox.de](http://www.thebasicparadox.de)
The basic PARADOX is a web-based project with around 30 participants who submitted texts on design foundations. It is based on the hypothesis that theoretical approaches in design are rooted in personal preferences, biographies, academic backgrounds, etc. and are evolving in communicative processes of negotiating positions. It is my intention to make these networks more transparent, i.e. to make them visible in one exemplary process: “Hetero-assessment” is requested in the form of short comments on selected (or all) other texts. “Auto-assessment” is requested as an indication of the own academic perspective, placement, working style. The outcome will be a kind of “cross-impact” - matrix of positions which (if well done by the participants) might serve as a database for further analysis as to theoretical clusters, mainstreams, fringe positions, etc. Results will be fed back into further reflection. Or, as Buchanan puts it (2001: 74):

“Indeed, our ability to reconstruct design in the future may depend for its creativity on an understanding of the fertile matrix of contrasting ideas and experiences that constitute the ecology of culture in the moving present.”
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The importance of explaining industrial design diversity

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Abstract

Clients in industry who come from disciplines other than design often experience deep frustration when working with or hiring industrial designers because they are not aware of the diversity in the field. Their frustration is understandable because designers themselves do not explain the diversity well and present themselves as generalists who can solve any problem. The real issue is that all designers cannot solve any problem and the word “research” has become as vague as the word “design”. In addition, some designers are wonderfully self-expressive and produce passionate designs and other designers produce wonderfully analytical solutions to complex problems. But designers are not always honest about their abilities and believe they can “do it all”.

While industry needs to educate themselves about the diversity in the field of design and the continuum of designers between the arts and sciences, the designers need to stop presenting themselves as the problem solvers for projects that require research, if they do not have traditional research training. While design generalists have a refreshing and useful “birds eye view” of the design process, this philosophy can damage the reputation and integrity of the profession, if the work is superficial in its solution. The clients need to ask the right questions of the designer, the designers need to ask the hard questions of the clients, and students thinking of entering a particular design school need to ask questions about design program philosophies and methods.

Industry in general, and other disciplines in the university, need to be informed of the diversity in our field and that it is a good thing when the right designer is chosen. The designers in our profession need to be able to say they are not the right person for the job, if they are not, and recommend a designer fit for the particular project. This integrity will help to ensure the growing respect for our profession.
The importance of explaining industrial design diversity

Introduction
I am often in the position of recommending industrial designers for employment, admitting undergraduate and graduate students to an educational institution, and explaining my own design and design research work to potential clients. Although the industrial design profession has made great strides in the past ten years introducing the benefits of design to industry and the general population, many clients do not know what an industrial designer does, and very few are aware of the great diversity that exists among the designers in the industrial design profession. They believe one designer fits all projects. The problem is that some designers believe this also. In 1949 George Nelson (Pulos, 1983) observed:

“In the end even this most prosperous and glamorous and complicated of professions comes down to a thing that is very old and simple: one man’s integrity against another’s, one man’s capacity as a working artist against another’s, the vision with which he establishes his standards and the courage with which he sticks by them” (George Nelson, 1949)

It is not always the fault of industry for not understanding the field of design, or designers, because the field is diverse and the designers have very diverse training. The designers, understandably eager for projects, will say they are capable of doing a particular design job, when in fact, they are not capable. The client’s confusion seems to emerge when he or she realizes the designer wants to personalize the design solution, self-express in ways that are not wanted or appropriate, or they do not understand the design problem to be solved (Newstetter and McCracken 2001).

Client confusion also arises when the design project warrants design research. Many designers say they do design research, when the term “research” has become as vague as the word “design”. The term “design research” has now stretched from viewing similar products on the market or doing visual concepts, to qualitative and quantitative systematic inquiries.

The problem is compounded further when the client does not know when design research is needed and neither does the designer who was hired for the project. These are the situations that label our profession superficial, confusing, frustrating, expensive, and hurt the entire profession. It may only take a few short years of badly chosen design projects, and poorly solved design problems, to make others wary of our profession. In a corporate interview on the design strategy for the company Master Lock, Gianfranco Zaccai discusses the successful process and strategy saying: “We did this by conducting qualitative research, analyzing the results, and then utilizing several iterations of illustrations, simulations, and rapid prototyping to test and expand the hypotheses.” While it is clear to Mr. Zaccai that research was a necessary part of the success of the Master Lock design, it is important that the designers on that team, and Mr. Zaccai, understand what qualitative research is and how to analyze the results properly. A designer with no understanding of research, who attempts to conduct or analyze research, runs the risk of skewed findings that lead to design solutions that are inappropriate.

The designers themselves do not agree on many issues about design and what constitutes design research, and design curricula differ around the world. I contend that diversity in design is not the problem but misrepresentation of designers to industry. Diversity in our design programs is natural because of our bridge between the arts and sciences. In the “Recommendations for Design” section of an article titled “Design Research: Building the Knowledge Base,” Charles Owen (1997) recommends that “research and professional advanced education” in the field of design are distinguished. He goes on to recommend: “Differentiate areas of design specialty and concentrate
resources. (p. 7) The result of distinguishing and differentiating content areas in the discipline of
design points to the building of expertise in particular areas of design. The benefit of this
differentiation is that we have expert designers working on projects for which they were trained.
The downside of the differentiation is that designers cannot move so easily (as generalists) to a
wide range of projects.

Design is a field that is very welcoming, and in turn, far reaching. But the problem lies in the
integrity of the field and the integrity of the people. The design field is in danger of losing its
credibility if misrepresentation persists, something most unfortunate because our current good
design reputation has been built by many diligent, caring people. We are in danger of losing our
credibility with other disciplines because designers do not take the time to choose the right design
projects, and turn down the ones they are not capable of taking on. A graphic designer who says he
or she can do information architecture, when their training only covered hierarchy of information in
a visual communication course, or the home interior designer who does a commercial environment
without understanding room programming, these designers also need to position themselves and
seek the correct projects.

Part of the problem for industrial designers is that they have been trained to become generalists,
taking a simplified design process diagram and using it as their wayfinding system. But many leave
off that last part of the problem solving process, “evaluation”, because of time constraints or lack of
good methods of evaluation. I hope the industrial designers who are trained in self-expressive
design treatments, and no formal research methods, will avoid projects for medical equipment,
nuclear controls, and airline cockpits, and that the words “Sure, I can do that!” do not escape their
lips.

Industry, also, is eager to capture the “magic” they see coming from designers and will hire external
consultants, who may be generalists, rather than train in-house specialists needed for a design
problem. In 1985, Cooper and Press discuss design in industry and the role of the generalist
consultant:

> “While the use of design expertise by companies grew significantly during the 1980s, they
were far more reliant upon the use of designers as external consultants than employing them
as in-house designers. This brought advantages for both users and providers of design
skills….But some have argued that it also engendered a superficial view of design and an
immature industry that was highly vulnerable to recession.” (p. 30)

The design generalists, trained in the arts and crafts methods, sometimes object to higher degrees
(Justice 1998). Many do not understand why a designer might want or need a Masters or Ph.D.
When the design generalist hears that research should be conducted in the design process they seem
to struggle with why this must be. Their confidence often exceeds their skill. The answers are
supposed to come from them, not from others. Yes, they believe it is OK to get information from
others but why make it a formal and systematic review? The design generalists’s simplified view can
be a wonderful thing for assessing the big picture, but for a design project that needs a detailed
analysis and testing of complex parts, such as the hardware/software interface for a product control
system, many designer’s attentions fall short.

Industry has become frustrated with the field of design because they often don’t get what they want
because the wrong designer was chosen for the problem that needed solved. But industry also needs
to educate themselves more about the fields of design and learn to ask the right questions.
Industry and academic issues
The following industry and academic cases happened in the past year and resulted in frustration, confusion, and sometimes anger with the design situation. In both cases the designers (professionals and students) experienced rejection due to uninformed clients and uninformed students on the same team.

Industry
This past year a CEO of a very profitable U.S. company expressed to me that he had fired designer after designer because he felt they were not offering proper solutions for his company. He was very dissatisfied with the approach to the problem the designers used, and the resulting process and solutions. They all seemed to miss the mark, he said, even after various company engineers spent hours discussing the product goals, functions and uses with the designers. He said the designers always seemed to “do what they wanted to do”, and the resulting design solutions were not a fit with the company, even though the designer thought they were great. He did not understand the disconnection between the designers hired and the resulting solutions proposed for the company, which is an engineering-driven company. At first, I believed he defined the problem well enough for the designers, but this was not the case. The problem was clearly defined as it was explained to me. I then thought the issue might be a lack of respect for designers by the engineers in the company, but this was not the case. This company wanted design, and designers. The corporate administration knew they wanted an industrial designer to help make their products attractive to consumers. By the end of my meeting with the CEO, I realized that he had been hiring the wrong type of designer. He was hiring designers who were self-expressive and trained (and wanting) to do unique and creative work that communicated their vision of what the product should look like. What he really needed was a designer who was trained (and wanting) to do work that provided a solution informed from the collective intelligence of a team of engineers, manufacturers, and marketers, and that design solution was supported by research. He was not comfortable moving forward on a project without some verification from data.

Academic
A similar situation occurred in a university project at a school last year. The design, computer, and business students all worked together on an industry project for a large American firm. After the project problem was introduced, project teams were formed. The business students immediately informed the other students that they had a minimum of two hours each week to devote to that particular project, and that they heard that design students stayed up all night just drawing. The computer students didn’t understand why the designers wanted to do initial observation of people using the products that needed re-design because they felt they really needed to nail the technology first, before they even decided to think about form. The business students were asked to find an acceptable target market to help decide whether a product redesign should be attempted at all. The business students said, “give us the idea and then we will do the numbers as to whether it is feasible or not.” The designers were frustrated and said they couldn’t possibly think “blue sky” when they were already under such parameters for the project. The entire project took a bad turn because of the attitudes of the students, and I might add, the instructors. Had the right questions been asked, and noted, at the beginning of the process, the frustration and disillusion might not have happened. All students walked away with a jaded view of the other disciplines, the very opposite of the goal of the interdisciplinary project in the first place. The prejudices, and lack of information on the part of the instructors, were carried by the students and leadership was weak. Early questions about working habits, best practices, expectations, etc. would have helped the students understand and begin to respect the other’s skills, but expectations for the others was unrealistic.
The need for communication
We have watched other professions that were once respected, fall into disrespect. Much of this disrespect was because the members of those disrespected professions did not respect the other members. The industrial design profession runs the risk of losing professional ground if it does not communicate to the world that, yes, it is a diverse profession, and diversity is a beneficial situation that offers a variety of designers for a variety of products. But the right designer must be matched to the design problem.

We can not continue to sell ourselves as researchers when we are not, or expressive designers when we are not. Nor should industrial designers take on a graphic design job without graphic training, or an architect take on an interior design job, without appropriate training. Like other professions, we need to find what we do best and promote ourselves in that niche.

We must also communicate our admiration for other types of designers who are not like us, and may have skills we don’t possess. This will help us to build a good design culture and have others eager to work with our profession. But successful communication has a sender and a receiver and the right questions need to be asked to assess if the design problem is right for your skills, or if someone else should be recommended. Listed in the next section are generalized queries for clients, designers, and students seeking a good fit.

Placement queries

Industry hiring query
The following questions are indications of the type of conversations I have with someone hiring a designer, especially for the first time. These will assist the client with probing for information about the right fit of designer to project.

What do you hope to accomplish with this project?
Does this project require research of any kind?
Does this project require the designer to solve the problem with a team of people?
Do you feel comfortable around designers or do you have notions about them?
What is your corporate culture like?
Is your corporate culture more science or art oriented?
Will the others in the team work easily with a creative designer?
Is your company engineering (or marketing, or manufacturing, etc.) driven?
Do you have people to carry out the design concept?
Are you looking for a solution that is artful and expressive, or analytical and supported by traditional research methods?

Student hiring query
The art and design schools in the United States fall into a continuum along art and sciences. Schools are either art schools that offer industrial design or research institutions that offer industrial design. Students often visit the schools to see which one is a good fit for them, but they may assess a school for other reasons than the industrial design curriculum. Listed below are questions I ask students before admitting them to the program:

Can you draw?
Have you had art or design classes in high school?
Do you have a portfolio?
Do you like to work on one thing until you have it right or come up with ideas and move on to the next thing?
Which types of products would you like to design? Housewares? Autos? Medical Equipment? Sporting goods?
If you were to re-design a product, can you think of one that needs improvement? Why?
Would you like to design for other age groups or would you like to design products for yourself?
Why do you want to become a product designer?
Would you rather go into Fine Art?
Do you think you need to be a designer, instead of an artist, to get employment?

If students seem more interested in Fine Art, or the more self-expressive products, then they should go to an art school that has an industrial design program. If students want to work on large complex projects that require research and the involvement of other disciplines, then those students should go to a research university. This is, of course, a simplification of the decision-making process but placement of the right student in the right school is important.

Design client query
The following questions can be used by designers to understand the type of designer and outcome the client wants and the process that will be involved. If the designer wants to do more expressive work and not be loaded down in details, and the client needs excessive amounts of traditional research, the designer should turn down the job offer.

What type of problem are you trying to solve?
Do you have a design team assembled already?
Do you already have a solution or do you need more?
Do you want something conservative or new and innovative?
Do you want me to come up with solutions and come back to present or do you want someone to work side by side with others to solve the problem?
Who is the decision maker(s)?
How innovative can I get with this? Total redesign or just this one area?
What type of process do you anticipate?
What type of research do you anticipate?
Do you like working with creative people or would you rather not be involved?

These questions are asked to learn if the client wants strict control over everything or will let the process unfold.

Conclusions
As many more designers are hired, the possibility exists for great confusion about the field of design. Since our profession is so diverse, and we do not have standards or licensing, we need to uphold our profession as honorable, and the designers themselves as having integrity. Part of that integrity is turning down a design project that is not a good fit for them. If designers become known as unreliable and difficult to work with, industry will find ways to work without us, and the reputation of all designers will be difficult to build. We may need to “police” our own profession and ask our fellow designers if they are asking the right questions and signing up for the right jobs. Communicating our diversity, and strengths, is of utmost importance to keep respect growing for our field of industrial design.
References


On semantic transformation
Product design elements as brand manifestations

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Abstract

The paper presents an extract of my doctoral research in progress. It discusses the notion of semantic transformation, both as a conceptual orientation in which product design is seen embodying semantic references to specific brand qualities, and as the actual transformation process through which (linguistic) brand definitions develop into (visual) design elements. The conceptual framework stems from the fields of design semantics, brand research, design management, and design research. Theoretical discussion is supported in the paper by illustrative examples, derived from the in-depth case study of Volvo cars.

First, the paper covers the themes of company identity, meaning transmission and creation, and brand representations. This is followed by brief viewpoints on product design as brand attribute embodying specific semantic references. Finally, I will elaborate on the issue of semantic transformation in the context of design process, particularly regarding identification of so-called traceable and non-traceable design elements.
On semantic transformation
Product design elements as brand manifestations

Introduction
The significance of design as a central brand identity attribute has been recognised in design management and brand literature. However, studies that focus on clarifying how brand identity is actually reinforced through specific product design features are rare. In this respect, more understanding might be gained by combining insights from different research fields, such as design semantics, brand research, and design management. This could contribute to novel insights regarding the notion of semantic transformation, both as a wide conceptual orientation in which product design is seen embodying semantic references to specific brand qualities, and as the actual transformation process through which (linguistic) definitions develop into (visual) design elements.

This paper presents an extract of my doctoral research in progress. The objective of my research is to study how specific identity references are formed in product design to signal certain brand or category membership or, in other words, how the semantic transformation is constructed. Accordingly, theoretical goals include clarifying what constitutes brand identity, and conceptualising the notion of identity references in product design (see figure 1). My conceptual framework stems, in specific, from the fields of design semantics, design management, brand research, and design research. This listing is, however, only indicative, while all of these fields are multidisciplinary by definition.

As figure 1 illustrates, the empirical goal of my research is also twofold. I focus, first, on studying the essence and representation of brand identity through specific product cases, and second, on explaining how these attributes are transferred into product design elements. My study approaches these themes in a qualitative manner through selected product and company cases. The prior data sources may be grouped into three categories. First, public documents and internal company documents are used to describe various representations of brand identity. Second, products themselves, and in specific their design features (as they occur), are analysed in order to clarify
functions of products as brand manifestations. Third, personal interviews enable potential insights of the transformation process as experienced and described by designers themselves. Personal interviews are included in two in-depth cases (2-5 designers in both). In addition, I have analysed a number of illustrative cases primarily on the basis on secondary material. In this particular paper, I will present extracts of Volvo cars that is one of the in-depth cases in my study.

**Identity of the company**

My research tackles meaning creation by regarding companies’ brands and products as social and cultural symbols. In this context, symbol is regarded in accordance to the view of Peirce (1998) as a conventional sign that depends on acquired or inborn habit and functions through associations. Within this extensive and utterly complex subject, I adhere to clarifying how companies charge meanings to various communicative replicas in a merely intentional manner, in other words, to achieve certain strategic goals. In specific, my interest is on product design that in various product categories serves as a central tool of identification. Even though being fully aware of the dual nature – the interactivity aspect – of the signification process, I have tried to elude the consumer interpretation of brand representations.

Hence, I regard the notion of identity as a strategic concept, which consequently suggests that it may be intentionally affected to a certain degree. Identity has three fundamental functions. It may contribute to company or brand recognition (identification), to differentiation of the company’s offerings from those of competitors (distinction, uniqueness), and to creation of coherence across different markets and product categories, as well as over time (consistency). I use (the metaphor of) “identity” as a converging term to indicate certain “sameness” (as the Latin word “identitas” suggests). As for instance Karvonen (1999: 45) notes, identity is a problematic concept - while being unambiguous - and might be used only to denote differentiation from something else. The ambiguous nature is highlighted by a number of overlapping terms - such as character, personality, philosophy, profile, reputation, image, perception, and positioning - which are used in a diverse manner depending on the user in question. I will not go deeper into different terms in this paper but confine myself to a generic statement that treats identity as something that through (intentional) messages appears as a specific projection of personality (see e.g. Bernstein 1984, Baker and Balmer 1997, Markkanen 1998, Karvonen 1999). This personality and, further, identity (or character) stems from an underlying philosophy or mission and impacts the ultimate perception, that is, image and reputation of the company (Baker and Balmer 1997).

Corporate identity is one of the established terms in this context. However, it has been used in various meanings (resulting in competing “schools of thought”) as illustrated, for instance, by Baker & Balmer (1997), van Riel and Balmer (1997), and Markkanen (1998). In generic manner, there appear two main perspectives: the strategic, performance-oriented view (internalisation of the identity) and the visual, operative-implementation view (externalisation) (see in specific Markkanen 1998: 48). To illustrate the idea of internal and external identity, I may use the rather simplifying iceberg metaphor. It suggests that, on the one hand, identity may be regarded as everything that the organisation "is" (Balmer 1995), but on the other hand, it consists of different elements. The part under the surface (congruent to the notion of internal identity) represents the identity dimension that might be seen as stemming from the company’s “being”. It is difficult to manipulate while embodying a subconscious dimension in the form of tacit knowledge. This dimension forms an important basis for the company’s “visible” (external) identity, illustrated as the tip of the iceberg. The connection between internal and external parts is of dynamic and bidirectional nature. Internal identity is the wellspring of external representations which in turn, while being perceived and interpreted by stakeholders, constantly shape the submerged part.
External identity, as the representation of the company’s being, emerges primarily through three designed areas: products or services, environments, and communications, as summarised by Olins (1990). I prefer to use communication in a generic manner to include all the messages (also products) that are formed within this realm, especially emphasising their symbolic characteristics. In this sense, product design functions as a strong identity manifestation.

**Meaning transmission and creation**

Symbols are created and used in the cultural and social context through communication. Fornäs (1998:173) points out that symbolic communication can be regarded from two different points. First, it may be considered as *transmission of embodied meanings* from a sender to a recipient (i.e. from the company to the customer in my context). Second, communication also deals with *creating shared meanings* in the social context. This is congruent to the general division of two main disciplines in communication research in which communication is regarded either as a *process* of transmitting messages or from a *semiotic* perspective as production and change of meanings (Fornäs 1998: 173). In the first, message is dependent on the meanings the “sender” encodes into it. In the latter, message is a sign construction that generates meaning only when it comes to interaction with the “recipient”. This gives, however, a rather simplified picture. Even though my research, by definition, grasps communication from the perspective of (intentional) meaning transmission (in order to reinforce certain strategic intentions), I put a strong emphasis on the semiotic aspect of meaning creation. As far as I can judge, these two views are inseparable. While encoding intentional meanings, for instance, to product design through specific semantic aspects to be subsequently transmitted to recipients, the company (designer) is also surmising potential interpretations of these aspects, thus in the actuality of shared meaning creation. Furthermore, the interactive dimension is stressed through the simple fact that the designer himself, as the consumer of designed artefacts, belongs also to the group of recipients.

Hence, my adoption of the transmission viewpoint is not to suggest that I would regard consumers as pure recipients of ready-coded meanings. It is a conceptual limitation through which I may set my focus on researching how the company (strategically) manages its identity through product design, thus by creating and communicating intentional messages. Thus, I regard meaning transmission merely as a strategic action (to affect others through goal-orientated means) instead of a sole communicative action. To investigate how customers actually interpret these messages (and often create unexpected meanings from them) would be another story. This choice also relates to my adoption of identity concept instead of “image”. Although these concepts as such are difficult to grasp, I regard identity in relation to the sending side of communication, whereas image is interpretation of a certain message from the receiver’s perspective. Brand image, for instance, is seen as perceptions about a brand as reflected by the brand associations held in consumer memory (Keller 1993).

**Brand representations**

How could then the concept of brand be understood? In order to illustrate the use of the concept in my framework and to intertwine it with the notions of identity and image, I present figure 2.
In generic use, brand might be considered as an intangible asset. Interlocked as a mental concept to identity and image, brand is embedded in the relationship between the company and the customer as a specific body of shared meanings. Within this relationship, it is important to notice the process nature of brand concept. Urde (1999) uses a term “brand orientation” to present his approach, in which “the processes of the organisation revolve around the creation, development, and protection of brand identity in an ongoing interaction with target customers with the aim of achieving lasting competitive advantages in the form of brands”. As Urde further points out, brand identity is formed through a process of value creation and meaning creation, through the brand (name) and other assets and competencies of the company. In this regard, the essence of the transmitted and jointly created net of meanings becomes “condensed” in the concept of brand. Further, the identity of a brand is fundamentally formed through specific associations. This statement is coherent with the definition of Aaker (1996: 68), according to which brand identity consists of a unique set of brand associations representing what the brand stands for.

Nonetheless, by this perspective I do not mean to undermine the fact that identity appears also on the tangible level, on the level of physical attributes that give existence for associations. This fact is emphasised in the semiotic analysis where various levels of signification process are conceptually important. The interaction of physical replicas and symbolic associations is a key issue also in my study of identity references. The most fundamental physical manifestation of the brand is notably its name. The brand name functions as a sign, connoting specific meanings by activating a network of associations, both intended and unpredictable. In my framework, specific design elements (brand’s “design cues”), when being linked to a certain brand, basically function with the same logic of embodying particular meanings, as the brand name does.

Brands usually possess certain key identity attributes through which (or through a unique combination of them) the brand is recognised and associated. “The lesson is to focus on a unique aspect of the brand that is easy for consumers to remember” (Farquhar 1989: 29). “Safety for life”, the brand theme of Volvo is an expression of concise and strongly established identity. Companies also provide lists of “core values” as explicit (and intentional) manifestations of their identity. These descriptions are usually regarded as fundamental principles that guide – at least should guide – the “behaviour” of the brand. The core values of Volvo include “quality, safety, and
environment”. As seen, these descriptions are rather ambiguous and as such do not usually provide sufficient base for differentiation. Nevertheless, both by reflecting the corporate culture and by placing certain frames for intentional communication, these descriptions function as organic elements of company reality. Their importance is stressed, for instance, in situations where there appear inconsistencies between them and the actual doings of the company. Regarding product design as brand manifestation, these values also make certain choices explicit, “understandable” for perceivers, by creating contents for interpretation. A specific design element may perfectly suit the purposes of Volvo, by referring to some Volvo-specific quality, but may lack meaning (in intentional sense) if applied to another product.

**Product design as brand attribute**

Product is often the strongest manifestation of brand identity, while it is usually the ultimate source through which a brand is evaluated. In regard to the view that regards the product as a (socio-cultural) symbol, as a specific means of visual and non-verbal communication, it is important to recognise the often extremely rich contents that, for instance, product design embodies in terms of brand associations. In the following I will pay closer attention to the character of product design as a carrier of semantic qualities.

The dimensions of product as an object of communication may be considered in a semiotic context. Vihma (1995) identifies four basic dimensions for a design product: **material, syntax, pragmatics,** and **semantics**. The material dimension deals, by definition, with the product’s material qualities. The syntactic dimension covers the product structure and technical functioning, and the pragmatic dimension relates to the use of the product. The pragmatic aspect can be further examined through different functions the product is inclined to perform. Gros (1983) presents a basic categorisation by dividing product functions into **practical functions** and **product language functions** (see also Steffen 2000). The latter group involves, for example, symbol functions that, instead of practical functions or formal aesthetic functions have a direct contact face to the semantic dimension. Product semantics focus on the representational product qualities. The semantic dimension emphasises the aspects of products as symbolic communication.

Specific product qualities – say design elements – function as signs that could be understood, for example, in accordance to the Peircean tradition of semiotics (Peirce 1955 and 1998). Regarding the reference relation, sign may be comprehended as a relation to its object, such as a specific quality of a brand it represents (e.g. “safety” in the case of Volvo). Concerning brand identity references, the emphasis is placed on the set of associations that functions within the triadic relation between the **sign** (“representamen”), the **object** (of reference), and the **interpretant**. Within this relation, sign may refer to its object in an iconic, indexical, or symbolic manner. According to Vihma (1995), we may talk about **iconic**, **indexical**, and **symbolic** references (or signs) that are to be traced in product design. Figure 3 presents an exemplary extract of this reference relation as applied to the Volvo case.
If used in a comprehensive manner, this frame can be used as a helpful tool to identify sign references embodied in physical replicas such as design elements. Every significant design element – its indexical, iconic, and symbolic references – may be analysed in relation to their objects of reference (brand identity attributes). In addition to a rather straightforward process of decomposing and connecting between R and O, it is important to notice the presence of the interpretant, while it adds complexity to the analysis by bringing along the “subjectivity factor”. In specific, interpretation of symbolic references varies between cultural and social contexts (e.g. between different countries), because symbols by definition are constructed within this realm.

**Symbolic signs and product categories**

By analysing design representations through specific replicas embodying conventional, culturally “agreed” signs, it is possible to form basic product categories. Muller (2001) presents a categorisation that groups products according to their solution-typical, prototypical and behaviour-typical qualities. Solution-typical categorisation relates to the form as such, whereas prototypical and, in specific, behaviour-typical categorisations stem from the use of products in cultural and social contexts. These categorisations involve the important notion of typicality. Namely, a product may be seen as more typical within a specific category than another one – a chair may look more or less “chair-like”, or a car more or less Volvo-like.

Consequently, this stresses the importance of selecting a proper level for analysis when identifying brand-specific design references. The typological model by Muller (2001: 169) suggests three main levels of categorisation. The basic level relates to prototypical features (stressing the basic function of the product). The super-ordinate level focuses on solution-typical features (forms as such), and the sub-ordinate level to behaviour-typical features (in the context of use, interaction). In my study, the analysis focuses on the latter level that consists of features that actually differentiate competing products. This level regards design elements in connection to culturally and socially created meanings. The basic level is inappropriate, for example, to the analysis of Volvo design cues, while it only includes features that are typical to every car and, thus, do not function as identifying attributes. The super-ordinate level is, of course, even less accurate.

The case could be somewhat different in other categories, especially in those that are still on the early phase of their life cycles. For example, in mobile phones the prototypical features – thus, the
features that a product should have in order to be included in the category of mobile phones – are less obvious. Especially in terms of design, there exist a number of alternative solutions even for “basic” elements, such as displays and buttons. Consequently, the higher order features can be important brand identifiers for a company like Nokia, while it as a powerful player strongly shapes the course of the whole mobile phone category. Some initially brand-specific (i.e. behaviour-typical) elements can even become product-specific (i.e. prototypical) elements. As Muller (2001: 61) points out, “knowledge and experience with certain category members turns out to greatly influence typicality”.

**Semantic transformation in the design process**

As a central manifestation of brand identity, as discussed earlier, product design has a pivotal role in communicating intentional messages to target customers. This act of encoding intentional meanings – as condensed and derived from merely linguistic definitions such as brand core values or product briefs – into product design elements is an example of a process within which semantic transformation takes place. The notion stresses the semantic and, in specific, symbolic aspects of product design. Alternatively, this process could be called, for instance, materialisation, embodiment design, or (visual) form creation (see e.g. Muller 2001: 15).

Figure 4 illustrates an overview of the semantic transformation in the case of Volvo. I will not discuss the figure in more detail in this paper. It, however, suggests a few important notions. First, brand-specific design elements refer both to the company’s (brand) heritage and contemporary market trends. The clue of nurturing consistent brand identity is to use familiar references, but not on the cost of losing “freshness”. Second, stemming from brand’s identity (core values, heritage, etc.) and its intentional communication, there appears a “mental” platform for design – called key concepts of design in Volvo’s case – that functions as a basis for all design activities within the company. Finally, it may be (and in most cases is) possible to recognise physical design elements that function as manifestations of brand identity (see figure 5). Some of these elements are long-term, present in subsequent products and entire product portfolios. I call them genuine elements. Moreover, there also exist contemporary elements that can be recognised as brand-specific. Another fundamental notion is to distinguish whether a certain design element is, what I call, traceable or non-traceable. I will elaborate a bit more on this division.

![Figure 4: Conceptual framework for analysis of the Volvo case](image-url)
Search for traceable design elements

Design elements can be reduced to basic-level ordering elements present through conceptual, structural, and formal material dimensions (Muller 2001). Some of the brand-specific design elements can also be characterised by these dimensions, thus traced back into basic ordering elements. These traceable elements may be explicated in detail and further written into design guidelines. They can even be analysed and utilised to construct formal computer-based models and procedures (see e.g. Smyth and Wallace 2000). This emphasises the product portfolio perspective, according to which specific design elements are systematically used in all a brand’s products to reinforce consistent brand identity.

Symbolic brand references (represented by design replicas) could be traced in a rather detailed manner, element by element, following the framework presented in figure 3. Vihma (1995: 141) and Warell (2001), for instance, present specifications of different references embodied in, and functions performed by, certain product features. By performing such an analysis, a long list of brand-specific references (and perhaps their relative weights) may be formed. Precise mappings can also be problematic, while they offer favourable grounds for subjective interpretations. When searching for brand identity references, it is often reasonable to adhere to specific “key” elements (and they are usually not many).

The (new) Volvo design language, for instance, is characterised by few strong design elements – such as V-shaped bonnet, strong “shoulders”, and massive Volvo-specific grille (see figure 5) – that are repeated in every recent model. Many of these cues have a strong link to Volvo heritage, as they were used (in a slightly different format) already in specific models of the 1940’s and 1950’s. Some of these elements hold clear references to safety, the fundamental core identity attribute of Volvo. For instance, the strong shoulders make doors look thicker. These design elements (“cues”) consist of different (sub-level) conceptual elements (such as points, lines, surfaces, and volumes). The interpretation of certain forms – such as the curved line as the dominant element of side shoulder – are usually based on fundamentals of human perception, as was illustrated by Volvo designers.

Figure 5: Volvo design cues (genuine design elements)
Volvo cues do not, however, mean the same thing for every person, which refers to the subjectivity factor in relation to the interpretant. Besides, it is fair to note that similar elements appear in products of other manufacturers as well (perhaps in a less systematic manner though). These elements become Volvo-specific only when they are strategically connected to a specific Volvo identity through consistent fortification of intentional associations. People outside the target segment may not recognise the “apparent” symbolic signs or interpret them in a “wrong” way. They can be characterised as lacking knowledge of relevant codes. Cultural artefacts may be sufficiently understood only in the social contexts of their use (Fornäs 1998: 171).

Design culture and heritage – non-traceable elements
Nonetheless, I would suggest that not every brand-specific reference could be traced, thus attached to a physical design replica (at least not on the wider product portfolio context). This refers to the generic notion of semantic transformation that may be made explicit only to a certain degree. Still, we often deem specific products incorporating indescribable familiarity in their design. We can characterise products and their design with representational adjectives or metaphors, but cannot necessarily indicate in concrete terms how, for example, is an Audi more “dolphin-like” than a BMW or Mercedes (see Karjalainen 2001).

Thus, in addition to traceable elements, product design seems to embody symbolic references on a more intangible level. Alternatively to the simple “lack” of these elements, we may not have any consistent or objective methods to reveal them. Nonetheless, certain design elements and entities may still be regarded as brand-specific, creating certain subconscious feelings of “right” design language for brand’s products. This refers to the notion of non-traceable (yet brand-specific) design references. It is suggested that this notion tackles the existence of tacit knowledge with regard to brand-specific product language that is transferred to designers’ work (and other parties of design process) through internal (design) culture and heritage of the company.

The notion of tacit knowledge in this context is perhaps an illogical remark. If those references were non-traceable, how could they be still recognisable? Or how could they be deemed brand-specific? From a theoretical point of view, this issue is explained by the complexity involved in the signification process. As opposed to the example provided by figure 3, the reference relation is never as static and rarely as straightforward as that. Instead, the reference relation is constructed by strings of signs that produce a process of complex chain reactions. A sign may activate certain associations that, in turn, lead to further associations, and so forth. Consequently, this entanglement of references can take us so far from the “genuine” relation that it is simply impossible to trace certain objects to any physical forms.

Concluding remarks
One central question remains still unanswered. How do designers experience and handle the process of semantic transformation? First of all, it seems that there is not great complexity involved in traceable design elements. A systematic use of them would certainly lead to consistent design language and further to stronger identity. But this would probably result in unsuccessful products. The art of developing desirable products usually rests on the capabilities of designers to balance between innovation and familiarity. Apart from the systematic utilisation of traceable brand elements in product design, the real challenge lies in designing innovative products that, however, manifest the intentional identity of the brand. This brings us again to the notion of non-traceable design elements that relate to specific “brand knowledge”, embedded in the design culture and heritage of the brand.
This issue was not approached in specific in this paper. Nonetheless, on the basis of preliminary analysis of my interviews, it seems that designers possess a specific body of knowledge – explicit and tacit – of the brand heritage and culture and reflect this knowledge in their work. This knowledge, which is a fundamental aspect in regard to the design of identity references, is learnt by personal experience. It involves knowledge of specific identity attributes and their relation to product functions and characteristics – particularly concerning symbolic contents and typicality of design features. This is supposed to result in abilities to judge whether specific design is “appropriate” to the brand or not. In many cases, designers seem to subconsciously create non-traceable design elements, if they have internalised the brand knowledge. Encoding of intentional references evidently requires more than sole abilities to implement a simple and systematic process of translating formal descriptions (provided by design briefs or brand identity definitions) into design elements.

Design is a reductive process while many solutions are always possible (Muller 2001: 158), also in terms of reference encoding. In this process, designers (and, importantly, also other parties’) experience and common vision becomes important in order to prevent concept development from being haphazard. As Schön (1983: 79) notes, there are more variables than can be ultimately represented, resulting also to consequences other than those intended. Moreover, when mere parties are involved in the process, subjective opinions become visible. In a situation with multiple paths to follow, the role of experienced design managers in making choices and guiding the formation of design language regarding individual products and wider portfolios becomes vital. In addition, gaining shared understanding of strategic goals and shared knowledge of the means to foster brand identity is an important objective to strive for. And not only among designers but within the product development team and the entire company. Besides necessitating various measures in practice, this multidisciplinary requirement also sets challenges for multidisciplinary research.

Thus, there remain a great number of interesting issues to explore for design-related research. Due to several limitations – such as the length of this paper and the initial nature of my data analysis – I was able to approach the issue of semantic transformation only in descriptive indicative manner in this particular paper.
References


A study in making a software development process visual

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Abstract

Recently, it has been more important for software designers to do the part in developing user-centered software. They produce visual document to help communication among developers. Visual diagram to analyze user need factors is based on user scenario. Case study of distributed virtual-reality services in architectural process can show a sample of developing process visually.

It is important to produce visual document of one combined opinion among developers in process of defining development boundary, developing main concept, and selecting development system. Visual document created by software designer is a step to recognize design factors in the process of collecting design factors of user and environment and analyzing design factor by user scenario. Also, in the process of interface and prototype development, visual document is needed for the concord process among developers. Those visual documents with visual language could help to define each developer’s role and duty, to develop user-centered concept and various interface proposals while developing software.
A study in making a software development process visual

Introduction

Research background
Nowadays software is used not only by special users with skills, but also by everyone. This fact supports that software should be developed based on human-centered factors, not on technical factors. Software designer excels to software programmer in the ability to research human-centered factors, because software designer tries to satisfy human needs through researching human in macro scope.

In this paper, the role of software designer is presented through a case study, especially in researching human needs, organizing research material, analyzing and visualizing human factors through diagrams, and communicating ideas to programmers and project manager. The case study is a development process of architecture integral solution software for networked virtual reality service, which was conducted in Electronic Telecommunication Research Institute (ETRI) in Korea for two years. This project was aimed to research and develop human-centered application software with 3D Multimedia technologies.

Research objective
There are three research objectives in this study.

First, the role of software designer who use visual language, among related people, is discussed in the software development process. In order to do so, various kinds of software are analyzed and the characteristics and kinds of human-centered software are figured out.

Second, software designer presents analyzed human needs with various visual languages. It is discussed what kinds of visual language are needed to communicate among designers, programmers, managers and investors. It is also discussed how visual languages are used and presented in the software development process in order to utilize systematic literary recording of user environments and needs, consistent interface development, usage process development with core functions, and reduce of development period.

Third, the successful software design process with visual language is demonstrated through a case study, in communicating among members more precisely and making all members participate more actively.

Research range and methods
Section 2 discusses roles of software designer and other development people. Section 3 discusses the kinds and characteristics of human-centered software in which software designer can actively employ his ability. Section 4 presents actual samples of visual development process, used by software designers in the case study. Section 5 analyzes merits and defects of result of a case study and suggests further and prospective assignment.

Visual language user: Software designer
As function-centered software has changed to human-centered software, software designer appeared in order to understand and respond to users’ needs. The role of software designer is different from role of graphic designer and interface designer.
In the early stage of this process, expert programmer, project manager, and investor become a center of the project and manage schedule and software functional range with certain document. However, the role of each member is divided in the latter stage, so that result and opinion of each member often end up delay of development period and over-expenditure.

Figure 1 shows relationship among developers with software designer being centered. Software designer uses visual language to record direction of development in each sub stage in order to make communication among members fluent. Software designer makes visual documents of schedule, user requirements, sample data analyzed, data flow diagram, future usage diagram, consistent visual concept of interface, graphic, and sound and so forth.

When software designer becomes center of the project and makes visual document in each sub-stage of whole development process, all related developers could reach united understanding. It also helps to figure out who goes in the wrong direction when there is trouble.

In the following, it will be discussed the role of software designer and relationship with other developers.

Figure 1: Relationship among developers with software designer in the center.

Project manager -- software designer
Project manager, who has charge of managing schedule, usually has an educational background in programming and marketing. Therefore, he/she is not good at analyzing design-related users' requirements. He/she also tends to make schedule from their past experience, because he/she does not have skills to analyze detailed and user-centered system factors. Software designer can help project manager to make his/her scheduling more precise with the information regarding each member's role and development period through detailed and user-centered system analysis.

Other related company -- software designer
When software has various units, other related company develops some part in form of OEM. Then, there is needed to make documents for range of job and period of other related company. Software designer makes document of structure diagram for whole software and each sub modules. For example, it needs a document prepared by an OEM company when AUTOCAD Company attempts to develop Korean Type ADT. With this visually presenting document of kinds of Korean type
window, door, and roof, AUTOCAD Company can visually understand what OEM company will develop in the future.

**Marketer -- software designer**
Software designer can give marketer materials for product promotion and description. Software designer draws this diagram and marketer can deliver product information to customer through this visual material.

**Client/Investor -- software designer**
In order to collect investment, software designer can participate in the project plan documentation with story-oriented and visually presenting procedure. This document helps investors to understand the invested company in short time.

**User -- software designer**
The most important role of the software designer is to analyze users' requirements. Software designer arranges users' requirement into visual form and describes how they are concretely applied in the final software.

**Graphic Designer -- software designer**
Graphic designer does not know the characteristics of developing software in detail. Software designer helps graphic designer to understand the characteristics of developing software and to keep consistency in graphic quality in software. In order to do this, software designer should be able to suggest representative graphic sample to graphic designer.

**Expert programmer -- Software designer**
Expert programmer often comes into conflict with software designer. Programmer tends to satisfy function-oriented arbitrary interface, which comes out in the middle of process. Software designer makes them understand detailed interface structure, whole data flow and why this interface design is needed through visual presentation, before expert programmer begins programming. This work has something to do with reduction of development period.

**Beginning Programmer -- Software designer**
Beginning Programmers are educated by expert programmer and codes relatively simple module among whole software. They are also educated in general knowledge regarding whole software structure, interface and data flow in short time through visual presentation which software designer prepared. This helps to prevent beginner programmer to code irreconcilable and inconsistent sub module, which they are likely to do.

Software designer should have general knowledge in marketing, user analysis, presentation, programming, graphic and interface design. Most of all, it is surely important for software designer to have an ability to document works with visual language in each stage of development process.

**Field using visual language: User-centered Software**
The type of software, in which software designer needs to make visualized document, is not function-oriented software, but user-centered software. The kinds of this type of software are as follows.

There are two criteria to categorize kinds of software. First is the kind of knowledge needed to developers, and second is the kind of user who will use software. Does software developer need to have domain knowledge more importantly —[Domain-Oriented], or need to have system knowledge
more importantly – [System-Oriented]. Will the final software be used by End user [End-User] or by Develop user [Develop-User], who create some data using this software.

For example, domain-knowledge and system-knowledge are both importantly needed in developing “Game” software. End user for playing, not used in the work process to develop other things, uses “Game” software. However, system knowledge is more importantly needed in developing “Modeling” software. “Modeling” software is used by develop users to create graphic models. This graphic model files will be used to create other software such as game. For the final example, in developing children's software, it is needed child domain knowledge and education psychology importantly. Children do not use this kind of software to produce something in the middle of work process.

In the categories of software, user-centered software comes under shaded area of [Domain-Oriented] and [End User]. This kind of software needs for software designer to analyze domain knowledge systematically, and to identify important factors including emotional, cognitive, social and cultural factors as well as fundamental needs. It is also needed to develop graphical and auditory interface more importantly. Software designer's ability to analyze users' requirement and visualize works to do in each stage, is more important in the developing process of user-centered software.

In the following section, the concrete samples of how software designer uses visual language in the case study of software development process.

**Case study: usage of visual language in software development process**

**Outline of case study**
First, this case was studied about a fundamental technology as developing 3D multimedia technology for distributed realistic services. Second, the research members used the fundamental
technology to create architectural drawing and managing software, which included 3D drawing, material mass estimating, price calculating, and construct managing.

14 members participated in the project for 2 years, acquiring fundamental technology, programming major engine, developing concept for the software in which core technology is applied, and finally working software. 14 members were composed of 1 project manager, 1 assistant project manager, 2 system designers, 2 expert application programmers, 2 beginning application programmers, 2 expert graphic engine programmers, 1 database designer, 1 graphic designer and 1 software designer. Also, there were many domain experts who helped research, software test, and consulting.

![Diagram of software development process]

**Figure 3: The process of user-centered software development.**

Figure 3 shows the main process of the case study. The first step is to select development range for software. It resulted in integrated solution software including a series of architectural process from 3D architectural drawing to construction management. The next steps are to develop various concepts and to decide on system to develop such as database system and network system. Then, users and usage contexts are collected and usage situation scenarios are analyzed into design factors. In the next step, main interface are designed and detailed modules of software are programmed, and the first prototype is made. In this process, the major function of software designer to use visual language is demonstrated in the stage of user/usage context research and factor analysis stage through scenarios.

**Fundamental technology and decision of developing range**

The Fundamental technology my team had was a virtual service to communicate with many users in networked space simultaneously. In this virtual service, users can share and interact with an object and save changed data in the 3D space. Additionally, video and voice chatting function is supplied. Integrated solution software including a series of architectural process is selected to apply fundamental technology, because virtual 3D model can deliver precise information among users in the process of architectural design, construction simulation, and virtual simulation in the networked environment.

This fundamental technology can connect people at a distance and make middle procedure more precise. Software designer usually participates in selecting developing range with various ideas, but
in this case study, top manager and investors already decided software item, so that software
designer made a visual document to explain more detailed development range. This visual diagram
presents major functions and user for the software to develop.

**Concept development and decision of developing system**

Concept development is to decide advantages for which users will use this software, for example, saving
time, precise data supply, stable system management, and so forth. In this stage, user research
and interview with domain expert was utilized. In this case study, the major content of concept was about
the kinds of running module, order and data flow. It should be solved how 3D CAD modeling
data flows from automatic calculation module for the architectural material, estimation module for material
cost database, time schedule module for construction procedure, to 3D distributed graphic data module for virtual simulation.

![Diagram of software modules](https://via.placeholder.com/150)

**Figure 4: Diagram that shows data creation concepts among 5 modules.**

Figure 4 is a diagram made through many times of meetings among developing members and
domain expert. Software designer develops this visual concept diagram with sample data domain
expert provided, developing direction top manager provided, and opinions about feasibility of
expert programmers. Figure 4 shows five kinds of software modules to develop, order to produce
data among five modules, and the concrete form of sample data. This helped other members who
joined in the meeting understand whole software structure and developing direction easily.

Software designer also makes a diagram for developing system such as database system and
network system structure and helps all other members understand.

**User and usage context research**

Software designer takes major role in collecting information about user and context and in
systematically arranging it, in order to communicate it to system designer, programmer, and
database designer. This kind of work is to make visual diagram or table with systemized vase data.
Collecting information is divided into two kinds. One is to collect digitalized data that will be saved in database system. The other is to collect information to understand user and contexts generally.

Figure 5: A visual document of sample research material (rest area with 2D floor plan).
When the walls is drawn with ADT, you can see figures like a drawing in the right on the screen. The wall of the drawing on the right has three layers in concrete, stylofoam and bricks. To estimate materials for the wall, three layers of 1, 2, 3 and the inside of brick wall of 4 should be selected. The wall with three layers needs concrete finishing and brick wall needs cement mortal finishing.

![Figure 6: A visual document for digitizing data from sample material.](image-url)
Figure 5 shows a sample page of information collecting. The floor plan in Figure 5 is a rest area. This partial drawing includes brief descriptions of material and construction method. The people who calculate architectural material usually do their work by looking at CAD drawings. Our intention was to insert automatic calculation module. Figure 6 shows 3D model for the rest area and how each dimension of this 3D model can be applied into dimensions of architectural materials as shown in Figure 5. Figure 5 shows real drawing data, which are made by architectural drawing software, will save, and Figure 6 shows digital data software will use. They have different form. How to change data form will be dealt in the next stage. In information collecting stage, the sample of data form should be shown. If sample data such as work area, kitchen, bathroom as well as rest area is prepared, it can be used as communication materials with other members and as materials for design concrete interface elements. Software designer has an ability to infer digitalized data from user research material with understanding concept and developing system.

Software designer prepares a documentation to explain user and usage context. Social, cultural characteristics of user group, and basic principles for routine activities of users are described in this document. Many factors to consider in developing human-centered software are figured out in this document. They also influence interface design. Based on the content of this document, factor analysis through scenario is implemented in the next step.

**Factor analysis through scenario**

Factor analysis through scenario is done in order to define functions of each module in the whole software, relationships among modules, and work order among modules. At first, virtual scenario is written briefly, and a visual diagram such as Figure 7 is drawn from the virtual scenario. The title of each category defers by user and context.
In this case study, category titles that were used to analyze scenarios are: User input mode (keyboard, mouse, other external system), Screen display mode (popup window for queries, popup window for 3D model display, DBGrid display, Location, Action, or Navigation, Hierarchical structure display), Document Text (Text, Diagram, Graphic image), Users' mental ability (Long-term memory, Short-term memory, immediate Judgment, considerate judgment based on past experience and knowledge), Users' physical ability (searching architectural drawings, searching price documentation), System A.I, and System access (log-on, Database access, Network access). Figure 7 shows an analyzed scenario under the software module of “project management & sample process opening”, and displays sequential order of user activities and software functions. It also shows the point to save the data. In this case study, about one hundred scenario analysis diagrams were made. This document uses as a basic material to design interface in the next stage.

**Main interface design**

Based on the factor analysis through scenarios, main functions, icons and command were decided in this stage. When this visual documentation for interface is finished, programmers start coding.
Figure 8 shows interface of main functions that programmers should know thoroughly before they start coding. Visual documentation for interface should consider the whole screen layout at first. Figure 8 also has a whole layout in the upper left corner. Software designer gives scene numbers such as MRDO001, RED001 shown in Figure 8, while he/she meets major change of interface in the activity sequence flow diagram.
Software designer makes this kind of visual document including rough idea sketch, description of characteristics of functions, and data types for scene such as MRD001. Software designer also actualizes a sample interface with programming language. Figure 9 shows a sample interface created by visual basic. Programmer should be able to copy and use the files of those interface samples. In order to do this, programmer and software designer beforehand decide the names of functions and variables to be used. Software designer sometimes does graphic work for the screen display in order to make programmers understand better. Especially, the concrete building image in figure 9 was not possible yet because the engine was not established yet. Software designer drew it to make programmers understand better.

In the case study, object-oriented programming language was mainly used. When there is needed a new object to develop interface such as DBGrid OCX, software designer present the characteristics of the object to newly develop with the visual document.

![User Interface](image)

**Prototype development**

Software designer takes two important roles in the process of prototype development. First, he/she should be able to integrate and summarize all the visual documents worked so far. Second, he should make sure that programming process is going to the right direction. Integrated and summarized visual document is made for project manager, investor, programmer, because they are not interested in enormous analyzed data.

Figure 10 Shows prototype that shows final feature of the software. Software designer should check repeatedly that development process is proceeding as the team planned, because sometimes-
unexpected functions can be added or interface can be changed by programmers' mistakes. Software designer needs to keep consistency and simplicity for the software.

When initial prototype is made, software designer captured the screen and write down all functional description on the captured screen. This visual document will be showed to domain expert for the prototype test. Sometimes domain expert could give advice and opinion without direct use, but with only this kind of visual document.

![Figure 10: An example of developed prototype for construction module.](image)

**Discussion of case study result**

There are four issues to discuss in applying visual documentation to the software development process.

Role distribution and participation of members: In software developing project, number of code lines made by each programmer express how much work he did. In general, expert programmer makes lesser lines than beginning programmer does. But, in some ill-managed project, certain expert programmers tend to make almost all code. In that case, role distribution and participation of members are not balanced and efficient. However, due to visual document, beginning programmers improve their understanding in system structure and user requirements in the case study, so that the role of all programmers was distributed with balance and they were induced to actively participate in the project.
User-centered concept development:
The major role of software designer was employed in the stage of user and context analysis and the stage of factor analysis. It was possible to develop user-centered concept with enormous data analyzed user requirements. When prototype was developed, test users are satisfied with quality of functions and interface. Therefore, there is much less redesign work than usual.

Clear identification of responsibility:
It commonly happens to interfere other's work or to neglect one's own responsibility in teamwork. However, in the case study, software designer made sure about each member's role and responsibility, there is not much of interference or neglect. Especially, the conflict between interface designer and programmer became reduced much. Because the visual documents regarding interface design software designer made, is decided by combined opinions of project manager, designer, domain expert and etc., programmer can put all effort into realization of prototype from the decided interface design.

Intuitive interface development of software designer:
In the case study, too many documents can confuse interface designer to develop intuitive interface. Software designer should produce really required visual document to help interface designer to design most appropriate and intuitive interface.

**Conclusion**
Previously in this paper, the role and relationship of the software designer with other members are discussed, and the kinds of human-centered software were discussed. Then, the work of software designer who uses visual language in documenting software development process is demonstrated with the case study. There are many kinds of diagrams displayed in the process of software development.

The documents using visual language vary according to the project, so that it was not possible to generalize shared form of visual language. If there are many case studies done using visual language in the future, standardized visual language may be identified. Sometimes, vast documentation make interface designer and beginning researcher confused, so that it is needed to develop way to present simplified structure and information out of whole system.
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Urban and regional design: a practical science

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Abstract

Widely held notions such as the uniqueness of each design and design situation and of learning the design craft in a studio with ‘apprentice’ and ‘master’ relationships, have hitherto left little room for thinking about urban design as a science.

In this paper it is argued that urban and regional design is basically a practical science like medicine, applied psychology and other technical sciences. In a practical science the objective of research is the application of science: research is focused on ‘what is possible’, be it desirable or not (yet) desirable. Practical sciences differ inter alia from empirical ones in that the concept of falsification (and conversely verification) has only limited application, owing to the complexity and heterogeneity of the concrete contextual conditions, and in some cases also of temporal and/or financial and/or ethical considerations. All these constraints apply in the case of urban design.

A heuristic research approach as developed by the philosopher of science Imre Lakatos is particularly suitable to develop a body of knowledge for urban and regional design, be it that the focus is on the context of discovery, instead of on the context of justification. Some examples of knowledge generated by this approach, in the form of ‘spatial organization principles’, are presented.

‘To approach a city, or even a city neighborhood as if it were a larger architectural problem, capable of being given order by converting it into a disciplined work of art, is to make the mistake of attempting to substitute art for life.’ (Jane Jacobs The Death and Life of Great American Cities 1961: 373)
Urban and regional design: a practical science

The field of urban and regional design
An implemented design of an urban area imposes long-term conditions on social processes, such as the opportunities people have to organize their lives in temporal/spatial respects in a healthy and safe living environment, and on the way social, cultural and economic institutions are able to function. ‘Cities are the largest and most complex objects that human beings make’ state Hillier and Penn (1991:2). In a world like ours, suffused as it is with scientific knowledge and its applications, one might reasonably expect the construction of these ‘objects’ to be scientifically based. This is all the more so considering that the functioning of neither people nor institutions can be described as trouble-free. Problems include the continued dispersal of regional facilities resulting in increasing traffic congestion (Klaasen and Jacobs 1999), the failure to create favourable conditions for mobility chains, inadequate use of location values (ibid.), ill-considered siting of metropolitan functions, the difficulty of accessing hospitals for people without private transport, poorly sited bus and rail halts, public spaces which are difficult to keep clean, windswept crossroads and perilous cycle routes. These spatial impediments are bad enough in themselves, but they also contribute to the inequality of opportunity among individual and social groups.

In the professional world, however, but for a few exceptions (e.g. Langenuizen, Ouwerkerk and Rosemann 2001) little interest has been shown in scientific approaches to urban and regional design [1], certainly in recent decades. Widely held notions such as the uniqueness of each design and design situation, such as urban design being an artistic activity based on individual creative capacities or focussed on conserving our cultural heritage, have hitherto left little room for thinking about urban design as a science. Neither has the custom of learning the design craft in a studio with ‘apprentice’ and ‘master’ relationships.

One explanation for the non-scientific status attributed to urban and regional design may be the tremendous complexity of the ‘object’, the urban area. At the same time, the considerable inborn adaptive capacity of mankind undoubtedly plays a role too (Huisman 1996). Another factor is that people tend to regard urban and regional design as a special case of architecture - albeit on a different scale or concerned with public space, as opposed to architecture which is concerned with buildings (Meyer e.a.2000). Not surprisingly then, the aspect of experiential value (or ‘beauty’), possibly but not necessarily related to cultural history, receives as much attention in urban design as it does in architecture. For example, urban design, including regional design, is one of the artistic categories for which the Dutch Prix de Rome is awarded. This conception of urban and regional design clearly does not leave much room for a scientific approach to the field.

In as far as designers concern themselves with a science of urban and regional design, the focus is mainly on the process: the development of procedural theories for design. However, substantive scientific knowledge impinges rather on the context of the design activity: on formulating present and future social needs, on implementation processes and on the evaluation of implemented designs. Apart from collections of historical examples and certain checklists, scarcely any work has been done to create a theoretical base for design in the form of a systematically assembled body of knowledge which can be drawn on in the design process. Research into the phenomenon of the ‘city’ and into the development of this concept take place mainly in the sciences of geography, sociology and history.

To look upon urban and regional design as a form of architecture, however, overlooks the real difference between the way people experience a building, i.e. katascopically (from the outside inwards), as opposed to a city or city district, i.e. anascopically (from the inside outwards). The
latter implies that the experiential value achieved is conditional on the use value. If for this reason alone, use value should take priority over design in the narrow sense when applied to cities or city districts (see Klaasen 2000). It must be borne in mind, however, that design in the narrow sense is an integral part of use value in that it provides support for the functional organization of the city. It helps people to find their bearings in and to identify - culturally, historically and personally - with their environment, and meets the need for aesthetically or otherwise attractive abiding and movement spaces.

Given that urban and regional design, seen from the standpoint stated here that use value takes priority over design in the narrow sense, is indeed a science, two questions arise:

1. What kind of science is it? And,
2. How can we build up a body of scientific knowledge?

**Practical sciences**

Every urban or regional design is unarguably unique. The same could be said of every patient who visits a doctor’s surgery or psychotherapist, or of every design for a teapot. Yet medical, psychological or technical decisions are based on scientific knowledge. Teapots provide a conveniently tangible example (see Fig.1).

Fig.1: four ‘teapot’ models.

Pouring tea from these four teapots could be a precarious business. A knowledge of the physics of communicating vessels, whether explicit or implicit, would save a great deal of messy experimentation.

The uniqueness of each specific design cannot justify denying a scientific character to urban and regional design. Unique spatial patterns can be seen as constructions of reproducible ‘building blocks’. These ‘building blocks’ must of course be adapted to the situation in hand, which means there is still room for design in the traditional sense.

In order to distinguish it from formal and empirical scientific knowledge, I refer to the kind of scientific knowledge for which I have used the metaphorical term ‘building blocks’ as an instance of ‘practical scientific knowledge’. Practical sciences are those sciences which have the application of science as their object of research (Peursen 1986: 61). That is a different matter from the application of science to concrete cases. Similarly, a practical science, such as applied psychology
for example, does not consist solely of knowledge obtained in practice (Drenth 1995:157). The same scientific rules and standards apply to both types of science: ‘both types of research lead to generalizable insights and laws. The difference concerns only the origin of the research question and the intention of the research.’ (ibid.:152). Or, as Thagard and Croft (1999:134) put it, ‘Despite the differences in the form of the questions asked …, there is no reason to believe that the cognitive processes underlying questioning … are fundamentally different.’ The knowledge obtained through research is, as in an empirical science, in principle objective (intersubjective) in character. Subjective value judgements come into play only in a concrete application.

The object of practical science can be equally a process, such as an agricultural technique, or a product. In the case of urban and regional design, the product is the built environment (including infrastructure and recreational areas) and its relation to its environing natural (and possibly rural) systems.

Given the extrascientific problem definition, a monodisciplinary approach is unlikely to be fruitful in a practical science. A practical science is a task-bound ‘conglomerate’ of two or more (empirical and/or formal) sciences (Veen 1976:19). As an illustration, if we ignore the practical task of curing people, medical science falls apart into biology, chemistry, psychology etc. (ibid.).

The ultimate (critical) question that a practical science has to address is not ‘what is true?’ but ‘does it work?’ In more precise terms, does the knowledge yielded make effective action possible in specific situations - be it desirable or not (yet) desirable.

Invaluable in this connection is knowledge of the conditions under which action (leading to a product or process) is justifiable, and an understanding of intentional/unintentional (or desirable/undesirable) effects the action will have. Since practical sciences usually have a direct impact on society, the question of ‘does it work’ has to be considered in an ethical context.

The future state of affairs is thus a matter of concern both to the practical and empirical sciences, although from different perspectives:

<table>
<thead>
<tr>
<th></th>
<th>(intersubjective) knowledge</th>
<th>what will probably be the case</th>
<th>progress generated by intrascientific considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>empirical</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>practical</td>
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</tbody>
</table>

Figure 1: empirical and practical science compared.

Not everything that can become reality (‘the possible’) is indeed realizable in every possible set of circumstances (Peursen 1986: 97). This is a consequence of the fact that the knowledge is generalized in character, and peculiarities of specific situations have been ignored (Radder 1996: 2-3).
The conduct of science
The rules laid down, mainly in the twentieth century, for the conduct of science were formulated with the empirical sciences in mind. An important rule concerned distinguishing the ‘context of discovery’ from that of ‘justification’. The ‘context of discovery’ was explicitly classed as external to science proper. Adherents of this view, which was introduced by members of the Vienna Circle, included Karl Popper. Popper instigated a revolution in the philosophy of the scientific method by rejecting the idea that science must strive to verify hypotheses, and replacing it by the idea of progress by the falsification of hypotheses. Increasing doubts were voiced from the 1960s onwards about the validity of this strict distinction as a criterion of science (for example Kuhn 1962; Putnam 1974; Urbach 1978). David Gooding (1996) argued on the basis of historical examples from the natural sciences that rationality and creativity do indeed meet head on in the ‘context of discovery’, when anomalies (unexplained deviations from current theories) give rise to ‘abductive inference’. New hypotheses, he proposes, come about through complex cognitive processes.

This is not to say that there are standard recipes for generating scientific hypotheses, or that such recipes could be developed. There exists no algorithmic method, no defined set of rules, for obtaining new scientific knowledge, but the generation of new knowledge is not based on purely arbitrary processes: ‘… the search has turned to looking for “logics” in some weaker sense. Heuristic procedures, strategies for discovery, and the like are explored.’ (Audi 1995 : lemma ‘abduction’). Van Koningsveld (1976: 201) describes heuristics as the mass of suggestions, hints and unformulated rules that induce researchers to investigate some avenues of research as potentially fruitful while blocking off other avenues of research. Heuristic rules are rules of behaviour that promote finding things in the ‘context of discovery’ (Roozenburg & Eekels 1991: 42). Heuristic strategies like ‘abduction’ and ‘plausible reasoning’ make use of explorative models, analogies, metaphors, tacit knowledge and other non-empirical considerations (Radder 1997). The method of ‘abduction’, a term which originates from the philosopher C. S. Peirce (1839-1941) ‘merely suggests that something may be.’ (Hanson 1958: 85). ‘The form of the inference is this: some surprising phenomenon P is observed; P would be explicable as a matter of course if H were true; Hence there is reason to think that H is true.’ (ibid.: 86). Von Schomberg (1991: 58) proceeds from this to define ‘plausible reasoning’ as the derivation of a defensible standpoint from partly inconsistent data and/or in the absence of data. Models, in particular visual representations, play an important part in plausible reasoning. ‘Visual representation is a powerful tool for science when sufficient constraints are incorporated into the reasoning process’, Nercessian (1999: 20) stated at a congress titled ‘Model-Based Reasoning in Scientific Discovery’.

Context of justification versus context of application
The realization that cognitive processes are at work in the ‘context of discovery’ is more important for the practical sciences than for the empirical sciences [3]. This realization creates room for the development of urban and regional design in a scientific direction.
As in the empirical sciences, efforts in practical sciences are directed at testing hypotheses and theories (empirically or otherwise) under controllable, repeatable conditions (a ‘lab situation’). In the practical sciences, however, one is less likely to seek a context in which the hypothesis or theory will be falsified as much as one in which it will be corroborated. On the basis of a series of applications, probable conclusions can then be drawn about necessary conditions and resulting effects. Hillary Putnam recognized this as long as 30 years ago: ‘Since the application of scientific laws does involve the anticipation of future successes, Popper is not right in maintaining that induction is unnecessary. Even if scientists do not inductively anticipate the future (and, of course, they do), men who apply scientific laws and theories do so. And don’t make inductions’ is hardly reasonable advice to give these men.’ (Putnam (1974) 1991:122).

There are several reasons why such a lab situation cannot always be created.

- Ethical considerations may prevent the experimental testing of a hypothesis of practical science, notably when people would be involved in the experiments.

- Sometimes financial considerations stand in the way, particularly where large ‘objects’ are concerned. The use of scale models may prove useful here, but one always has to be alert for the risk of ‘overstretching’ the model.

- Time, too, is a potential bottleneck in various respects.

- Experiments may require time that is unavailable because the requirement for effective action is too urgent.

- The conditions may be subject to long-term changes which cannot be artificially accelerated.

- Changes in conditions which occur in the course of time may also be extremely unpredictable, particularly for processes and/or products where a large ‘temporal grain’ stands in the way of long-term corroboration.

In situations such as these, one either withholds from applying the theory, or relies on the feedback from the application of theories in various situations with successively unique conditions. A series of applications can lead to conclusions (albeit cautious ones), in the manner of ‘under a certain range of conditions, it is not improbable that effect X will occur’, but only subject to the proviso that the conditions have a measure of consistency. If a certain assumption turns out to be inapplicable in practice or the effects are not the expected ones, there are two possibilities: either the theory is inadequate, or the specific conditions under which its application took place were misconstrued.

Since, if laboratory-type experiments are possible they delivery merely corroboration, and if only practical applications are possible these may occur under once-only conditions that are only roughly similar on each occasion, a scientific or at least rational underpinning of hypotheses (‘context of discovery’) is even more necessary in the case of practical sciences than that of empirical science. In the practical sciences therefore the term ‘justification’ loses much of its meaning. It seems more appropriate to speak of the ‘context of application’. This context does not supply a justification of hypotheses/theories so much as feedback for a heuristic approach to the ‘context of discovery’.
A scientific perspective for urban and regional design
I conclude from the points raised above that urban and regional design is, at least potentially, a practical science. However, urban and regional design occupies a unique place within the practical and technical sciences. This is because all the above-mentioned potential constraints on the ‘context of justification’ or the ‘context of application’ do in fact occur. A laboratory situation is uncreatable because of

- the large financial investment required before anything can be tested;
- the long time required for the implementation of proposals;
- the long period over which validity would have to be tested;
- ethical complications.

As to the ‘context of application’, the following complications occur:

- the conditions under which proposals are implemented in practice show relatively few similarities;
- the conditions cannot be even partially manipulated - there is very little ethical scope for experimentation in practice.

In this light, the conduct of the science of urban/regional design must concentrate on the ‘context of discovery’, on what is presumed to be possibly true. Empirical and formal scientific knowledge must supply the necessary constraints. This constitutes an answer to the first of the two questions formulated above.

Developing a scientific body of knowledge
The second question, how can we go about creating a body of scientific knowledge, brings me, as a scientific realist (and how can one be anything but a realist in the practical sciences?) to the Popperian follower Imre Lakatos (1922-1974), most of whose work was only published posthumously (Lakatos 191976, 1978, 1999). Lakatos devised a heuristic approach in which the term ‘theory’, as a hypothesis open to falsification, is replaced by the concept of a ‘research programme’, which comprise both chains of theories and methodologies. He renounces the ‘strict’ falsificationalism of Popper. A research programme consists of a ‘hard core’ and a ‘protective belt around the hard core’ (1978: 104) . He follows Kuhn to the extent of proposing that the hard core should be considered temporarily immune to criticism (ibid.). He proves to be a true disciple of Popper, however, in the emphasis he places on seeking counterexamples (‘monsters’ – Lakatos 1976) to strengthen hypotheses and theories by a process of falsification (ibid.). Lakatos distinguishes two kinds of counterexample; local and global counterexamples. The first results in an improvement of the argumentation, while the second refutes the hypothesis or theory. This refutation is then used as a basis for seeking tacit assumptions implicit in the theory and making them explicit (because they may be wrong). He explains this methodology by reference to model-controlled thought experiments. ‘A “model” is a set of initial conditions (possibly together with some observational theories) which one knows is bound to be replaced during further development of the programme, and one even knows, more or less, how. This shows once more how irrelevant “refutations” of any specific variant are in a research programme: their existence is fully expected, the positive heuristic is there as a strategy both for predicting (producing) and digesting them.’ (ibid.: 51). Contrary to general suppositions, he demonstrates that deduction can lead to an increase of content. ‘If a deduction does not increase content I would not call it deduction, but ‘verification’. (ibid.:81).
Radnitsky noted in the 1970s that Lakatos’ heuristic is a methodology that addresses the context of discovery. ‘The structural study of hypothesis generation is not only compatible with but is suggested and guided by the Popperian approach’ (Radnitsky 1979: 251 note).

Lakatos rules for the development of knowledge offer the prospect of scientific theorization in urban and regional design, considering the importance attached in that field to heuristics, deductive guesswork and the manipulation of pictorial (visual) models, which are recognized in advance as unimplementable but serve only to boost understanding. Not that the rules have to be followed to the letter, but they can serves as a general guide.

**Some ‘spatial organization principles’ for urban and regional design**

Research taking place in accordance with this guideline in the Urbanism cluster of the Delft Faculty of Architecture towards principles (‘building blocks’) for urban and regional design relates both to ‘spatial organization principles’ (a term devised within this research project) and to theoretical models for urban and regional scale designs. Some examples of ‘spatial organization principles’ are shown below.

Fig.2: organization principles for transport links: a. radial structure; b. tangential structure.

The universal spatial organization principles at city level are here, a. the radial mobility structure that is desirable to make collective transport possible, and b. a tangential structure that is necessary for private car transport. Collective transport calls for the ‘bundling’ of transport movements, while cars benefit from distribution, owing to their relatively large space demand both during driving and when parked. At a smaller scale, low-speed individual transport (walking, cycling) is once again availed by bundling and thus by a radial pattern. The bundling of transport movements creates opportunities for symbiosis (among other things public safety) along the routes and reduces the financial and spatial investment for a given link.

Fig.3: organization principles for the siting of collective functions at neighbourhood level.
In a, the centre of a circle is in a homogeneous situation, generally the most easily accessible place and thus appropriate for siting collective functions. The radius of the circle is a criterion for the functional spatial quality - the time and energy required for assumedly equivalent movement options (walking, cycling). The residential density and the surface area of the circle a joint criterion for the potential quality of the collective functions. In b and c, the residential area is linked to the outside world. All residents and visitors pass through a single entry point. In b the point is a bus or metro station, one of the collective functions that are situated in the central zone. In c, the entry point is e.g. a town-centre parking garage located on the edge of a pedestrians-only residential area. Example d has a combination of a bus or metro station and a parking garage. The zone between the centrally sited station and the eccentrically sited parking garage now has the highest location value for collective functions.

![Diagram](image.png)

Fig.4: an example (at regional level) of a spatially determined - visual-spatial - organization principle.

The relation between the viewing distance and the visibility of spatial objects is affected by among other things the curvature of the earth. The connection between the height of an object and the distance at which it remains visible is non-linear. This is relevant both to the siting of features such as of landmarks and to the prevention of visual pollution.
Fig. 5: accessibility study.

a shows a limitless space that has not been made accessible. All points in this space are equal in terms of (un)accessibility. b depicts this space again but adds access by means of a road (individual transport). This makes a zone along the road accessible: say, the limits of the marked zone can be reached in 10 minutes walking at right angles to the road. In c access to the area is provided by a rail link, or rather railway stations (collective transport); the zone depicted in b has been transformed into separate (10 minute) circles around these stops.

The area around the crossing of the two roads in d is the most accessible site because it can be reached from four directions instead of two. We now have created a hierarchy in accessibility along the original path or road. The same goes for the railroad crossing in e. The crossings in both d and e are features of a radial system. Tangential systems on the other hand result in equality of accessibility. All sites in f will be accessible in at the most 10 minutes walking from a road. A tangential railway system on the other hand will still result in a variation in accessibility unless the users density is very high indeed, making overlapping circles possible (g; Manhattan?). In that case of course, private transport would be out of the question, as there simply wouldn't be enough room for all the cars. Transportation by bicycle, would probably still be possible. Private (car) transportation will probably already be problematic in the situation depicted in d. By adding a ring road as is the case in h, the resulting accessibility along this tangential road equals that at the crossing itself. It might indeed be even greater, depending on the quality of the radial roads inside its perimeter.

Notes
[1] ‘Urban and regional design’ is the translation of the Dutch term *stedebouwkundig ontwerpen* which I have chosen for the purpose of this paper. I have added the adjective ‘regional’ because the English term ‘urban design’ is mainly used in Dutch professional circles to refer to a scale of operation close to that of ‘architecture’.

[2] Generalized knowledge does not have to be universally valid, but can also relate to a specific region in space or time.

[3] The ‘context of discovery’ is sometimes also referred to in the practical sciences as the ‘context of invention’. I am not in favour of the latter.
References


Understanding the user-experience: tools for user-centred design of interactive media

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Abstract

Designing a usable web site structure requires understanding users’ concepts of the content. There are many approaches to usability that advocate human factors research methods and lengthy engineering style approaches to design. Such methods however, can be time consuming and may involve expertise outside the remit of the designer. We describe a user-centred design tool, whereby a proposed information architecture can be tested against users’ understanding via the web. Pilot studies suggest that the web is an effective medium for user-testing and enabled us to conduct tests quickly and efficiently. This supports our view of the efficacy of the tool approach to user-centred design research. We argue that usability cannot be achieved by applying prescriptive methods and design guidelines, but rather by applying a set of practical and focused tools that leave the design in the hands of the designer.
Understanding the user-experience: tools for user-centred design of interactive media

Introduction

“The most important component to design properly is... the user’s conceptual model. Everything else should be subordinated to making that model clear, obvious, and substantial. That is almost exactly the opposite of how most software is designed.” (Liddle, 1996: 21).

Despite the demonstrable values of usability (Bevan, 2000a), there is little evidence that usability methods are widely used (e.g. Nielsen 1994; Landauer 1996). Full-scale methods based on usability engineering approaches (e.g. Mayhew, 1999) can be time consuming and may require skills beyond the remit of the designer. Only large organisations can afford a dedicated human factors team, and design guidelines for usability are often used as the alternative. Other methods advocate following key principles (e.g. Gould and Lewis, 1985) and using simple and cost effective usability methods that involve real users (e.g. Nielsen, 1994; Bevan, 2000b). User-Lab has been set up at the Birmingham Institute of Art and Design to explore ways in which usability can be made more useful and accessible to the designer. We have piloted a tool aimed at giving designers an understanding of their users through simple empirical methods, to support the key principles of user-centred design within a discount usability approach.

The usability literature is awash with guidelines and heuristics but there is little evidence that they are widely used. Grose et al (1998: 127) suggest that the high degree of non-compliance to web design guidelines is due, in part, to that fact that designers find themselves overwhelmed and intimidated by their abundance. Guidelines can be hard to interpret and apply, they are often contradictory, and even experts cannot agree on them (Landauer 1996, Vogt 2000). The validity of guidelines can be questionable. Grose et al (1998) found that web style guidelines were not based on rigorous research methods. Vogt (2000) cites examples of studies that found over-generalisation, lack of focus, inappropriate levels of detail, conflicts between guidelines, poor illustration, incorrectness, and transience.

Grose et al (1998: 129) point out that the use of guidelines will never be a substitute for human factors input to design. Indeed, there is compelling evidence that there is no substitute for actual user involvement. Lee et al (1984) for example, conducted an empirical study in which a group of experts ranked menus using the criterion of ‘ease of use’. Virtually no correlation was found between the rankings of the experts. When a group of representative users ranked the menus, however, there was high agreement among them as to which menus would be easier to use. Furthermore, performance measures were highly correlated with the users’ predictions. Users were the best judges of menu design and the best predictors of future performance.

Grudin (1989: 1164) points out that the focussing on guidelines such as ‘interface consistency’, implies that good design can be found in properties of the interface, which he argues, is attractive but misguided. Guidelines are often derived from human computer interaction research, which seeks to abstract rules about behaviour. Much usability research focuses on looking for these rules, which we argue are of limited value, and instead research effort should be directed at supporting designers, not prescribing designs. This can better be achieved through promoting and facilitating the principles of user-centred design.

Gould and Lewis outlined 4 key principles to designing usable systems: early focus on users and tasks; empirical measurement through early and continual user testing; integrated design; and iterative design (Gould and Lewis, 1985; Gould 1995). They advocate early and direct contact with
users “through interviews, observations, surveys, participative design… to understand cognitive, behavioral, attitudinal, and anthropometric characteristics of users and their jobs.” (Gould 1995: 95), and the use of “actual behavioural measurements of learnability and usability and conducting these experimental and empirical studies very early in the development process” (Gould and Lewis 1985).

In a survey of designers’ attitudes, Eason and Harker (1988) found a number of obstacles to integrating user-centred principles into design practice. Designers felt that information was either not available, not available when needed or was not relevant. Objections to user-centred methods included that they take too long, are not cost effective, and they do not fit in with design philosophy. Nielsen suggests that the perceived cost of usability engineering is one of the key reasons that it is not used in practice and suggests the “discount usability engineering” and “simpler usability methods” (Nielsen 1994: 246-247) including the use of scenarios, simplified thinking aloud and heuristic evaluation based on ten basic usability principles (249-252). Bevan (2000b) describes cost effective methods including stakeholder meetings, paper prototyping and usability testing. Such methods support the principles of user focus, user testing and iteration.

We propose to use and develop tools that can be used by the designer to meet the principles of user-centred design, within the philosophy of ‘discount usability’.

**Tools to understand the user-experience**

Tools are an integral part of software engineering and digital media design. Generally, however, tools have focused on technological aspects of design, either in terms of making coding easier or automating aspects of design. Where tools have related to usability this has often focused on evaluation. Such tools include those relying on rules and heuristics (e.g. Becker et al 2000); logging data from users’ interaction (Rubin, 1994: 160); standardised usability questionnaires such as QUIS, PUEU and WAMMI (see Perlman, 1998); tools that augment usability testing (e.g. Al-Qaimari and McRostie, 1999); and facilitate remote usability evaluation (Hartson et al 1996 and Hammontree et al 1994). A less developed area is in tools that support the understanding of the user at early stages of design (e.g. NIST’s WebCAT, 1998), and indeed, supporting the entire user-centred design process (e.g. HISER, 1994).

Increasingly tools are being developed to work across networks. The advantages of such tools are that, once developed, they are very cheap to administer, can be run on many users at a time, and can reach remote and diverse users. The Internet has been used extensively as a platform for conducting research in many domains, including market research, social science research and collaborative approaches to design. One of the most well known online surveys is the Graphics Visualisation and Usability Centres (GVU) user survey (Pitkow and Recker, 1995) providing evidence of the changing character of the online population. This survey illustrates one of the disadvantages of using the Internet, namely the skewed population, which is still substantially different to the offline population. For web media this is less of an issue, since they are by definition representative of the user base. There remains however a sampling problem in that online subjects are often self-selected. The Internet does, however, offer opportunities in accessing groups that would be otherwise inaccessible or excluded from offline surveys (e.g. Coomber, 1997). Furthermore, online social groups provide useful sources of specialist target users. In addition the nature of online behaviour suggests some positive qualities for research. Joinson (1998) found that users are less inhibited in expressing their opinions in computer-mediated communication.

Our aim is to use and develop a set of low cost, easy to use tools based on user centred design methods. As a first step we piloted one such tool. The tool was initially developed to assist in the re-design of a menu structure for BIAD’s Centre for Product Design Information web site (CPDI).
The design team wanted to compare users’ performance on a new navigation menu before building it. Vora (1998) points out that category titles are important in setting up the user’s expectation of section content and that an inappropriate title can lead the user to visit several different sections, or can prevent the user from exploring the correct page. Spool (2001) found that when users navigated a site by categories rather than by searching they spent more time shopping and made more purchases on e-commerce sites. Furthermore, users only used searches when the categories were poorly designed. The CPDI design team wanted to be sure that users would be able to navigate their site intuitively based on the top level menu categories. The best way to test this was to try it on real users. Working to a tight deadline, the challenge was to reach their target audience quickly and cheaply. Since they had a body of registered users, it was decided to develop a test that could be used remotely and quickly online.

The tool was based on elements of card sorting techniques in which users are asked to sort a set of content items into meaningful categories. The technique can be used both to generate and to verify categories. NIST (1998) have developed an automated card-sorting tool, which enables users to sort items and generate their own categories. In this instance, however, our client had already categorised the content and was interested in the verification of their top-level menu structure. Although the card sorting approach could be adapted by fixing categories, and asking users to assign a list of items, we felt that it was important to emulate as closely as possible, an information finding task.

The tool, which we have called the online data collection instrument (ODCI), was designed with three components: a database, a management interface and a test interface. Tests are set up via the management interface. A set of top level items or categories (menu) are entered into the database. Then any number of sub category items (representing the site content) are entered. The number of items to be presented to each user is set, and may be a subset of the total number of sub-category items.

The test interface consists of two parts. The first is a user-profiling questionnaire, which gathers a range of information about each user and can be used to ensure the sample is representative of the target user group. This includes gender, disabilities, age, ethnic origin, occupation, computer and internet use, but does not include identifying data. This information is then stored in the database. This is followed by the test itself. Each user is randomly assigned with one of the menus (independent variable), and the sub-category items are presented one at a time. The user is requested to select the top level menu category that would best describe or categorise the item (dependent variable). Once a selection has been made the user clicks submit and the next item is automatically displayed. The items are presented in random order. When the specified number of items have been presented to the user the test is terminated and the user is thanked for their participation. Results are stored in the database. The system ensures that all content items are presented in equal numbers to all test conditions (menus).

Analysis of the results is done via the management interface. Results can be viewed by individual user or by the percentage of users choosing each menu option for each subcategory item. Results are displayed in tabular format in the form of a matrix showing menu option on the x-axis and the content items on the y-axis. Analysis involves manually comparing levels of consensus amongst subjects’ choices of menu option for each item. High percentages of agreement suggest a commonality in users responses, whilst low percentages imply a lack of consensus. The measure of the usability of a menu item is taken to be the degree of consensus amongst users, and match to intended content structure.
Using this tool the CPDI team were able to compare the usability of their original menu to that of their proposed menu, and confirm that their new menu did in fact match users’ understanding of the content structure. The number of users tested was too small to warrant statistical analysis, but the results were convincing enough to inform the re-design. As Nielsen (1994) points out, statistical significance though required for research and scientific claims, is not necessary to inform design (p.248).

This initial pilot suggested that the tool had the potential to be a useful research tool to support user-centred design for the non-usability professional, and we decided to trial it on a different project with a larger population. User-Lab had been approached by a large local authority, again to assist in the redesign of its web site’s menu structure. The information structure on the current site was based largely on the internal structure of the organisation, a common feature of web sites (Heller and Rivers, 1996), and it was unclear whether this was intuitive to members of the public. The number menu options was constrained to 8 ± 2 by the user-interface, and the information to be presented on the site was predefined. Thus the question was how could this information be best categorised. The client had already come up with two possible solutions. The client wanted to see which of the two was the most intuitive for users, and as such was a similar research question to the original pilot, providing us with an opportunity to test it further.

The ODCI was used to test the categorisation of 150 sub menu items taken from the current site against the two proposed top-level menus. A small number of users were taken from our participant database (N=6) and it became clear immediately that neither menu was optimal, and so a further set of menus were designed, based on the results.

It was decided that information finding activities could be a more realistic, and so the test was adapted to allow the input of written task scenarios. Task scenarios were derived from a log of telephone and face-to-face queries made by the general public. Altogether 60 tasks were designed to test 2nd and 3rd level menu items. Using the task scenarios the online tool was used to test a further 4 iterations of the menu, and was finally delivered via the client’s current web site, ensuring that participants were representative of current site users. Altogether over 150 users participated, far more than would have been possible in the lab within the time and budget constraints, resulting in a refined and usable menu structure. User testing of the final design resulted in an average 76% success rate using only menu navigation. This compares favourably with Spool’s study of e-commerce web sites in which a maximum 42% success rate was achieved using all the navigational aids available on these sites (Spool et al, 1997:5).

In parallel to running the ODCI, another set of users were given paper-based questionnaires and face-to-face interviews to ascertain the same information. The results were compared with those of the ODCI and were found to be equivalent. Interviews and questionnaires provided a more descriptive analysis of subjects’ behaviour including subjects’ verbalisations and levels of confidence, but little difference in levels of consensus. This suggests that the OCDI results were valid, despite taking a fraction of the time and resources taken by the other methods. Levels of consensus remained relatively stable above the twenty-subject mark, suggesting that the results were also reliable.

**Conclusions**

Our focus on tools is based on the following assumptions:

- Designers need to understand the way their users think and respond;
- Usability is context dependent;
- Iterative design is key to a user-centred approach to designing new technology;
Designers work under tight time pressures and budgetary constraints;
The designer is a trained professional who is best placed to assimilate the evidence available
and to incorporate this knowledge in the design.

The pilots described suggest that the ODCI tool has potential for further development. The tool
proved to be very useful in providing a fast and efficient means of testing a menu structure. There
are a number of limitations however. The online tool is unable to detect why users made the
choices they did. By contrast the face-to-face interviews were able to pick up levels of uncertainty
and feedback, and the paper-based questionnaires contained some written notes. The online test has
no provision for comments. One solution may be to measure the degree of confidence that users
feel in making their choice, by adding an extra step to each task or adding a notes window. The
problem with this is that it slows the user down, and encourages a reflective approach rather than a
more natural intuitive response. Another problem associated with testing online is that it is difficult
to ensure that the same user is not repeating the test several times, nor can it detect whether users
are collaborating or discussing their results with each other.

Our user profiling data confirmed the skewed nature of the web population. The self selected users
from the client’s web site, for example, had an average age of 26-36, 88% used the internet on a
daily basis, 50% were professionals, 61% had a university level education or equivalent, and 69%
described their ethnic origin as white UK. Interestingly, however, 51% were female. While this
population may be representative of the current web site user base, it does not account for new or
target users, and would be unsuitable for a non-web based application.

One of the Client’s key considerations in the design of the menu was what type of words to use to
describe the menu options. Our results suggested that verb based menus under performed compared
to noun based ones. This contradicts one of Dumas's guideline for menu design (1988), which
states "Use words for your menu options that clearly and specifically describe what the user is
selecting; use simple, active verbs to describe menu options". This supports the argument that
guidelines can be misleading, and that testing with real users is preferable.

The tool does not provide any statistical analysis of the data. The intention is to provide an
interface that is easy to use and to present the results in a way that are easy to interpret. It does not
assume any statistical knowledge on the part of the designer. It would however, be useful to be able
to output the results to a statistical package, and to enable the analysis of trends and correlations
between user profiles and test results for example. This is the subject of further development. We
are also looking at the issue of defining acceptability criteria, although we are reluctant to build this
in to the system, preferring to leave it to the discretion of the design team.

The current tool is not designed to test interface design. Menus are presented out of context to avoid
any interference due to layout or presentation issues, and to enable the use of the tool at an early
stage of design, before the look and feel has been established. The tool is not intended to be used in
isolation, but rather it should be used as one of many simple devices to aid the entire design
process, and it is our intention to adapt it to fulfil a number of knowledge elicitation and prototype
testing tasks.

To conclude we argue that usability cannot be achieved by following a set of rules or guidelines,
and lengthy and prescriptive processes are inaccessible to many designers. Rather, research effort
should be focussed on building a set of practical and focussed tools that designers can use at their
discretion, within the principles of user-centred design.
Our pilot studies have shown that a simple focussed tool can be useful for iterative design in a practical time critical design situation. The technology enabled us to conduct the testing efficiently and to provide evidence to validate our conclusions with a large sample of participants. The tool has provided valuable knowledge, as the first stage of a suite of simple user-centred design tools.
References


Deciphering myths in design: towards restoring the materiality of the object through the technique of re-sketching

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Abstract

Architecture or Revolution. Revolution can be avoided.
Le Corbusier
Deciphering myths in design: towards restoring the materiality of the object through the technique of re-sketching

Introduction
What is a designed product today? What kind of relationship between people and material artefacts is inscribed within it? Apart from the manifest design intentionality that shapes it, what social and historical intentions motivate the contemporary designed product and color our appreciation of it?

For us, these questions are not posed as a rhetorical manoeuvre that will allow an opportunity for an ill-founded discussion about design on the occasion of a conference. They are, rather, of paramount importance, since to reflect on the social significance and the historical fate of its objects is what distinguishes a discipline from a profession. In this article, it is claimed that the contemporary 'designed product' as a cultural category of our daily life has become myth for some time. Worse, not only individual products of design have become preys of mythical speech but also design itself has become a myth when it assumed status as a value in itself. Worst of all these, however, occurs when these myths are internalized by design practitioners and students. In this paper, we will first examine the notion of myth, as the French critic Roland Barthes understood it, then, discuss its outcomes in the field of design and, finally, propose a technique of deciphering myths in design.

Before demonstrating how the pattern of mythical significations came to be superimposed on designed products and the idea of design as such, we should first briefly explain myth as the dovetailing of a semiological form with an ideological function.

Barthes as mythoclast
Mythology, as Roland Barthes (1993) conceived in his Mythologies, is both a formal science inasmuch as myth is a particular mode of signification and a historical study inasmuch as the function of myth is to transform a historical intention into a natural, eternal fact or to represent a localized intention as something universal. In other words, the Barthesian study of myths is an unprecedented juxtaposition of semiology and ideology.

From a semiological perspective, myth is a second-order signification which is brought to bear upon an already signifying unit. Myth appropriates the final term of a given system and utilizes it as the first term (i.e., the signifier) of its signification. In other words, the contingent meaning of a signifying unit is put at a certain distance so that a space is emptied for the mythical concept to fill it. The concept, as the mythical signified, introduces an intentional knowledge of reality into the appropriated system and, thereby, justifies its intentions through the agency of this first system. Of course, the new reality introduced into the first system by the mythical concept is a certain representation of reality favored by bourgeoisie. It is important to note that this intentional representation of reality is totally dependent for its acceptance by masses upon the existence of an already signifying, self-sufficient first-system. Mythical speech could not have been successful if it had attempted to communicate its representations by means of a first-order linguistic system. It is a parasitical form totally in need of a pre-existing, ready-made signifying unit. The literalness of the first system is offered as a reason for the mythical concept in case it is asked for an explanation. Myth, therefore, does not hide its intentions. Rather, it makes its intention accepted as a statement of fact through the presence of the literal meaning of the first system. Since it still holds the first system at its disposal, myth is relieved of the burden of providing the receivers with an explanation. For it intentionally confuses the two systems so that the literalness of the first system is made to appear as the explanation of the second, mythical system. As a result, it presents things as if they mean something magically by themselves, while, in fact, it endows things with a preferred meaning.
Barthes illustrates this sorcery of myth with an example of the vogue for the building of imitated Basque chalets among French bourgeoisie (1993: 124-125). When he first saw these buildings in Spain, he did not feel personally addressed by them. Having seen their imitations in Paris, however, he could not help feeling that he, as an observer, was called for naming them as Basque chalets. Barthes deduced that his feeling of being interpellated was probably due to the appropriative nature of the concept of basquity. That is, he was confronted with Basque chalet as an object appropriated by the mythical metalanguage of bourgeois speech, forcing him "to acknowledge the body of intentions which have motivated it and arranged it there as the signal of an individual history, as a confidence and a complicity" (Barthes 1993: 125). Divested of its historical determinations, the Basque chalet in Paris appeared in the eyes of the beholder as if it was something that magically came into being before him and for him. As Barthes expressed,

“…the adhomination is so frank that I feel this chalet has just been created on the spot, for me, like a magical object springing up in my present life without any trace of the history which has caused it” (1993: 125).

As this example illustrates, virtually everything can be caught up in the network of mythical speech inasmuch as their meaning is already complete in a linguistic system of apprehension. In other words, not only linguistic signs but also pictorial representations, objects, events, even persons can lend themselves to myth. Myth, therefore, is a kind of metalanguage with a particular intention. While the meaning of the first term already "postulates a kind of knowledge, a past, a memory, a comparative order of facts, ideas, decisions," myth puts all this historical contingency at a distance better to fill it with an intentional signification by sleight of hand (Barthes 1993: 117). Therefore, it transforms "the reality of the world into an image of the world, History into Nature" by giving "an historical intention a natural justification, and making contingency appear eternal" (Barthes 1993: 141-142). Captured by mythical speech, the complexity of historical facts and the richness of meanings undergo a profound impoverishment. Through myth, the fabricated quality of class interests appears as natural, eternal or universal facts. Briefly, myth replaces the complexity and contradiction of social relations and their material outcomes with the simplicity of essences. This is the point at which a semiological form is put in the service of ideology.

**Design as myth**

As the Basque chalet example clearly illustrates, the material artefacts of our daily use can also offer themselves to mythical significations. This is all the more so for contemporary design and its products. Today, we observe design phenomenon mythified in three distinct but closely interrelated ways:

*First myth: design as proper name*

Design has become myth when it came to be understood as a value in itself rather than a material activity of professionals engaged in the process of decision making in a larger network of industrial production. Accordingly, design itself becomes a marketable commodity to the extent that it is released from its material, social and political determinations in the popular consciousness. In many instances, we see designed products whose sole signification is that of being designed. Thanks to this myth, there emerges a new regime of valence in which individual products are given value according to their position in a semantic scale of designed-ness. That is, the success of a product on the market depends on its capacity to employ semantic devices that will make it signify Design as its proper name. In this first myth, design as a generic concept is the object which is appropriated and purified by the second order signification of myth. If design is perceived as such a magical quality separable from concrete products, the designer also comes to be mythified as a 'magician' separated from the social and material circumstances that condition his/her work. This gives rise to a corresponding myth of the designer.
The influence of this myth on the understanding of design has been disastrous because once design is mythified, it can no longer be explained by terms other than design's own. Because it is elevated to the rank of a purely creative activity undertaken by certain talented individuals, design activity becomes increasingly isolated from the social map. The designer is depicted as a genius who works alone in his studio, immersed in the privacy of his inspirations. As a result, the design process comes to be regarded as a nucleus impervious to any influences outside of its immediate concerns. The practical and discursive existence of design gradually disappears from the scene, giving way to a 'mystique of design'. The prevalence of this myth not only closes the channels of critical reflection on design but also reduces the scope of design activity to a pretentious preoccupation with the creation of 'serve-the-rich' and 'serve-the-gallery' objects. According to this myth, design can not be defined, since it is an intuitive talent of a few privileged individuals. This myth, therefore, restores design, under the protective shield of the mythical notion of 'genius', to an unattainable world from where its power emanates. As a consequence, the only response expected of the critics and users to the products of design becomes limited to one of admiration rather than understanding and questioning.

Second myth: designers' myths
The second myth concerns designers themselves. The intransitive language employed by designers when characterizing their works prepares the ground for some myths to emerge among designers. As is well known, there have been a number of metalinguistic statements that prescribe particular norms and rules of designing. These include well-established design statements and themes in the form of maxims that permeate design practice and implicitly or explicitly define what makes up good design, what designers should and should not seek to achieve through their designs. Prominent examples of such maxims include "form follows function" or "less is more" of modernist era as well as "form follows meaning" of product semantics in the so-called postmodern period. Now, though at the beginning these statements might have been uttered with operational intent and had transitive links to their objects (i.e., designs), through the process of canonisation they have quickly transformed into mythical significations. In other words, when in 1896 the American architect Louis Sullivan (1975: 11-14) first uttered the "form follows function" phrase, he was trying to demonstrate the meaning of his design decisions by transitively linking his language to the making of his famous tall office building. However, no sooner this phrase started to be employed metalinguistically in order to celebrate existing or would-be designs than it turned out to be a myth. That is, the phrase ceased to be the language-object of practising designers and became the metalinguage of rhetoricians intent, in design practice, on persuading the public or, in education, indoctrinating design students with a higher principle to which they were expected to subscribe. By virtue of such myths, designers come to believe that instead of being historically determined they are engaged, through their work, in the truths of essence. In fact, through these designers' myths, a historically identifiable style begins to pass as a timeless value of true design. In this respect, Peter Dormer was quite correct when he interpreted "form follows function" as having been merely a style among others (1991: 20).

Third myth: myths as projected into designed objects
The final myth concerns designed objects themselves. Beginning with the rise of consumer culture after World War II, designed objects have gradually become purveyors of a diversity of mythical significations. According to Adrian Forty, manufactured goods all the more readily lend themselves to mythical appropriation since their unquestionable materiality and the overwhelming sense of actuality that they induce in people turns them into a suitable substance that the mythical speech generally seeks. This is precisely because myth prefers to inhabit forms that stand in the most insistent ways. Such forms as designed objects allow the mythical significations to enjoy both a prolonged life and credibility in society that the less concrete forms such as movies may lack. As
Forty (1986: 9) puts it, "unlike the more or less ephemeral media, design has the capacity to cast myths into an enduring, solid and tangible form, so that they seem to be reality itself".

Contrary to the doxological poverty of the first myth of design as a proper name, the myths embodied in designed objects manifest the most thematic expression of mythical significations. They are the bearers of a diversity of mythical conceptions ranging form ideas about technology and progress to a number of lifestyles particularly favored by consumer capitalism. As an example to this richness let me refer to two cases of mythical projection embodied in designed objects. The first example is the myth of modern office work as an enjoyable vocation suggested by Adrian Forty (1986). It is worth quoting here at some length:

We can take as an example the common assumption that modern office work is more friendly, more fun, more varied and generally better than office work was in 'the old days'. The myth serves to reconcile most people's experience of the boredom and monotony of office work with their wish to think that it carries more status than alternatives, such as factory work, where there is no pretence about the monotony. Although advertisements for office jobs, magazine stories and television serials have been responsible for implanting in people's minds the myth that office work is fun, sociable and exciting, it is given daily sustenance and credibility by modern equipment in bright colours and slightly humorous shapes, designs that help make the office match up to the myth (Forty 1986: 9).

A colleague, Ali Berkman, who studies products that employ ergonomics as style, offered the second example. According to Berkman (2001: 2), once having been a strict science of work, ergonomics has started recently to be employed only as a style in order to convey a "sense of ergonomics and ease of use" to the consumers. Therefore, according to him,

“It [ergonomics] is transformed into a vocabulary of expressing concepts like ease of use, comfort and also the myth of 'science behind design forms'. This vocabulary is comprised of textures, angles, softpads and biomorphic shapes. Consumers do not perceive it as a visual attitude and easily accept it. This exploitation of ergonomics is usually seen in product groups for which no more structural innovation is possible – toothbrushes, hand tools, sports shoes, etc. – and is used as a means of enhancing product differentiation in the market. However, western competition culture cannot cope with such a lack of progression. Pseudo-ergonomics and over-ergonomics are valuable tools for designers or producers for giving the sense of progression in some cases” (sic) (Berkman 2001: 2).

As these two examples illustrate, designed objects have become supports for countless myths about the world in contemporary consumer culture. Thanks to the reality reference suggested by the spontaneous materiality of designed objects, these myths begin to appear "as real as the products in which they are embedded" (Forty 1986: 9). In fact, however, what myth engenders in and through the product is a profound dematerialization. Under the sway of mythical speech both the materiality of the object itself – that is, the materiality of a number of decisions made during the process of its production – and the materiality of relations in which the object is socially produced and endowed with meaning disappears and gives way to a mystique of the object. In other words, myth divests the designed object of its individual as well as social history. In the literal sense of the term, myth robs the object of its memory, which consists of "the sum total of all the choices and fixings made at each stage in the passage of the object from conception, production and mediation to mass-circulation, sale and use" (Hebdige 1988: 82).

Through this dematerialization, the "social logic" that governs the production and circulation of objects disappears from the sight and the contemporary product begins to assume sign-value in a
"hierarchical code of significations" (Baudrillard 1981: 64, 68). This is the moment when designed objects are totally transformed into objects of consumption. Worse, the more the object is dematerialized, the less the transparency of social relations that produced it becomes intelligible. In other words, mythical appropriation of manufactured objects in the contemporary consumer culture has turned into a form of social control (Baudrillard 1981: 68). This is because dematerialization is one of the preferred formulas for the process of depoliticization. We must remember that the object, as the product of human labor, is always already political in every society and historical period. As Marx once remarked, "the most natural object contains a political trace, however faint and diluted, the more or less memorable presence of the human act which has produced, fitted up, used, subjected or rejected it" (Barthes 1993: 143). This is even more so for the industrially produced object that prefers to hide the political traces of its production behind innumerable myths.

The birth of styling as dematerialization

We have shown that myth dematerialises manufactured objects by turning them into signs that exchange among themselves in a differential code of significations. Of course, by dematerialization we do not mean a liquidation of the object. Rather, it signals a new type of relation established between the user and the object, in which the perception of the material conditions that gave birth to the object as well as its consumer is eclipsed by the newly emerging consumer sensibility mediated by styling. We claim that the process of stylization as a cultural phenomenon emerged gradually after World War II is responsible for this dematerialization. Stylization, as the prevailing ethos of consumer culture, is what best defines the mythical appropriation of material relations in our society. A parallel mythical appropriation of the manufactured goods occurs concurrently with the emergence of styling in design.

In design literature, styling is defined as "the application of surface effects to a product after the internal mechanism has been designed" with the intention "either to disguise or to enhance the relationship between form and function" (Julier 1993: 182). Though it is generally acknowledged that styling is used as a means for stimulating consumer demand, its social implications have been given little attention by designers. When we consult Dick Hebdige, however, we can get quite a clear picture of its social consequences. According to Hebdige (1988), the birth of styling after World War II marks the passage from a production-led economy to one of consumption. Specifically, the turning point was the decision of the Italian company Innocenti to offer both the "dressed" and the "undressed" versions of its Lambretta motor scooters simultaneously to the market. However, the consumer demand for the dressed version was so great that Innocenti quickly decided to stop the production of undressed models (Hebdige 1988: 91, 96). This anonymous vote signaled both the emergence of a new value (i.e., styling) in design and the growing importance and the potential malleability of consumer preferences. The age of the product in its traditional sense was over; by means of styling, the superimposition of the image on the object finally became possible. In other words, products were transformed into language-objects upon which the mythical speech could easily descend through the agency of the image.

From the viewpoint of design, this was made possible through such design decisions as "the encasement of mechanical parts in metal or plastic 'envelopes'" which endowed products with sculptural elegance (Hebdige 1988: 92). However, this tendency of design towards the perfection of surfaces and the disappearance of mechanical components radically transformed the relation of users to the products. As Hebdige (1988: 97) remarks, this was a "more remote" and "less physical" relationship of ease. Thanks to the mediation of styling, the user is led to relate even to the most tool-like object through an interface. In other words, the phenomenon of styling not only enveloped certain products amenable to stylization but also inserted a generalized interface between users and the product environment with which they are surrounded. This generalized interface is nothing but the cloud of mythical speech hovering over objects; and the form of myth in our consumer society
is the image linked to the object through the relay of styling. The social consequence of styling is to effect a general sublimation of the object. It does so by actively imposing separations "between the human and the technical, the aesthetic and the practical, between knowledge and use" upon the contemporary designed object (Hebdige 1988: 97). Through such separations the object is dematerialised and becomes an image ready to be coded as a sign of a desired lifestyle.

Re-materialization through mythoclasm

What Barthes did in his Mythologies was an attempt to decipher myths by means of a perverse linguistic move. He turned myth against itself by mythifying it in turn. In other words, he tried to recreate the object by introducing still another mythical speech into it. Barthes achieved this by using the given myth "as the departure point for the third semiological chain" and taking "its signification as the first term of a second myth" (1993: 135). To employ an odd terminology, the Barthesian technique of mythoclasm involved the production of a meta-meta-language. As was demonstrated in Mythologies, more often than not the linguistic clues for the second, artificial myth are to be found within the first myth. This was precisely the case, for example, in Barthes' treatment of the new Citroen (1993: 88-90). In this essay, he tried to restore Citroen DS19 to its "premythical components" by fabricating a second myth from the homophony of its name (Hebdige 1988: 79). That is, he made use of the pun suggested by its series name DS (originally, short for Diffusion Special), which can also be pronounced Déesee (i.e., goddess in French).

Note that deciphering myths in Barthesian sense was not an attempt to reduce the given myth to its original, essential form. Barthes was perfectly aware that breaking through the illusions of mythical consciousness should not entail a pursuit of origins. For if it were so, it would lead the analyst to the supreme illusion of Platonic essentialism. As Barthes himself showed, deciphering myths was not so much a matter of reduction as one of elaboration. It was a procedure by which the materiality of social relations that gave birth to the object becomes intelligible once again as a result of an elaboration. More precisely, the Barthesian procedure involved bringing forth a displacement of the given mythical elements through textual elaborations of the object.

The Barthesian technique of deciphering myths brings us to the question of designerly ways of dealing with myth. Barthes was, after all, a man of letters who contrived a textual technique as a weapon against myth. We should, therefore, ask whether we could develop a corresponding technique for the field of design criticism. In other words, how shall designers, as men of ideas in matter, be dealing with the mythical speech that prevails over their products? We suggest that this can be achieved through a technique we call 're-sketching'. However, we also claim that the technique of 're-sketching' has already been practised, albeit tacitly, in the form of some impromptu tactics within our material culture. In other words, we can observe some informal applications of this technique among the works of some designers and within the realm of popular appropriation of products. This was, for example, precisely the case when mods, having exhausted the expressive potential of the motor scooter to its limits by means of a vast number of customising practices, started to strip the scooter of its side panels and front mudguards (Hebdige 1988: 112). Having been repeatedly mythified, the scooter reached a stage in which it can no longer be mythified. As Hebdige (1988: 112) aptly puts, "after baroque" came the stage of "minimalism: the image of the scooter was deconstructed, the object 're-materialised'". Taking this anecdote as my key metaphor, let me now formulate the technique of 're-sketching' in a formal fashion.

Re-sketching as a technique of re-materialising designed products

The status of sketching among other drawings for design has not so much been questioned as taken for granted. It has come to be regarded as axiomatic that sketching is an indispensable and relatively isolated stage of the design process, involving the gradual development of a concrete form from an initial pattern. In such accounts, the emphasis is placed more strongly on formalistic and inward-
looking aspects of the process than its communicative functions that involve the generation and interpretation of signs as symbols within a social, material context. However, this conception of sketching as an introspective search of a designer for the evolution of form allocates the *figural* function of design thinking solely to the process of sketching, while the role of *discursivity* and *materiality* in design is altogether removed from the scene and assigned to the production and presentation drawings. This is probably because sketching is the least codified one among design drawings. Therefore, regarded as the least discursive and the most figural drawing of design thinking, sketching becomes mystified, unable to be penetrated either theoretically or in practice.

We suggest that to penetrate into the processes involved in sketching is crucial since the reasoning carried out and the outcomes achieved during sketching constitute and reflect the vary materiality of design activity. That is, the material descent of designed products can only be revealed through their analyses at the level of sketches. In other words, the myth of designed product can only be deciphered by treating them as if they were still in the form of sketches. To explain this, we should first offer an ontological definition of what a product is within consumer society.

An object of consumption is, by definition, an entity which does not readily yield information about the process of its production. What lends a product the character of an object of consumption is the success of industrial manufacturing methods in either erasing or concealing the traces of its technical as well as social production. For this reason, the end products of design present themselves to perception as impenetrable, opaque, and therefore, indisputable items that magically came into existence. In a similar vein, David Fleming (1998: 42) states that,

"[T]he process of construction involves the use of certain devices whereby all traces of production are made extremely difficult to detect.' If we want to examine the 'coming-into-being' of an object which could have been other than it is, we will need some way to 'break open' the object and view the history of its construction”.

A sketch, on the other hand, lends itself to such an opening that Fleming remarks, because it does not conceal the traces of its production. This trait of sketches enables one not only to perceive the "coming-into-being" of the object but also to trace the multiplicity of paths that were opened but not followed, the multiplicity of alternatives that were alluded to but not solidified by the designer. My point might have already been understood. Sketching has a special significance for deciphering the myth of designed object and re-materialising it.

Sketches allow the entry of the analyst into the shop floor of design whereas the illustrated, final drawings can only represent the shop front of design. When considered at the level of individual products, sketches, in a sense, perform their own genealogies since they are the genealogical records of products, demonstrating the 'descent' of final design decisions. The myth of a given designed object, therefore, could only be deciphered by reconstituting its sketches. Note, however, that the significance of sketching for this technique is not dependent upon the availability of sketches. In other words, we do not have to reconstitute the object as faithful as possible to its original sketches in order to re-materialise it. We should, rather, treat the given product as the first term of a new mythical elaboration. Contrary to Barthesian technique of textual elaboration, however, we should once more mythify the object by practicing a formal elaboration on it. More specifically, the technique of re-sketching involves trying to appropriate the mythical object by subjecting it to another myth.

For example, nothing is more alienating (and re-materialising) than the effect resulting from reading the postmodern myth of product symbolism into an object that embodies the myth of functional form, that is, an effect resulting from countering the myth of "form follows function" with that of
"form follows meaning"! This would allow us to see the fabricated quality of what was once considered as the natural outcome of the function of an object. In other words, re-sketching might allow us to see the unacknowledged activity of product semantics behind functional form. And, indeed, this was precisely the case when the ideal of function became itself a source of symbolic inspiration and, instead of following function, form became a conveyor of images reminiscent of machines with the advent of ‘machine aesthetics’.

Another way of re-sketching the given mythical object is to treat it as a *bricolage* rather than a *nucleus*. In other words, the mythical object can be re-materialised if it is treated as an assemblage of haphazard or incongruous elements. According to this conception, a designed product is not a nucleus. Both the formal unity and the functional identity of a product are myths. That is, each designed product has, by definition, a mixed lineage.

The unity of form is not a 'given', not an *a priori* category of designing. Rather, the unity of form is fabricated from extraneous elements in a piecemeal fashion. In order to allow the disparity at the very origin of a designed product to appear, the analyst should decompose the gestalt (i.e., the unity of form). This can be done by disregarding the given articulations of the object and creating new articulations in it so that the multiplicity of disparate forms whose traces were erased begin to reappear.

This procedure may also involve an attempt to dissolve the functional identity of the product. This can be done by deliberately erasing the species boundaries between products so that the functional identity of a product ceases to supply the stable ground on which to build a design argument. In other words, the analyst should re-sketch the object until it ceases to be a *product* and turns into a *chimera* [1]. As you may already know, the chimera is also a mythological figure. We have deliberately chosen this ancient myth with which to counter the myth of designed object. What is it that the myth most abhors? To be cancelled by means of an immemorial ancestor!

**Notes:**

[1] *Chimera*. 1. (a) A fire-breathing she-monster in Greek mythology having a lion's head, a goat's body, and a serpent's tail. (b) An imaginary monster compounded of incongruous parts. 2. An illusion or fabrication of the mind, esp. an unrealizable dream. 3. An individual organ or part consisting of tissues of diverse genetic constitution (*Webster's Ninth Collegiate Dictionary*, 1989).
References:


Distributed design teams: embedded one-on-one conversations in one-to-many

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Abstract

Engineering design is fundamentally social, requiring a lot of interaction and communication between the people involved. Additionally, good design often relies upon the ability of a cross-functional team to create a shared understanding of the task, the process and the respective roles of its members. The negotiation and bargaining for common ground are essential in the design process. It is important to provide tools and methods so that also geographically distributed design teams are given the opportunity to engage in such social interactions. This paper presents a study of interpersonal communication within the Distributed Team Innovation (DTI) framework; a joint product design project between Luleå University of Technology and Stanford University that investigates the future of collaborative product development. The common object of the work is to design “Virtual Pedals” for Volvo Car Corporation.

In the study, we noticed that one-on-one conversations, held in parallel to a main discussion, were common in co-located teamwork and that they are a natural part of creative teamwork. These conversations were mainly used to clarify things and to discuss vague ideas or personal disagreements. Additionally, they were often used instead of, or as a precursor to, bringing up a topic with the whole group.

In distributed meetings side conversations were discouraged and current systems for distributed collaboration could not provide sufficient support for these subtle interactions. This has important implications for supporting and improving the performance of global teams, and it suggests that the one-to-many channel of today's video conferencing technology is severely limiting.
Distributed design teams: embedded one-on-one conversations in one-to-many

Introduction

Engineering design is not a purely technical activity; it is also a highly social process. Technical artefacts are ultimately designed for human needs and purposes, and the design activities involve intense communication and interaction between individuals and groups in complex social settings. Social activity can not be separated from technical results - they are intertwined in the “…meetings that produce the specifications; the discussions around rough calculations and sketches that create understandings among the participants; the arguments about interpreting test results and prototype qualities that contribute to ‘feel’ and ‘intuition’ about aspects of the design; and the debates about whether the design is ‘done’, if the specifications have been ‘met’, and if the result is ‘good’…” (Minneman 1991: 63).

Interpersonal communication is the basis for innovation, since these interactions provide for the creation of shared understanding – the starting point from which initial concepts can be further developed into well-designed artefacts. In face-to-face settings, interpersonal communication is a truly interactive process of making sense of each other and the world – a moment-to-moment search for common ground that has been hard to replicate in geographically distributed settings. However, in the light of increasing globalization, it is of great importance to be able to support geographically distributed teams by giving them the opportunity to uncover and utilize the collective knowledge, creativity and meaning that spring from the multifaceted, situated and social interactions that are characteristic of successful design.

In order to make suggestions about the design of computer support for collaborative engineering work, it is critical to first examine the social and interactional dimensions of work. The understanding derived from observations of engineering work practice can then be used to inform the design of appropriate technology.

The object of our research is a joint product development effort between Luleå University of Technology, Stanford University and Volvo Car Corporation. The distributed design team consists of four students from the ME310 course at Stanford and four students from the SIRIUS course at Luleå. The goal of the project is to design “Virtual Pedals”, taking into account the fact that the need for mechanical connections between pedals and actuators has disappeared with the introduction of “drive-by-wire” technology.

Our study of co-located and distributed teamwork in this project showed that the design team lost a powerful aspect of co-located teamwork when moving into distributed collaboration. The more or less chaotic, but still effortless, ways in which they interacted locally were almost invisible in the distributed setting. The sense-making process, the collective search for shared understanding, and the subtle interactions that characterized their co-located efforts were in many regards reduced to a formal, rigid process where team members stopped “thinking together” and instead started “explaining to each other”. This paper aims to highlight the occurrence and importance of embedded one-on-one conversations in the context of one-to-many settings, and the implications this has for supporting and improving the performance of global teams.
The social dimension of teamwork

Informal communication
In everyday work, informal communication surrounds us in the shape of unplanned, spur-of-the-moment interactions (Root 1998; Fish, Kraut, Root and Rice 1992; Kraut, Fish, Root and Chalfonte 1993; Kraut, Egido and Galegher 1990). Informal communication is interactive in the sense that it depends on the highly unpredictable character of each situation. Agendas or plans are only to be seen as resources for situated action (Suchman 1987), since we always need to respond to the particulars of an event in order to “make things work”. The improvisational aspects of communication are easily recognized as natural parts of the everyday work environment. A colleague might ask for your opinion on a design change as you read the newspaper in the lunch room; you get an economical briefing while you wait for a printout; you decide a meeting time with your boss as he happens to walk by your door; you give your new phone number to a business associate as you bump into him in the hallway on your way to a meeting. This kind of casual, everyday interaction is vital to successful co-located collaboration, since you rapidly and continually can seize opportunities to exchange information, monitor progress, and learn about what others are doing (Kraut et al. 1990).

Socially natural groupware
Informal communication, as most social interaction, is “unremarkable” by nature. We adapt to situations as we face them, and we do not become overly amazed or confused by the many different situations we end up in. In face-to-face settings we are very sensitive to the actions and interactions of others, and if anything, it is remarkable how radically things change when we move from the ordinary world into the digital world. Much of our knowledge about people, our sensitivity to their interactions, our ability to improvise in changing situations, is neglected. In the world of computer systems, we are “socially blind” (Erickson and Kellogg 2000).

Undoubtedly, technology is functional in the sense that we have access to text chat, digital voice and video, and shared applications when working in geographically distributed settings. However, in use these systems are far from natural tools that efficiently and smoothly facilitate our work. In this respect, groupware is not “socially natural”. (Greenberg and Gutwin 1998) It seems that many of the difficulties with today’s technology have more to do with the assumptions that inform system design, than the current limitations of technology. (Heath, Luff and Sellen 1995). A static and inflexible conception of collaborative activity has prevented the evolution of useful environments where people can work and socialize with each other in a socially natural way (Heath et al. 1995).

Method
The research upon which we base this paper was carried out during six months of the seven-month DTI project. Our initial aim was to provide the distributed team with supporting technology that would enable team members to interact and communicate using different modalities. It is important to note that team members were not “forced” to use a particular technology for a particular purpose. Rather, we wanted to provide them with several alternatives, so that they themselves could choose the tools that they found suitable in every situation. Thus, the goal was to study communication as it was played out in a real-world product development activity. Drawing from the concept of ethnomethodology (Dourish and Button 1998), we felt it important to try to understand things in the context in which they occur, without making assumptions about what modes of communication could be useful for successful collaboration. The study was performed using ethnographic methods such as observations, field notes and videotaping. (Blomberg, Giacomi, Mosher and Swenton-Wall 1993) Apart from our intentions to strive for an “inside perspective”, ethnographic methods were also suitable since the structure of groups and communication is continually changing. As Gale (1990) points out, “the effects of technology on a group may take weeks, months, or even years
Several modes of communication were observed during the study, such as co-located teamwork, telephone conferences, and videoconferences of different quality. Observations of co-located teamwork were carried out during a total of three weeks, while the Stanford team and the Luleå team were meeting face-to-face (two weeks at Stanford and one week in Luleå). Both synchronous and asynchronous distributed collaboration was observed continually throughout the study, even though this paper is focused on side conversations occurring in synchronous collaboration.

It is worth mentioning that the distributed team, during the course of our study, got the opportunity to meet using SMILE! (Johanson 2002), a high-quality videoconferencing system. Equipped with wireless microphones, team members were free to walk around in their team rooms while still communicating with very high audio and video quality. These meetings were mostly very informal, and local side conversations were accepted to a greater extent, compared to other videoconferences and telephone conferences. However, despite the high-quality communication channel that the videoconferencing system provided there are still issues that remain to be solved.

Embedded one-on-one conversations: a hidden potential for distributed design teams?
As noted above, we had the possibility to observe the design team in many different types of synchronous collaboration. The goal is not to make an extensive comparison between these different modes of communication, but rather to share our understanding of the role of side conversations in co-located design, and to emphasize that the potential of such conversations remains unutilized when moving into distributed collaboration.

Parallel conversation
The first example of embedded one-on-one conversations in the context of a group discussion concerns the way in which team members in a co-located, face-to-face setting are able to attend to a main discussion, while occasionally entering into parallel, more or less private conversations with a fellow team member. In the fieldnote excerpt below, the Luleå team and the Stanford team are having a face-to-face discussion about virtual pedal concepts during the Luleå team’s visit to Stanford.

Fieldnote excerpt #1 – Parallel conversation in a face-to-face setting:
…MB (Luleå) is describing a pedal concept. He gestures to emphasize his point, but JW (Stanford) uses the video game pedals on the table to clarify that he has understood MB correctly. SS (Stanford) and BC (Stanford) join in on the conversation and ask MB questions about his concept idea. MP (Luleå) seems eager to speak on the subject and requests the word by standing up, raising
his arm and snapping his fingers. He gets the word explicitly from JP (Stanford), and goes over to the notice board to elaborate. However, MB and JW continue their conversation even though MP is now officially “in charge” of the main discussion. The other members pay attention to MP’s discussion … As soon as MB and JW are ready with their side conversation they return to the main discussion...

This example points to an aspect of communication that is natural in co-located settings. During the course of our study, we observed that team members devote most of their attention to the main discussion, but that they also engage in occasional parallel conversations when they feel the need to discuss a matter with someone without interfering explicitly with the main discussion. In this situation, MB was actually hosting the main discussion from the beginning. However, as MP took over the initiative, MB and JW continued to have a conversation in parallel with the main discussion for several minutes.

Although such extended parallel conversations often can be considered impolite and disturbing, that was not a problem in the co-located discussions of this project. On the contrary, parallel conversations of this type were sometimes transformed into a main discussion. The other team members overheard parts of the parallel conversations and found opportunities to take an active part in the discussion, thus gradually bringing it to a main discussion. Few parallel conversations did actually interfere with the agenda; rather they added a creative dimension to the inherent formality of the agenda. Undoubtedly, there are suitable and less suitable times for such parallel conversations, but in the face-to-face sessions that we have observed, team members have had no difficulties making smooth and non-disturbing transitions between a main discussion and parallel conversations.

When working together in a distributed setting, parallel conversations were not as naturally intertwined in the discussions. In telephone conferences, they were very disturbing and team members refrained from having side conversations since they almost always introduced a visible "breakdown" in the communication. Even in high-quality videoconferencing, side conversations were sometimes problematic, as exemplified in the fieldnote excerpt below where attempts to have local side conversations at the Stanford site were considered disruptive.

![Figure 2: Parallel conversation in a distributed setting.](image)

**Fieldnote excerpt #2 – Parallel conversation in a distributed setting:**

...JW (Stanford) is talking to NG, MP and MB (Luleå) over the videoconference. TP, JP, and SS (Stanford) start having a local side conversation. JW is disturbed by continues to talk for a while, before he decides to wait for TP, JP, SS to join the discussion. “OK, I got to wait for these guys…”
... BC (Stanford) leaves her chair and starts a local side conversation at Stanford. JW is disturbed and decides to wait for the others to finish. ”Hold on one second…” ... “I’m sorry, we’re not trying to have separate conversations here…” ”Why don't we all just focus on having one conversation here, OK?” ...

The observations briefly described above point out that although current communication technologies provide improved possibilities for global collaboration, the nature of teamwork shifts with the introduction of such technologies. Change is not always bad, but in the light of creative teamwork, extra formality and rigidity should not be introduced without special consideration.

**Instant feedback**

In addition to extended parallel conversations in face-to-face settings, we have also observed brief side conversations that are even less intrusive, and which also seem to serve a valuable purpose in design collaboration by enabling instant feedback. Among other things, these brief interactions provide a channel for instant feedback and they thereby promote a quick and iterative process for negotiation of shared understanding. A brief side conversation can be all that is needed to make sure that shared understanding has been reached, as exemplified in the fieldnote excerpt below.

![Figure 3: Instant feedback in a face-to-face setting.](image)

**Fieldnote excerpt #3 – Instant feedback in a face-to-face setting:**

...JP and JL are talking about JL:s concept. MP and NG join the discussion. They take quick turns when talking. MB is working separately, putting up another concept sketch on the wall. MP elaborates on another concept together with JP. On her way back to her seat, JL is having a very brief side conversation with MB. They clarify that they agree on the understanding of the concept ...

In this situation, there was a rather obvious informality about the collaboration. Basically, it was a very open discussion about the different concepts that team members come up with. The turn-taking flowed very smoothly, and in contrast to the parallel conversation in fieldnote excerpt #1, there was no one “in charge” of the discussion. The communication was very subtle and nuanced, in the sense that the situation lacked in formality. In a way, it was a chaotic conversation, with team members talking more or less at the same time, in an unplanned, spur-of-the-moment style. If something was unclear or confusing, it was possible to get instant feedback without waiting for “your turn”. It is an example of an iterative mode of communication, which enables team members to find common ground through a rapid exchange of perspectives, thoughts, and ideas. Also, such brief conversations let team members discuss vague or crazy ideas that they might not want to discuss with the whole group before consulting a colleague first.
Another type of instant feedback conversation was based on the fact that the Swedish team members were not as fluent in the English language as their American colleagues. This often resulted in brief conversations between two of the Swedish members, trying to make sense of a particular detail of the discussion. “What did he mean by that?” “What is the meaning of that word?” Such brief interactions were undoubtedly crucial for a common understanding.

In our study, this type of instant feedback has been almost non-existent in the distributed settings. Informal, brief conversations and quick-fire responses were replaced by rather formal and extensive turns of speech where team members ask each other questions, and mostly receive elaborate answers. Distributed collaboration was characterized by team members “explaining to each other”, but in a global, cross-cultural product development project, the real creative power might very well lie in the ability of distributed design teams to “think together”.

**Discussion**

On a general note, the addition of video in distributed collaboration has provided visual cues that help us make valid interpretations of each other’s actions in distributed settings. For example, the visual channel has proven to be useful for interpreting the meaning of pauses in conversation, something that often must be explained in audio-only conversations (Isaacs and Tang 1994). The visual monitoring of remote activities makes it easier to make sense of not only speech, but also of body language and facial expressions. It has been suggested that remote collaborators are likely to have fewer misunderstandings and more effective interactions if they have the ability to communicate richer information more easily (Isaacs and Tang 1994).

However, even today’s advanced videoconferencing systems have not yet been able to recreate the “information richness” that we are used to in face-to-face interactions (Hollan and Stornetta 1992). The physical closeness of people at the same videoconference site tend to make them more aware of their physical neighbours than of their video neighbours, and it is common to address people in the same physical room rather than people at the remote site (Mantei, Baecker, Sellen, Buxton, Milligan and Wellman 1991). Among other things, this means that current possibilities to engage in private conversations within a public discussion is reserved for people in the same physical location.

It has been observed that such private conversations are difficult in videoconferencing, much because people cannot address particular participants and because everyone uses the same audio channel (Isaacs and Tang 1994). In face-to-face interactions it is possible to “open” a second audio channel, and the visual cues enable the other participants to understand who is participating in which conversation when (Isaacs and Tang 1994). In videoconferencing, private conversations are often discouraged, but if they do occur, the other participants tend to wait for the conversation to become more general (Ruhleder and Jordan 2001). In contrast, Isaacs’ observations of a face-to-face meeting with five persons highlighted that the conversation occasionally broke into two parallel conversations and then seamlessly transitioned back to a single conversation (Isaacs and Tang 1994).

Parallel communication can promote broader input and reduce the risk of a few people dominating a meeting (Nunamaker, Dennis, Valacich, Vogel and George 1991), but even in face-to-face settings, side conversations can be seen as disruptive. Even if participants step outside the meeting room, everyone knows who is involved and may even be able to make sense of what they are talking about (Ruhleder and Jordan 2001). In face-to-face meetings, side conversations, note passing, and body language is visible to other participants, and although they are generally discouraged, they may also be integral, very important parts of the overall event (Ruhleder and Jordan 2001).
Our findings have shown that we need to be careful to dismiss side conversations as disruptive elements only. We imply that side conversations are of great importance for the creative stage in product development. Parallel conversations were very common in creative sessions, such as a brainstorm, but were less common in administrative meetings, such as a budget discussion. Maybe the potential of side conversations in distributed collaboration has been lost because the majority of such meetings are characterized by formality and rigidity?

Side conversations are vital in creating a common understanding between team members, and they enable a “chaotic”, but efficient, way of working on several ideas at the same time without forcing all team members to work on the same task. Also, these side conversations provide opportunities to explore vague ideas and alternative paths in a quick, informal and iterative way.

A fundamental aspect that must not be forgotten when it comes to distributed collaboration is that the different types of side conversations must be supported in a way that enables cross-site interaction. Even though high-quality videoconferencing makes local side conversations visible and understandable, it is almost impossible to have such side conversations with a remote team member. Hence, it is also difficult to fully utilize the creative power of a global, culturally diverse, design team.

In a co-located brainstorm people are "thinking together" by using fragments of other’s ideas, gestures and drawings to create new ideas. This way of working is difficult to achieve in a distributed setting, due to the fact that many of the subtle informal communication channels are lost, and because much of the time is concentrated on making rather formal explanations to each other. When comparing co-located and distributed teamwork activities, it was evident that issues that were considered trivial in a face-to-face setting could turn out to be a major challenge in a distributed setting. For example, one of the team members pointed out the striking fact that they had “spent two and a half hours in a videoconference, trying to explain to the other team what they had agreed on locally in about five minutes before the meeting started”.

Shared understanding can sometimes be hard to achieve, since it relies on many different elements of human communication. Fundamentally, our findings suggest that the ability to engage in cross-site side conversations could add an extra dimension to distributed collaboration.

**Conclusion and future work**

By studying a design team working together over a period of six months, we had the possibility to see how team members communicated in both co-located and distributed settings, and especially how the tools they used for distributed collaboration influenced their teamwork.

In the study, we noticed that one-on-one conversations, held in parallel to a main discussion, were common in co-located teamwork and that they served as a natural part of creative teamwork. These side conversations were usually “private” conversations between two members, in the context of a larger meeting, and they were often used to clarify things and to discuss vague ideas or personal disagreements. In addition they were used instead of, or as a precursor to, bringing up a topic with the whole group, and seem to be very useful to promote shared understanding without having to interfere explicitly with the main discussion.

Future work includes an effort to bring the findings of this paper into the design of appropriate technology, which can better support cross-site side conversations. A starting point could be to introduce instant messaging functionality and parallel audio channels as a complement to the visual channel.
Acknowledgements
Support for this research is provided by the Polhem Laboratory at Luleå University of Technology, the Center for Design Research at Stanford University, and the Stanford Learning Lab. The Distributed Team Innovation project is funded by Volvo Car Corporation and Volvo Aero Corporation. Special thanks to the students in the DTI project.
References


Understanding characteristics and typology of proportion in product design

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Abstract

Proportion is one of the aesthetic elements in product design. It has been widely considered in aesthetic researches. However, no clear conclusion on proportion in product design has been suggested yet and the debate over the aesthetic pleasingness of the proportion is still ongoing. The aim of the present study is to clarify part of this ambiguity in product design through identifying characteristics and typology of product proportion through experimental design and consumer survey. For this, we constructed stimulus sets for one product category (e.g., a refrigerator) by distortion of its prototype design into various forms. Each design form was made into a product card. Then we collected consumer data by asking subjects with questionnaire to reply to questions related to product proportion. The results show that there exist various types of proportion such as stability proportion, usability proportion, functionality proportion, aesthetics proportion, conventionality proportion and harmony proportion and each product category has its own important types of proportion. Because each product category has its own important types of proportion, designers should know the important elements expressed by proportion first before they consider proportion in product design. This study gives a good answer about the matters of 'Is it possible for golden section to be applied to product design?', 'What is proportion?' and 'How it should be applied?'. In addition, preferred proportion structure is different according to the consumer characteristics, successful design strategy such as niche market penetration could be performed if designers classify consumer characteristics systematically.
Understanding characteristics and typology of proportion in product design

Introduction
Few would disagree with the idea that product design and product aesthetics can be powerful marketing tools. They have been characterized as key marketing elements by prominent scholars (Kotler and Rath, 1984) and practitioners. They are important strategic variables not only for consumer goods, but also for industrial products (Yamamoto and Lambert, 1994). Therefore, the importance of product design and aesthetics is gaining more systematic attention. As Nussbaum(1991) points out, “Recently, business has grown increasingly aware that design sells, U.S. companies, in particular, are rediscovering that good design translates into quality products, greater market share, and heftier profits.

Therefore, aesthetic design can take an important role in product differentiation strategies because companies will have more competitive advantages in marketplaces if they understand aesthetics as elements of differentiation. Generally, product design elements regarded as factors influencing consumer’s aesthetic responses are Simplicity/Complexity, Harmony, Balance, Unity, Dynamics, Timeliness/Style, Novelty, Gestalt, Proportion and Prototypicality and so on (Ellis 1993; Brunel 1998; Veryzer 1993b). Among these elements, proportion in product design has been widely considered in aesthetic researches. However, no clear conclusion on proportion in product design has been suggested yet and the debate over the aesthetic pleasingness of the proportion is still ongoing. One main research stream in proportion is on “Golden Section’’(Benjafield, 1985). The Golden Section is a proportion ratio that finds its origins in Greek antiquity. The Golden Section proportion is obtained by dividing a line in two segments such that the ratio of the smallest segment to the largest one is the same as the ratio of the largest segment to the total line. It assumes that shapes based on this ratio are more pleasing and more natural. Advocates of the merits of the Golden Section argue that it is also a reflection of shapes (e.g. fish, shells) that can be commonly found in nature (Benjafiled, 1985; Crowley, 1991). However, other findings contradict the value of the Golden Section, and propose that it has indeed “no merits” (Boselie, 1994). Also, in a recent study, Duke (1992) applied Golden Section principles to the design of products, but did not find evidence for its superiority over other proportion ratios. We claim that the main reason of this inconsistency on Golden Section is, existing researchers just tried to answer the question of “what is the best proportion in product design?”. And they regarded proportion as one-dimensional single relationship structure or exclusive single factor.

However, we assume that proportion is not one-dimensional or exclusive but multi-dimensional and/or defendant on some related factors. For this assumption, consider the product examples of Figure 1.
Examples above in Figure 1 are actual products being transacted in the real market. It can be said that each product has its own appropriate proportion. However, it’s not easy to answer the question of “why can it be said that these products have their own appropriate proportion?” Because proportion cannot be explained by mere size structure of length and width which are generally considered as proportion elements. For example, product samples in Figure 1 mean that each product has appropriate proportion. However, it can not be said that product samples in Figure 2 which have mutually reversed proportion of the refrigerator and the air conditioner have appropriate proportion. And also it’s not easy to answer why these proportion reversed products are not perceived to have appropriate proportion.

It implies that Golden Section can not be explained by only simple relationship of width and length but be explained by multiple relationship. It means that there exist various kinds of proportion in
product design and different kinds of proportion are considered important across product category. So, each product category such as the refrigerator and the air conditioner in Figure 1 and Figure 2 includes different kinds of its own proportion. Therefore, in case that proportion is reversed in product examples such as in Figure 2, products cannot maintain appropriate proportion structure because important proportion relationship is broken. Thus, what types of proportion exist? and what are the characteristics of proportion? The study aims at answering these two questions. If these two questions can be answered, this study will clearly explain why existing proportion-related researches have given inconsistent suggestions on proportion in product design. And also, the result of this study will give useful theoretical and practical insights on how to understand and apply proportion to product design. For this, we collected proportion-related data through questionnaire from consumers and analyzed typology and characteristics of proportion, then suggested theoretical and practical implications on proportion of product design.

Proportion as product aesthetic element

In order to define product aesthetics, it’s helpful to mention a few observations about the origins of the aesthetic field. According to philosophers, aesthetics concerns the theory of art and beauty (Titus, Smith and Nolan 1986). More specifically, aesthetics is “the study of value in art” (Titus et al 1986). In the context of product evaluations, aesthetics refers to the overall beauty and attractiveness of a product. Product aesthetics relate to the artistic dimensions of products. Aesthetics elements of features such as the overall line, color, shape, pattern, texture, proportions, etc. represent artistic executional choices for product design. Overall, product aesthetics is considered as one of the important elements for product aesthetics. The proportion is obtained when the ratio of the shortest to the longest of two lengths, for example of a rectangle or a cross, equals the ratio of the longest to the sum of the two. Various researches on the relationship between proportion and consumer’s aesthetic responses have been performed for a long time. For thousands of years a widespread belief was maintained that a ratio according to the golden section deserved the status of embodying beauty beyond compare (Borissavlievitch, 1958). Ever since the pioneering work of Fechner(1876) research has therefore been focused on confirming the special attractivity of this particular ratio. The golden section ratio has obtained this special attention mainly thanks to its unchallenged mathematical beauty. However, aesthetic attractivity of the golden section was never convincingly demonstrated. Previous reviews (Zusne 1970; Berlynne 1971; Benjafeld 1985; McWhinnie 1987) have pointed out that the results of empirical studies concerning the relation between the golden section and perceptual attractiveness are ambiguous and lead to opposing interpretations and conclusions. However one clear thing inferred from the past studies is that proportion is related to perceptual attractiveness. The aim of the present study is to clarify part of this ambiguity in product design.

Experiment

This study aims at suggesting theoretical background on inconsistency of existing researches on dealing with proportion as an product aesthetic element by understanding typology and characteristics of proportion in product design and giving useful insights on how to apply proportion element to product design. For this, we constructed stimulus sets for one product category (e.g., a refrigerator) by distortion of its prototype design into various forms. Each design form was made into a product card. Then we collected consumer data by asking subjects with questionnaire to reply on the questions related to product proportion.

Stimulus design

A refrigerator was selected for experiment stimulus from focus group interview with 9 product design-majoring graduate students. The reason that a refrigerator was selected was that design elements excepting proportion were relatively less than other products. Product cards of 21 real
refrigerators were collected from magazines and merchandise catalogs. Then one typical refrigerator was selected as a prototypical stimulus. The stimulus sets were constructed by distortion of proportion of prototypical stimulus using Adobe Photoshop 5.0. Many aspects of an object’s appearance (e.g., color, perspective, shading) have the potential to affect aesthetic response. To isolate specific factors, all over visual properties were eliminated or controlled. Stimulus sets were constructed by distortion of three factors of the refrigerator (proportion of width and length, proportion of top compartment and bottom compartment, and proportion of whole size and handle size). Each factor was modified with 3 levels (high medium and low). Finally, total 27 product cards (3 × 3 × 3) were made. 3 factors for distortion and levels of distortion for designing stimulus sets are shown in Figure 3 and Table 1.

![Diagram showing factors for distortion](image)

Figure 3: 3 factors for distortion
<table>
<thead>
<tr>
<th>Category</th>
<th>Width /length</th>
<th>Top compartment /bottom compartment</th>
<th>Whole size /handle size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of distortion</td>
<td>Extension of length</td>
<td>Extension of top compartment</td>
<td>Downsize of handle size</td>
</tr>
<tr>
<td>Typical</td>
<td>Typical</td>
<td>Typical</td>
<td>Typical</td>
</tr>
<tr>
<td>Extension of width</td>
<td>Extension of bottom compartment</td>
<td>Extension of Handle size</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Levels of distortion
Figure 4: Shows the final stimulus sets for experiment of this study.
**Procedure**
To identify the characteristics and typology of product proportion, three hundred undergraduates in an introductory design course at Chosun University participated in the experiment. Subjects were randomly assigned to a set of stimuli including five decks of products. They were asked to think of proportion only for about ten minutes on how good or bad the proportion is. Then they were given a response sheet including instructions that were read aloud to the subjects and reviewed. Then we asked subjects to write down whatever they think of proportion of stimulus sets they are looking at. So we collected the data by open-ended question method. The instructions included in the response sheet were shown in Table 2.

You are now looking five kinds of product examples. And you’ve thought proportion only for about ten minutes up to now. In case that you think of proportion only, which one do you think includes good or bad proportion structure. What are the reasons you think like that. Please write down whatever you think of in the response sheet. There are no right or wrong answers. Whatever you think of would be good for the responses. For example, your feeling, thinking, the reasons that you like or dislike, whatever and also, all kinds of expression such as words, phrases, short statements and long statements will be possible. There is no restriction to respond and write down whatever you think of. But please write down as many as possible.

Table 2: Instructions in the response sheet

The purpose of this experiment is first to identify the characteristics and typology of proportion from consumer’s opinion and therefore, second to understand the characteristics and typology of proportion. There was no restriction on how and what to respond, and also there was no time limit so that subjects had enough time to write down their thoughts freely. From the subjects 1,193 usable responses were obtained. The responses were then coded by two independent judges. The coding categories were developed by examining the responses by ten randomly chosen subjects (whose responses were then eliminated from further analysis). The researcher identified six categories that appeared in these responses (i.e., these categories were not based on any theory but were directly taken from subjects’ responses). The number of categories was deliberately kept large since it was considered desirable to be conservative and not omit any category. The two coders then independently coded these ten responses as a practice task. The coders examined each sentence and classified it in one of the six categories that were setup earlier. This resulted in an inter-coder agreement of 89%. The coders then met and went over the responses together. The subsequent meetings with the researcher led to the coders having a better understanding of the coding procedure. Following this training phase, the coders then proceeded to code the responses of the remaining 1,179 subjects.

Among the respondents of 290 in the experiment, male is 56% and female is 44%. For the age groups, 18% are for under 10, 36% for under 20, 23% for under 30, 18% for under 40 and 5% for over 50.

**Results and discussion**
The coding of the subjects’ responses were first examined to find out the extent of inter-coder agreement. To assess the level of observed agreement between the two coders a kappa coefficient (Cohen’s kappa), corrected for chance agreement, was calculated at an overall level for responses.
Further, kappa values were also calculated at a category level for each of the six categories to check for any major deviations in level of agreement at an individual category level compared to the overall level. The overall kappa coefficient for responses was .81. These kappa levels indicate observed agreement well above chance level (Landis and Koch 1977).

The results of categorization of responses can be seen in Table 3. The result shows that proportion in product design is not an exclusive single dimensional factor but an inter-dependent with other product characteristics and multi-dimensional factor. The coders categorized the typology of proportion into 6. They are stability proportion, usability proportion, functionality proportion, aesthetics proportion, conventionality proportion and harmony proportion. These categories were not based on any theory but were directly taken from subjects’ responses. That is a kind of experimental categorization which gives useful insights to the definition of proportion which has not been effectively conceptualized. The result means that proportion in product design includes not only the ratio of width and length but also stability of product itself, ergonomic structure for user-convenience and functional form to perform the original function of product itself effectively. Also, product proportion includes conventionality which means the degree of perception of how a certain object looks typical or atypical against the existing products of same category. Changes of typical proportion led consumers to feel more new or less preferable because of difference from existing products. It means that some of consumers judge typical and familiar product proportion more aesthetic and others judge atypical and unfamiliar product proportion more appealing because of newness. In addition, product proportion is related to the harmony with the places in which the products are located and with other products which are placed together. The results, as we mentioned earlier, imply that proportion in product design is not an exclusive single dimensional factor but an inter-dependent with other product characteristics and multi-dimensional factor. That is, the proportion of product design includes not a single element but several kinds of factors such as stability, usability, functionality, aesthetics, conventionality and harmony.
<table>
<thead>
<tr>
<th>Category No.</th>
<th>Meanings</th>
<th>Frequency</th>
<th>Response rate(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stability proportion</td>
<td>Stable</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not stable</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Felt uneasy</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Balanced</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not balanced</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Usability Proportion</td>
<td>Convenient to use</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not easy to use</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Easy to use</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suitable size for the user</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inconvenient location of handle</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not ergonomic</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not suitable for user’s body size</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Functionality proportion</td>
<td>Felt functional</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Felt not functional</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perform original function effectively</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not perform original function effectively</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>Aesthetics proportion</td>
<td>Good external appearance</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Felt good mood</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aesthetic</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Easy visual view</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visual inconvenience</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visual convenience</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Felt narrow and close</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pleasing</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Felt heavy</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>Conventionality proportion</td>
<td>Novel</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unusual</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innovative</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usual</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obsolete</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conventional</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Familiar</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unfamiliar</td>
<td>33</td>
</tr>
<tr>
<td>6</td>
<td>Harmony proportion</td>
<td>Fit for the locating place</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not fit for the locating places</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good harmony with other products</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bad harmony with other products</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>38</td>
<td>1,179</td>
</tr>
</tbody>
</table>

Table 3: Consumers’ response categories related to product proportion

The results of this study give useful insights on understanding theoretical inconsistency of existing researches which have dealt with the usefulness of golden section and regarded proportion as an aesthetic element, also have significant meanings to product design in which the proportion is
importantly considered. For the question of “Is it possible for golden section to be applied to product design?”, we suggest from the results of this study that proportion in product design plays roles as not only an aesthetic element but also stable, usable, functional, conventional and harmonic elements. The important thing here is that different types of proportion are considered according to the product categories. Only aesthetic proportion can be considered importantly in some product categories whereas more than one types of proportion are considered in other product categories. We can see some interesting proportion matters in Figure 5.

![Figure 5: Various types of proportion structure](image)

Product examples in Figure 5 have various kinds of proportion structures. It would be impossible to explain the proportion structures of above products by only golden section. The proportion structures of these products are as following in Table 4.

<table>
<thead>
<tr>
<th>Products</th>
<th>Ratio</th>
<th>Width X length (cm)</th>
<th>Golden section</th>
</tr>
</thead>
<tbody>
<tr>
<td>a cellular phone</td>
<td>1 : 1.72</td>
<td>43 X 74</td>
<td>1 : 1.618</td>
</tr>
<tr>
<td>a TV</td>
<td>1 : 1.52</td>
<td>580 X 880</td>
<td></td>
</tr>
<tr>
<td>a refrigerator</td>
<td>1 : 2.34</td>
<td>740 X 1,729</td>
<td></td>
</tr>
<tr>
<td>an air-conditioner</td>
<td>1 : 3.19</td>
<td>570 X 1,820</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Proportion structures of product examples

As we can see in Table 4, there exist various kinds of proportion structures in product design. Some product categories (e.g., a cellular phone, a TV etc.) have similar proportion structure to that of golden section whereas some other products (e.g., a refrigerator, an air-conditioner etc.) have quite different types of proportion structure from that of golden section.

The possible reason on the matter that proportion structures are different according to the product categories is that product categories have their own important proportion types. For example, some types of proportions like stability and harmony are not important in some product categories such as cellular phones. That’s why the proportion structure of a cellular phone is similar to that of golden
section. In some product categories such as a refrigerator, however, other types of proportions such as functionality and usability are more important than aesthetic proportion because proportion structure decides the efficiency of functional performance and ergonomic usage. In case of air-conditioner categories, if the proportion of product is structured by the ratio of golden section, the products would become more short and wide. Then they occupy more floor space and also cool air comes from middle of the air of the space. Therefore, they become inefficient for space usage and functionality. So, golden section is not suitable for those product categories.

Now we can understand why past researches trying to find out the best proportion structure in product form have suggested inconsistent results. According to the results, there exist various kinds of proportion in product form. And ideal proportion is expressed differently according to product categories because they include different types of important proportion. Therefore, it’s necessary to identify important elements deciding proportion before considering proportion in product design because ideal proportion structure is influenced by those elements.

**General discussion**

The results of this study suggest reasonable insights to the matter of inconsistent results of past researches on ideal proportion structure by investigating characteristics and typology of proportion through experimental stimulus design and questionnaire survey. Proportion in product design has been widely considered but no clear conclusion has been suggested yet. For this, we, from the results of our study, suggest that the proportion is multi-dimensional and includes various types. And each product category includes different types of ideal proportion structure because it includes its own important proportion. Throughout this research, 6 proportion types are identified: stability proportion, usability proportion, functionality proportion, aesthetic proportion, conventionality proportion and harmony proportion. Each product category includes its own appropriate proportion types. Therefore, golden section can be applied to some product categories whereas other types of proportion can be more appealing in other cases. Therefore, it’s not reasonable to consider proportion as a single-dimensional factor such as aesthetics. Proportion in product design must be approached by multi-dimensional perspective according to characteristics of product categories. We can find out one more interesting result through the experiment that consumers’ responses on same stimulus expresses wide span of preference scope from high to low. It means that preferred proportion structures, even for the same product, are different according to consumer types. Therefore, niche market penetration strategy will be possible if the preferred proportion structure is identified according to the consumer types.

In sum, the implications of the study are as follows.

First, there exist various kinds of proportion such as not only aesthetics but also stability, usability, functionality, conventionality and harmony.

Second, it’s not possible to apply one common ideal proportion structure to product design and therefore designers should deliberate what types of proportion are considered important in the product they are planning to design.

Third, niche market penetration strategy will be successful if we understand the characteristics of consumer segment market because consumers’ responses on even the same proportion structure are different according to consumer types.

Although the results of this study suggest useful implications to understand and apply proportion in product design, this study has several research limitations and future researches are required.
First, in the experiment of this study, we used operational stimulus sets for data collection from consumers. There is possibility that the market environment differ from these sets because they are not real in the market. In the future researches, it’s necessary to use real market products to get more precise information of proportion.

Second, 6 types of proportions investigated in this study were not based on any theory but were categorized by coders’ judgment. Therefore, categorization of proportion in this study is not clear and only a kind of exploratory research results to understand characteristics and typology of proportion. Next researches need to be based on clear theoretical background for categorization of proportion.

Third, in this study, only 300 subjects participated in the experiment. It’s not enough to find out all kinds of proportion. Therefore, sample size should be considered for investigating more proportion types.

Finally, preferred proportion structures, even for the same product, are different according to consumer types. Therefore, it’s necessary in the future researches to investigate the relationship between preference on proportion structure and consumer characteristics for niche market penetration strategy of product design.
References


Remote usability testing for information appliances through WWW - with the emphasis on the development of tools

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Abstract

As the importance of interface design in information appliances became recognized, usability testing has been widely introduced. However usability testing in the environment of a closed laboratory has been known to cause some significant difficulties: cost, time, unnatural environment, and lack of opportunity for idea generation. The goal of this study is to propose the new prototype of tool for ‘remote usability testing for information appliances through World Wide Web’.

At first, existing usability testing methods for information appliances are reviewed to identify major problems. Based on the problems of existing usability testing, the concept of remote usability testing through WWW is established and the prototype called RUTIA is developed and introduced. In the new tool, the specially developed browser is distributed to users who are required to download. Once users download browser they are guided through stages of usability testing: introduction, identifying user himself, performing given tasks over computer-simulated information appliances, and generating user’s ideas on interface design. After users finished the given tasks and generation of ideas, all the interaction data including time taken, operational path, think-aloud and generated ideas are saved on a server for further analyses and generating solutions. In the analysis module, a researcher can conduct diverse analyses with saved data. Analyses can be done with various forms: visualized user’s operational paths and a table of statistics of time and pressed buttons. It was found that some further refinements of tool are required: product size limited less than screen size and limited user type.
Remote usability testing for information appliances through WWW - with the emphasis on the development of tools

Introduction
Since the introduction of computer technology, the fundamental nature of products has become changed: more interactive and less physical. This change, in turn, has made new type of product come into being: ‘information appliance’ which is defined ‘a computer-enhanced consumer device dedicated to a restricted cluster of tasks’ (Mohageg and Wagner 2000). Mohageg and Wagner (2000) argue that the design approach for information appliance should be differentiated from conventional products and computer for two main reasons: very wide base of non-expert-consumers and different characteristics of information appliance itself. That is, work of human being with information appliance has become less physical and more mental, and accordingly the key criteria of effective worker performance have shifted from the physical one like the speed or range of motion of their limbs to the quality and flexibility of their thinking (Adler et al. 1992). In addition, the substitute of microchips for mechanical parts, the product has become less tangible and ‘black box’, which makes the key success factor of product as ‘the usability: the capability to be used by humans easily and effectively’ (Shackel 1991). Particularly, the concept of usability has become highly valued in the area of information appliances and software where users’ works are mainly mental. Other advantages of usability listed include ‘reduced customer support, service and training costs’, ‘avoidance of costly delay in schedule’, ‘simpler-to-prepare product documentation’ and ‘accurate, ready-to-use marketing claims based on tests’ (Wiklund 1994). This introduction of the concept of usability to information appliances has led to the wide application of ‘usability testing’ for ensuring the quality of usability before launching the product to the market. Usability testing employs techniques to collect empirical data while observing representative end users using the product to perform representative tasks (Rubin 1994). Typical methods for usability testing include interview, guidelines, heuristics, cognitive walkthrough, prototypes, protocol analysis, cognitive modeling, observations and so on (Mack and Nielsen 1994). Although most of usability testing methods are useful in their own context, the most valuable method of usability testing is to let users perform tasks and observe them for its rich contextual data and users’ direct behavior. Usually this kind of testing is done in the closed laboratory equipped with one-way mirror for uninterrupted observation, video recording facilities, and data logging computers. However, despite advantages of usability testing, usability testing in the environment of closed laboratory has been known to cause some significant problems: high cost, unnatural environment and limited focus only on measurement. The goal of this study is to develop the prototype of a tool for remote usability testing for information appliances by using World Wide Web.’

Problems of usability testing in the closed laboratory
Among existing methods of usability testing, the most reliable and frequently used method is the empirical experiment done in the environment of closed laboratory with representative users of the target population. Normally the environment is set up and simulated so that the user feels as natural like real working environment as possible. Representative users are brought to the laboratory and are given tasks to perform for evaluating the degree to which a product meets specific usability criteria: efficiency, learnability, memorability, errors, and satisfaction (Nielsen 1993). User’s interaction behavior with product while performing task is observed and recorded. The observation of tacit user behavior in usability testing is one of the strong advantages compared with conventional user-studies like questionnaire or focus group interview. The observation of behavior can reveal problems in performing tasks which even users cannot be aware of while opinion-oriented user studies can only show problems users can recognize in the conscious level. For securing the reliable quality of data, the usability testing should go through rigorous process of multiple stages: developing the test plan, selecting and acquiring participants, preparing test
Despite of advantages of usability testing in the laboratory, there are some critical known problems. At first, setting up usability testing laboratory and running the usability testing cost lots of money and takes quite long time and significant efforts. Setting up usability testing laboratory requires spaces for testing room and observation and control room, full set of video recording equipment, computer and video monitors, video editors, time generators, intercoms, data logging software and other state of art electronic devices. This kind of setup requires a large capital outlay and commitment to testing by management. Without appropriate management of the laboratory, highly costing and sophisticated usability laboratory can be easily operated as the world’s most elaborate storage rooms (Rubin 1994). Conducting usability testing also requires time, cost, and effort. Although 4 to 5 participants are known to be enough for a less formal usability test covering 80 percent of the usability deficiencies of a product (Virzi 1990), for a true formal experimental design, a minimum of 10 to 12 participants per condition must be utilized (Spyridakis 1992). However if a researcher wants to find some differences between groups like novice vs. expert, then the number of participants should be increased. All the subjects should be physically brought in the laboratory one by one and each of them should spend at least one to two hours for answering pre-test questionnaire, performing the number of given tasks and joining debriefing sessions. In addition, while subjects are performing tasks, there should be (usually in the other side of one way mirror) other people such as test monitor, data logger, timers, video recording operator, product/technical expert, and test observers. After recording of all user performance is done, the data should get through exhaustive analysis process: measuring time, picking up errors, logging the data, transforming data into findings and recommendations and so on.

Secondly, problem lies in the unnatural atmosphere of laboratory where users participate the testing. The closed environment of usability testing room equipped with one-way mirror and video cameras are very impersonal. Except for special cases where moderator joins the testing with subject, in usual cases, a user is left alone to perform the tasks according to the instructions given through intercom. Although there are number of techniques to soothe subject’s uncomfortable emotional state, this kind of ‘prison-like environment’ can intimidate inexperienced users and they can easily get nervous. This so called ‘guinea pig’ syndrome makes the subject feel overly self-conscious during the test, which prevents them from showing natural responses and performance.

Finally, a session of usability testing focuses mainly on ‘measuring’ aspects: i.e. a researcher focuses on evaluating the degree to which a product meets specific criteria. As a result, types of data from a session of usability testing include data on time duration for performing tasks, number of errors, percentage of tasks completed successfully, ratings or rankings of the product, and number of negative references to the product. However, users’ suggestions for new idea are also as much important as measuring the usability. For user’s participation to idea generation, some methods have been developed such as ‘exploratory test (Rubin 1994)’, ‘card sorting’, ‘scenario-based design (Carroll 1995)’, ‘collaging’, ‘velcro modeling’, and ‘cognitive mapping’ (Sanders and Williams 2001). These kinds of user-participatory design methods should be more systematically incorporated in the process of usability testing. These three main problems should be considered in the development of new tool for usability testing.

**Development of tool for remote usability testing through WWW**

There have been developed various ways to solve above-mentioned problems in conventional laboratory based usability testing. Those include ‘third-party laboratory evaluation’, ‘third-party usability inspection’, ‘remote questionnaire or survey’, collaborative remote evaluation’, ‘video-conferencing-supported evaluation’, ‘instrumented or automated data collection for remote
evaluation’ and ‘user-reported critical incident method’ (Castillo 1997). The common point those methods share lies in the ‘remoteness’ of location where evaluators are separated in space and/or time from users. The first problem of expensive cost for setting up usability laboratory and running usability can be solved by ‘automating’ implementing ‘on-line remote usability testing’. Castillo further classified those remote usability testing methods by number of dimensions: types of users involved, time of evaluation, user location during evaluation, person or role who identifies critical problems, types of tasks, level of interaction between user and evaluator, types of data gathered, type of equipment used for collecting data, cost to collect data, cost to analyze data, and quality or usefulness of collected data. Particularly, by the major concern of cost-effectiveness and quality of data, methods are mapped like Figure 1. According to Figure 1, the most reliable quality of collected data, the method that costs less, is identified ‘instrumented or automated data collection’.

Figure 1: Remote usability testing methods in terms of quality of data and equipment required (Castillo 1997)

Instrumented or automated data collection method refers to instrument some application program to automate the collection of a log of data occurring as a natural usage in users’ normal working environment. Once user downloads and installs an application program in his or her computer, all user should do is just to work normally as usual in his own environment. Then the application program takes care of collecting and reporting data such as program usage, project time, internet usage, comments to usage, keystrokes and mouse movements, and any other activity. Nielsen (1996) also mentioned the advantage of collecting usability data through Internet. These advantages of ‘remoteness’, ‘asynchrony’, ‘natural environment’, and ‘simple management’ cover almost all the problems identified above in the traditional usability testing. However there still remain some problems uncovered. At first, it still does not allow users to participate in idea generation. User is only ‘using’ the testing product without having ‘testing and generating ideas’ in his mind. All the data evaluator can get is users’ usage pattern rather than their conscious effort to reflect their ideas on interface design. Secondly, major area of application of instrumented or automated data collection method is limited in software or web. Information appliance requires different attributes to be added to the instrumented or automated data collection method. The method should allow a researcher to have more control and collaborative attribute. Keeping these in mind, the new tool of remote usability testing for information appliance was developed with the following objectives:
• Use Internet for automating usability session.
• Make users’ testing environment very comfortable and natural.
• Let users participate to generate ideas for interface design.
• Make the way of collecting user’s performance data as simple as possible.
• Make the tool work with the collaboration of other related tools like ordinary statistical programs or word processor.

Structure of Tool-RUTIA
The tool called RUTIA (Remote Usability Testing for Information Appliance) was developed based on objectives mentioned above. RUTIA has the structure comprising of three main modules: testing module, idea module and analysis module. These three modules go through the process shown in Figure 2.

![Figure 2: The structure and process of the tool, RUTIA](image)

Testing module
In the testing module, at first, the overall purpose and process of the usability testing is introduced and then user is guided to input their demographic data like gender, age and so on as pre-questionnaire before actual usability testing. In the pre-questionnaire other items than demographic data can be included for basic data for later analysis: e.g. user’s experience with testing product or general use-behavior. After understanding user’s basic profile, a warming-up session is given to user for familiarizing herself or himself with on-line usability testing. The warming-up task is usually very simple like setting up alarm of digital clock. If user feels confident enough to her or his capability of interacting with the warming-up task, then user can go ahead to start main usability testing. Various tasks are provided one by one and user performs the tasks by operating the computer-simulated information appliances. User uses mouse to press control buttons, for which the product responds exactly same as real product: display, sound, or other various states. While performing tasks, user can refer user’s manual for help or skip the task if she or he cannot continue the task for its difficulties at anytime. In addition, if user is equipped with microphone she or he can perform ‘think aloud’. The sample screen of testing module is composed as shown in Figure 3. As shown in Figure 3, the computer-simulated product for testing is shown on the screen with the task bar, other control buttons for skipping task and opening user’s manual.
Figure 3: Sample screen of testing module

**Idea module**

After finishing all the given tasks, user is guided to participate in the idea-generation session. In the session of idea-generation, user can actively generate her or his own ideas regarding layout of control buttons, grouping menus, arranging interacting process and organizing interface structure. Figure 4 shows sample screen of user’s idea generation of layout of control button. User can drag control buttons and configure his preferred way of layout. Or he can comment new ideas for improving the usability in ‘idea box’. These kinds of various ideas generated by users themselves can be important means to understand their conceptual model on user-interface of testing product. After ending up with the session of idea-generation the debriefing session starts to ask few more questions regarding test itself or to get other feedbacks from users. Or some other additional questions can be given to users: asking some reasons for particular behaviors.
Analysis module
As soon as the user finishes the usability-testing session and idea-generation session, all the usability data including time taken, operational path, voices recorded from ‘think aloud’ and user’s idea generated in the idea-generation session are transmitted to and saved in the evaluator’s server. These data are analyzed in various ways for finding problems and insights for generating solutions.

At first, all the interacting processes by users while they were engaging the usability testing are replayed with exactly the same operational paths, sequences and time. The operational traces are visualized in line over the product so that analyzer can easily see how user interacted, moved around, made errors and so forth in sequence. This replay is done with the interface like a VCR: a researcher can stop, pause, play, fast forward or rewind by clicking control buttons. In addition, user’s protocol data from think aloud is also replayed. If analyzer needs to analyze user’s particular interaction in detail, he can always stop and resume the play.

While the user’s interaction is replayed, at the same time, the interaction process is visualized in another way. This time, the user’s interaction is visualized in terms of interface structure. In parallel with a small window of product where user’s interaction is replayed over actual physical product, there is another small window where interface structure of product is shown. A researcher can see user’s interacting behavior in terms of the structure of interface: how deeply user went down, how frequently user changed the level of interface depth and so on. The play in the window of interface structure is synchronized with the play in the product window so that a researcher can get the view of a user’s interacting behavior on product and interface structure simultaneously.

Finally, all the data are summarized in the table: pressed buttons, time taken, user’s action, sequence, user’s protocol data, and researcher’s comment. In this summarizing table, a researcher can sort out the time and easily search for specific interaction by simple click of relevant cell of table. For further analyses, researcher can cross-tabulate between different elements. For example,
researcher can find out what type of users made specific types of errors by cross-tabulating element of ‘user’ and ‘error’. All the data can be exported to other conventional software like statistical program or word processing software for further analyses. These data can be accumulated for certain period of time to make database for usability. The sample screen of analysis module is shown in Figure 5.

![Sample screen of analysis module](image)

**Figure 5: Sample screen of analysis module**

**Conclusion and further study**

The current tool is still in the stage of development of prototyping. The tool shows potential advantages in several respects: low cost of management, easy collection of testing data, short time to conduct usability testing, provision of natural atmosphere to user to test the usability, user’s active participation in idea generation and availability of diverse ways of insightful analyses.

However, even with those various advantages of on-line remote usability testing, it needs further refinements in several respects. At first, a product bigger than the size of computer monitor-screen can cause a problem because the product shown on the screen is shown smaller than actual size. This problem can seriously reduce ‘the reality’ of product. Secondly, since the tool is working on World Wide Web, types of users participating in usability testing can be limited only in those who can access and use Internet without any serious difficulties. For effective implementation of the tool these problems should be further improved.
References


Intervention strategies for alleviating problems in international co-operative design projects

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Abstract

Small design teams engaged on co-operative work in the international arena typically find themselves beset by problems relating to time schedules, inadequate briefs, information flow and communication, project management, language and cultural issues. Such problems, when arising in projects of short duration, and not having the benefits of dedicated management, may increase project length, decrease the efficiency and satisfaction of project members (and reduce their willingness to participate in such ventures again) and reduce the extent to which the finished design meets the initial requirements.

This paper outlines a series of low cost, high impact intervention strategies to assist design teams working in this area. The starting point for the development of these strategies was the development of a method to uncover and trace problems through the design process. The method we developed to do this is described. Along with the resultant intervention strategies and an assessment of their efficiency.
**Intervention strategies for alleviating problems in international co-operative design projects**

**Introduction**

Small international design projects are becoming more prevalent as a means of quickly getting products to market. Such projects may involve a designer located in the target market heartland and a client and manufacturer in another country. For example, this research involved UK designers and Taiwanese clients. Such ventures are sponsored by the Taiwanese government as a means of promoting Taiwanese design. The benefits for the client are that the designer, being based in the target market is better able to design a product that meets the needs of that market through his first hand knowledge of it. Although such alliances generate advantages for partners, problems may arise when trying to communicate across different disciplines, languages, borders and time zones. Such problems may impede the progress and the eventual success of the project, and may be difficult for small companies to overcome.

In such projects the designers, clients and the project manager may not meet up face to face during the project, or only at its inception, as it is costly and difficult to arrange when key people may be very busy. This means that any design communication which does take place has to be done at a distance either synchronously (through the use of videoconference and telephone) or asynchronously (mediated by fax, mail, email or image transfer). This in itself may be a cause of problems and is certainly likely to exacerbate any which do occur, as their probable resolution is more difficult.

The overall aim of the research was to understand the nature of problems arising in international co-operative design projects and to develop methods for uncovering and alleviating them. In order to achieve this it was necessary to develop a method which would allow the identification of problems during design sessions and determine whether and how these were resolved in later sessions. The final outcome of the research was a set of low cost procedures which could be implemented by design teams.

**Discovering problems arising in ICDPS**

At the start of the research we conducted a literature review, which indicated the type of problems arising in international co-operative projects. These related to information flow and communication (e.g. Enshassi, 1994; McDonough and Kahn, 1997), project management (e.g. Hetland, 1994; Eggington, 1996), language and culture (e.g. Schneider, 1994; Cleland, 1994), political and economic (e.g. Pandia, 1994; Coates, 1985). However, the literature seldom provided an in depth of analysis of the type of problems that occurred or differentiated between different stages of the design process. Information of this nature was required in order to develop solutions to design teams on how to deal with such issues when they arise.

In order to supplement the review, a retrospective analysis of project documents from the pre-concept to detailed design stages of over 20 international product design projects (such as the design of computer and peripherals, communications and domestic equipment) commissioned by CETRA (China External Development Trade Association) between 1993 and 1997 (see Woodcock, Lee and Scrivener 2000) revealed additional problems relating to brief specification and participation (e.g. key members of the project were not always available to verify decisions). Typically these projects were characterised by a small number of actors (the mean number of designers was 6) with an average project duration of 5.9 months.
From these projects, 143 problems were identified and classified into the categories elucidated above. Just over 70% of these problems were classified as having a medium or high impact on the project, with only 50% of them being resolved during the lifetime of the project; and just under 70% were deemed in part as relating to the inter-nationality of the project. This appears to be a high number of problems, which may well impede the design process (i.e. time spent on resolution of problems cannot be equated with making progress on the design itself).

The prevalence of problems in these design projects should be a cause of concern for anyone commissioning an international project. Typically problems will affect the satisfaction of the project participants, their ability to work together, the quality of the end result and the efficiency with which that result will be achieved. It was hypothesized that if we knew more about the lifecycle of problems within international design projects we could develop low cost strategies that would enable design teams to anticipate and rectify problems before they had a major impact on the design.

Therefore, to further our understanding of the ontology of problems in international collaborative design projects we set up a controlled, realistic case study to gather information for the identification and collection of problems as they occurred. Such a case study would add to our knowledge by providing a complete set of project documentation; take into account the use of different forms of communication (and the problems especially associated with these); characterise the emergence of problems in different stages of product design; and provide detailed information for us to generate intervention strategies. Such a strategy would be in line with that proposed by Collins (1995) who stated that managerial and communication problems arising during a new product development project can be alleviated through active intervention in looking at the problems and deriving solutions.

The next section focuses on the way in which potential and actual problems were identified during the case study, prior to an explanation of the development of the intervention strategy, which could be used to alleviate them. The final section of the paper assesses the usefulness of the intervention strategy in a second design project.

Method for uncovering problems in design projects
In this section we will introduce the data collection and analysis procedure used to uncover problems in a short duration, product design project similar to those supported by CETRA (China External Trade Development Council) and which were used in the earlier stages of our analysis (see above). It is believed that such an approach is generalisable to other design projects. In identifying potential and actual problems during the ICDP we hoped to:

- understand why they occurred
- understand the context in which they occurred
- assess their effects in terms of the design progress

Description of project
Three participants formed the design team, a UK product design consultant, a mediator and a client in Taiwan. The design brief was to design a laminator for small offices and was issued by the client, who was an office product manufacturer having an in-house design team. The project was studied from preparation to detail development over a period of approximately two months.

Communication between project members was supported by synchronous and asynchronous communication technologies namely a face-to-face meeting, telephone, videoconferencing, postal
mail, facsimile, email and World Wide Web (WWW). The project was completed successfully, though not to schedule.

Data collection
In terms of data collection, all synchronous communication was observed and recorded during the videoconferencing sessions, and asynchronous communication was monitored in the intervening periods.

These records were subsequently analysed to provide reference material for semi structured interviews and debriefing sessions. The interviews were held with both the designer and the client to establish what kind of problems they had experienced during the videoconferencing sessions and the problems they perceived in remote interaction. No prejudgement was made regarding the nature of the problems that emerged, i.e. we were equally interested in technological and managerial issues.

The debriefing sessions occurred after the tapes had been analysed. These were used to confirm problems that had arisen in the session and the researcher’s interpretation of the discourse. Typically the videotape was reviewed, accompanied by its transcript with participants so that material (i.e., the design session) was in their minds during questioning. The video therefore provided visual cues (Tang and Isaacs, 1993), which participants could use to elaborate important events. Through the use of debriefing it was possible to compare the reactions and perceptions of each participant to incidents which had been designated as potential or actual problems by the researcher in the light of his experience as a designer and from our prior research (see above).

Data analysis
This section considers the methods employed to identify potential and actual problems and trace their resolution or otherwise, through the design life cycle. The session transcripts and other discourse were inspected to determine whether they contained any instances where discourse was not centred on the design, but related to a problem (such as a missing piece of information, a communication breakdown). At such times the design team would not be focused on the design itself but on the problem. These were classified as ‘actual problems’ firstly in terms of whether they related to one of the categories that had emerged from our earlier investigations (e.g. information flow and communication, brief specification); and secondly in terms of breakdown analysis (see below).

Likewise during the course of the analysis the researcher also found it useful to note those times when one party promised to do something (e.g. send a specification). These were classified as ‘potential problems’, because if the commitment was not honoured it might lead to a problem later in the project lifecycle.

Breakdown analysis
A breakdown in design communication may be defined as an occasion when the actors have to stop work on their main activity because they become conscious of some issue which prevents their continuation on it. For example, during design interaction, participants send and received messages to each other. If something happens to cause a failure in the receipt or understanding of a message, this may force participants to shift their attention away from the primary task to resolve the problem.

Scrivener et al. (1996) defined 6 types of breakdowns as being between user-user, user-task, user-tool, user-environment, task-tool and tool-environment interaction. These relationships are
represented in Figure 1, and refer to vectors 1, 2, 3, 4, 5 and 6 respectively. For example, a user-environment breakdown occurs ‘when the users becomes conscious of some property of the environment’. Similar interruptions may occur between one user and another and between a user and tool. For instance, participants using the videoconferencing system to complete a task, may be interrupted by a software crash (e.g., whiteboard may not work). This interruption ceases communication about the design problem and compels the participants to take action, either by restoring the application, or using an alternative method to interact with their design partner, such as gesture. This is described as a user-tool breakdown.

Breakdown analysis has been used previously by the authors to understand problems in design communication over a distance, for example in the ROCOCO project between designers in Australia and UK Scrivener et al. (1996) and in the FashionNet project during which breakdown analysis was applied as a tool to measure usability. In this, Woodcock and Scrivener (1999) determined that breakdown analysis ‘clearly identified the nature of the problem, the impact on the overall quality of the interaction and the ability of the designers to perform the task using the tools at their disposal’.

Uncovering potential and actual problems
We were not concerned with classifying all significant design related events such as discussion, problem solving, negotiation and decision making. Although these may produce disagreements between members of the design team having different viewpoints, these are seen as a natural part of design progression. Neither were we interested primarily in the use of different forms of communication to advance design discussion, except in those instances where actors used different modes of communication to resolve a particular problem (e.g. request material which had been promised but which was not forthcoming).
What we were interested in, and what could only be achieved through careful analysis of the transcripts, was in finding clear verbal expressions of problems or breakdowns (i.e. a time when the actors attention was taken away from the primary task) and then uncovering the origin of this problem either through discussion with the participants or in the explanation of the transcripts of earlier sessions. Once we know that a certain action may give rise to a problem in the future then we can develop guidelines to reduce the likelihood of a potential problem turning into an actual one. For example, when an agreement is made, especially during a meeting, this could be targeted as a ‘potential problem’ on the assumption that it is possible participants might disagree/disregard such an agreement in the future time. Potential problems may be found in both synchronous (e.g., transcripts of videoconferencing sessions) and asynchronous communication (e.g., emails). Through the identification of these in the case study we could develop a set of recommendations which can be used to alert small design teams to possible problem areas.

Obviously, not all problems have their antecedents in the history of the design discourse. These problems arise spontaneously and are usually not within the control of the actors (for example, they may be interrupted by visitors, there may be a system breakdown or one of the team may use unfamiliar terminology). When an interruption occurs, the design task terminates because the participants need to pay attention to and spend time on repairing the breakdown. If the breakdown cannot be resolved, the design task will cease. If the breakdown is repaired design activity resumes. The documentation of such events can inform the development of guidelines to reduce the number of spontaneous problems.

In summary, the following stages were undertaken to discover problems

1. Record (and where possible observe) design activity
2. Transcribe design discourse where necessary (e.g. from video records)
3. Note those times where there is a breakdown in design related communication, such occurrences are usually flagged verbally, for example one participant may ask another to repeat a certain phrase, say it another way or ask for a translation; participants may indicate that they cannot ‘see’ drawings imported on to the whiteboard
4. Code the problem as relating to time, information flow and communication, brief-specification, project management, participation, language (and culture), political and economic, product and quality, technology and environment and where appropriate in terms of breakdown analysis
5. Assess whether the problem arose spontaneously or had it’s origins in earlier sessions (e.g. design activity could not be progressed because certain information had not been provided on time)
6. Note whether any agreements or promises had been made which might give rise to problems in the future
7. Check the interpretation of the coding of the problem (and whether it was seen as a problem) with the actors and get their views on the session, using the edited video and transcripts as prompts.

Although a verbatim transcription of the design sessions is not essential for uncovering actual problems, it is useful for tracing the origin of non spontaneous problems, which may have their origins in previous meetings or project documents.

Tracing non spontaneous problems requires the researcher to;

1. Inspect previous documents looking for likely antecedents to the actual problem e.g. an agreement was made to provide information by a certain date
2. Mark these as ‘possible problems’
3. Verifying the relationship between the possible and actual problems with the actors.

**Results from the case study**

50 problems were found through the course of the case study with most of these occurring early in the project (during design briefing, analysis and the first concept stage). Just over a third of these related to information flow and communication, a further sixth were related to project management. This was further substantiated by breakdown analysis, revealing that 21 problems related to user-user breakdowns and that these could mostly be attributed to language issues (this also applied to potential problems, see Table 1).

By using the steps outlined above, we found the following relationships between potential and actual problems (see Table 1) for the design project described above. From this it can be seen that it was possible to trace problems through the design lifecycle, and that some of the problems were of long duration.

Although the aim of the research was not primarily to develop a method for tracing the effect of problems on design activity, but in determining ways in which these could be reduced in future projects, this method leads us to a set of problem predictive events that we can look for when managing projects. The next part of the paper considers the development of the intervention strategy and evaluates its efficacy when used in a small design project.

**Development of the intervention strategy**

The literature review, our investigation of project documents and the case study outlined above led us to believe that it might be relatively easy to reduce the number of problems commonly faced by small international collaborative design projects (ICDPs). To this end we developed an intervention strategy, which could be used by either project managers or the design team itself to reduce problems. It should be noted that small ICDPs of this nature may not be formally managed, be well specified or cognisant of the special nature of problems which might arise in international co-operative design projects. For example, when working in close proximity or the same time zone it is relatively easy to request and promptly receive information, when there is only one hour during which synchronous communication can take place (as in Taiwan-UK collaboration) it is less easy to arrange some matters, or to keep a check on progress. As such the design team may become overwhelmed by problems. In our previous paper (Woodcock, Scrivener and Lee, 1999) we suggested that designers should be formally educated in the skills needed for them to work productively in this environment (e.g. in terms of training in videoconferencing, multi-tasking and project management). In this paper we consider a different approach, i.e. an intervention strategy, consisting of a plan to prevent problems from arising and the development of a set of actions to resolve problems once they have emerged.
and improve their situation. Once they realized a problem was going to occur they should intervene. This required project participants (or the manager) to adopt an action research approach to change.

### Table 1: Possible Problems becoming Actual Problems

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<th>Stage</th>
<th>Possible Problems</th>
<th>Actual Problems</th>
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<td>Design requirement discussed</td>
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<td>Design requirement discussed</td>
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<td>Agreement made (n-pt)</td>
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<td>Agreement made (pt)</td>
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<td>Design requirement discussed</td>
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<td>Meeting arranged</td>
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<td>Agreement made (pt)</td>
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<td>Agreement made (n-pt)</td>
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<td>Design requirement discussed</td>
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<td></td>
<td>Meeting arranged</td>
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<td>Agreement made (pt)</td>
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<td></td>
<td>Design requirement discussed</td>
<td></td>
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<tr>
<td></td>
<td>Agreement made (n-pt)</td>
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<tr>
<td>Inter-meeting 1</td>
<td></td>
<td>Failure to fulfill an agreement</td>
<td>3</td>
</tr>
<tr>
<td>Design Briefing</td>
<td></td>
<td>Misunderstanding</td>
<td>2</td>
</tr>
<tr>
<td>Design Analysis</td>
<td></td>
<td>Failure to honor deadline</td>
<td>1</td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Inter-meeting 2</td>
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<td></td>
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<tr>
<td>Inter-meeting 3</td>
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<tr>
<td>Inter-meeting 4</td>
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<tr>
<td>Inter-meeting 5</td>
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<td></td>
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<tr>
<td>Inter-meeting 6</td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

Key: N= number of occurrences, n-pt = non preordained time, pt= preordained time

**Intervention strategies for preventing and overcoming problems**

The intervention strategy consisted of:

1. a set of interventions to inhibit the onset of problems or reduce their severity
2. recommendations for effective working during meetings (i.e. project start-up, pre-meeting, meeting and post-meeting stages in the project)

This required project participants (or the manager) to adopt an action research approach to change and improve their situation. Once they realized a problem was going to occur they should intervene immediately. The following section summarises the two parts of the strategy.
Interventions

Table 2 shows, for each potential problem, the intervention strategy that is required to reduce its likelihood of developing into an actual problem. The third column illustrates the type of problem that might arise without such intervention.

<table>
<thead>
<tr>
<th>Potential Problems</th>
<th>Proposed Intervention Strategies</th>
<th>Actual Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreement made</td>
<td>1 Make notes for any agreements</td>
<td>• Failure to fulfill agreement</td>
</tr>
<tr>
<td></td>
<td>2 Verbal reminder of the actions</td>
<td>• Ignoring agreement</td>
</tr>
<tr>
<td></td>
<td>3 Record on minutes and distribute</td>
<td>• Lack of information</td>
</tr>
<tr>
<td></td>
<td>4 Trace the actions and remind</td>
<td></td>
</tr>
<tr>
<td>Translation issues</td>
<td>1 Translate the discourse</td>
<td>• Inaccurate translation</td>
</tr>
<tr>
<td></td>
<td>2 Explain requirements to the designer</td>
<td>• Omission of translation</td>
</tr>
<tr>
<td></td>
<td>3 Help to define terminology and correct misinterpretations</td>
<td>• Misunderstanding</td>
</tr>
<tr>
<td></td>
<td>4 Trace the actions and remind</td>
<td>• Lack of understanding</td>
</tr>
<tr>
<td>Viewpoint from the client or client’s</td>
<td>1 Assure the elaboration of the product design brief</td>
<td>• Client inconsistency of viewpoint</td>
</tr>
<tr>
<td>colleagues</td>
<td>2 Encourage project members to attend meetings</td>
<td>• Lack of information</td>
</tr>
<tr>
<td></td>
<td>3 Suggest that the client reaches a common ground within their</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Trace the actions and remind</td>
<td></td>
</tr>
<tr>
<td>Renegotiation of the schedule</td>
<td>1 Explain the consequence of delays</td>
<td>• Failure to honour deadline</td>
</tr>
<tr>
<td>Design requirement discussion (during a</td>
<td>1 Translate the discourse for both sites, mostly for the designer</td>
<td>• Failure to resolve viewpoints</td>
</tr>
<tr>
<td>meeting)</td>
<td>2 Explain the design requirement</td>
<td>• Lack of understanding</td>
</tr>
<tr>
<td></td>
<td>3 Refer to agenda items</td>
<td>• Misunderstanding</td>
</tr>
<tr>
<td></td>
<td>4 Enhance communication flow</td>
<td></td>
</tr>
<tr>
<td>Design requirement discussion (before or</td>
<td>1 Monitor email exchanges</td>
<td>• Lack of understanding</td>
</tr>
<tr>
<td>after a meeting)</td>
<td>2 Phone participants to resolve misinterpretations</td>
<td>• Failure to honour deadline</td>
</tr>
<tr>
<td></td>
<td>3 Trace the actions and remind</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Summary of intervention strategies

As can be seen from Table 1, most of the interventions relate to good project management. For example, minuting meetings, producing action lists and reminders of approaching deadlines. Such interventions will prevent actual problems from arising such as failure to fulfill an agreement, ignoring an agreement and lack of information to discuss design requirements. Similarly, for dealing with translation issues, intervention strategies required a translator to be present to clarify design requirements, help to redefine the terminology and correct any misinterpretations during meetings. These actions should affect the number of problems relating to inaccurate translation, omission of translation, misunderstanding and lack of understanding. The mediator in this case study was not proactive, and as such had not undertaken many of these actions. Considering the findings of the review and the analysis of CETRA project documents, the main problem for ICDP’s is that they fall behind schedule. The intervention strategies outlined above will reduce this likelihood and create greater satisfaction amongst participants.


**Recommenations for effective working during meetings**

Meetings are of prime importance in design projects as they are the time when decisions are made, and design ideas approved. It is therefore essential that they be well managed. Table 3 summarises the type of intervention strategies that could be employed to facilitate such events.

<table>
<thead>
<tr>
<th>Stages</th>
<th>Proposed Intervention Strategies</th>
<th>Problems Targetted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project start-up</td>
<td>1 Train participants to use communication media appropriately</td>
<td>1.1 Whiteboard does not work properly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 Difficult to do the task</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 Slow transmissions speed</td>
</tr>
<tr>
<td></td>
<td>2 Assure the elaboration of the product design brief</td>
<td>2.1 Lack of information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 Addition or modification of design requirements</td>
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<td></td>
<td></td>
<td>2.3 Failure to fulfil agreements</td>
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<tr>
<td></td>
<td>3 Provide a shared vocabulary for the project</td>
<td>3.1 Lack of understanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2 Misunderstandings</td>
</tr>
<tr>
<td></td>
<td>4 Define the rules of feedback and response</td>
<td>4.1 Lack of feedback and response</td>
</tr>
<tr>
<td>Pre-meeting</td>
<td>5 Develop and collect agenda items and distribute them by email</td>
<td>5.1 Failure to resolve viewpoints</td>
</tr>
<tr>
<td></td>
<td>6 Suggest pre-discussion</td>
<td></td>
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<tr>
<td></td>
<td>7 Monitor and contact participants</td>
<td>7.1 Lack of understanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.2 Failure to honour deadlines</td>
</tr>
<tr>
<td>During the meeting</td>
<td>8 Facilitate and resolve communication and translation issues</td>
<td>8.1 Misunderstanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.2 Lack of understanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.3 Failure to resolve viewpoints</td>
</tr>
<tr>
<td></td>
<td>9 Overcome technological breakdowns (technological training)</td>
<td>9.1 Difficult to do a design task</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.2 Slow transmission speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.3 ISDN connection interrupted</td>
</tr>
<tr>
<td></td>
<td>10 Make notes of agreements</td>
<td>10.1 Failure to fulfil agreements</td>
</tr>
<tr>
<td></td>
<td>11 Remind participants of agreements and actions</td>
<td>10.2 Ignoring agreements</td>
</tr>
<tr>
<td>Post-meeting</td>
<td>12 Record and distribute minutes</td>
<td>12.1 Failure to fulfil an agreement</td>
</tr>
<tr>
<td></td>
<td>13 Trace agreements and monitor progress towards completion</td>
<td>13.1 Ignore an agreement</td>
</tr>
<tr>
<td></td>
<td>14 Monitor and contact participants to remind them of the consequences of delays</td>
<td>14.1 Failure to honour deadlines</td>
</tr>
</tbody>
</table>

Table 3: Intervention strategies to be employed around meetings

The rationale behind the development of these strategies is outlined below:

During project start-up, participants might find themselves working with unfamiliar technology (eg videoconferencing, or use of the web). Not only do such tools require technical knowledge to set up, and resolve problems they also require a different way of working. If these issues are not dealt with at the start of the project they may seriously impede progress later on by creating problems relating to whiteboard and other applications misuse, slow transmission speed and participants being nervous of the new technology.

For meetings to be effective, steps should be undertaken, whether by the project manager or the
participants themselves to produce an agenda, which can be distributed prior to the meeting, so that all participants can consider the issues in advance, discuss them with their colleagues and bring necessary documents to the meeting.

During the meeting, participants should be alert to the possibility of misunderstandings and have a translator on hand and also someone who can help with technological breakdowns. Anecdotal evidence from this and other studies suggests that non academic users of technology face a very steep learning curve before they can use technology to its most optimum effect. Training and installation manuals are not enough to enable them to work effectively or to rectify problems when they arise in a working context.

Post meeting follow ups should include circulation of the minutes, action items and careful monitoring of participants to ensure that deadlines and promises are honoured.

**Evaluation of the intervention strategies**

In order to evaluate the intervention strategies we embedded them in a real design project, with a similar number of actors (in Taiwan and UK) and of a similar duration to the first project. This time the design brief was to design a world clock. It should be noted that both projects were commissioned by Taiwanese manufacturers, the designers negotiated their contracts and the designs were expected to be launched as products in the near future. Unfortunately the high ecological validity of the studies means that any comparisons have to be treated carefully as we could not control extraneous variables such as the familiarity of the actors with the technology, their linguistic skills and the complexity of the design. In this study, the researcher, rather than just recording problems, took a more active role in the project by implementing his intervention strategies. This meant he actively looked for potential problem areas, alleviated spontaneous problems when they arose (e.g. by offering technical and linguistic support) and checked to ensure agreements were met.

Figure 2 illustrates the nature of the actions the researcher undertook to support design meetings. These are described on the right hand side of the figure. For example, once an informal verbal agreement occurred, the researcher made notes and wrote down the ‘tentative agreements’ (Beer and Stief, 1997). At the end of the meeting, the researcher reminded the participants of the agreements, the actions, who was responsible for them and the deadlines. These were emphasised in the minutes generated and distributed by the researcher. As a consequence, of these interventions most were fulfilled.
Figure 3 compares the number of breakdowns in the two studies (but note the caution above). Similarly the number of actual problems was reduced from 50 in the first study to 15 when the interventions were applied in case study 2.

**Summary**

In this paper we have outlined a general purpose method to identify, classify and trace problems through the design lifecycle. It is believed that this method, applied to more case studies will enable the design research community to achieve new insights into issues such as the reasons for design drift, and bring about a greater understanding of ways to increase efficiency in distributed design.

The intervention strategies we have developed as a result of the analysis may be classified as being one which has low cost and high impact. It is therefore ideally suited to small, international design projects, which are of short duration and liable to run behind schedule. Typically such ventures cannot afford a dedicated project manager. In such cases the design team itself needs to be aware of potential problems it might encounter and be able to take remedial and preventative action to ensure the design remains on course. We believe that the strategies outlined in this paper will therefore be of benefit to design practitioners.
References


Building on virtual common ground: design participation for the network age

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A. Ando School of Communication, Tokyo Keizai University, Japan

Abstract

This paper describes a set of action research initiatives intended to disseminate the technical skills necessary to participation in an increasingly globalised design discourse. It starts by examining the shifting relationship between design, production and consumption triggered by globalisation. An account of partnerships between a network of “experts” and a range of “users” follows. This is premised on the use of available infrastructure and the sharing of modest technical skills. This has allowed partners in peripheral locations to embark on the more rewarding process of social learning and exploration of available ICTs without first having to climb a steep technical learning curve.

Using available free web-sites, which provide simple on-line editors, and a minimum of HTML instructions, a sustainable presence has been developed for a range of individuals and organisations. Face-to-face contact in workshops has been supplemented with subsequent on-line contact and knowledge sharing. A combination of simply designed web pages has been linked with the leveraging of already available internet-accessible material to provide the means to create a sustainable presence from the margins. A model developed in the context of West Africa has proved useful to the U.K. periphery with real-time monitoring of public service provision being piloted in North-East England. This approach offers a framework for the design and delivery of goods and services to increasingly diverse and extensive markets. The paper describes the approach at the level of discrete design project, problem formulation and analysis and policy formulation and feedback.
Building on virtual common ground: design participation for the network age

Globalisation: networks and organisations
Globalisation of the world economy has increased the significance of intellectual capital leveraged by information and communication technology. The deployment of these technologies has undermined the distinction between manufacturing and service activities and produced new forms of locational and functional differentiation across a globalised network of invention, innovation and implementation (see Castells, 1996, 1997; Ohmae, 1990). The imperatives of an emerging global market have led developed economies to shift their focus towards the end of the production chain. This allows product differentiation and customer support to maintain the value of goods and services in the face of growing price competition from newer competitors. As a consequence, the distinction between products and services becomes less obvious. This end of the chain requires closer adjustment to cultural variation among the users and customers. James and Howell (2000) examine the use that Asian companies are making of the R & D facilities they are establishing or acquiring within the United Kingdom. Evidence suggests the objectives are both access to knowledge for market adjustments and broader intellectual capital for application in the home environment.

Evidence of an increasing focus on the end of the chain where product differentiation and service provision allow competitive advantage to be developed can be seen at ICL, once the "national champion" of the U.K. computer industry and now a component of Fujitsu, a former foreign competitor. ICL has moved further from its original manufacturing hardware base to position itself as an information services provider that can support the specificities of a European business environment. This end of the chain is more culturally variable and success reflects specific local or regional knowledge. Evidence of a “value chain” approach (Porter 1990) can be seen in a very different industry. Both ICI and Unilever have been engaged in moving along the production chain, to higher added value, with Unilever passing its specialist chemical division to ICI in order to concentrate on the delivery of differentiated brands based on these feedstocks. Meanwhile ICI has off-loaded its bulk chemical business to firms content to compete primarily on price at the commodity end of this chain.

Both the British government and the European commission are encouraging companies to seek alliances and opportunities in the opposite direction, both as a means of accessing the market potential of Asian growing economies and as a means of improving offshore manufacturing resources in relation to both home and export markets. In this inter-dependent environment design has become the key activity unifying product, process and organisation across geographical and cultural boundaries.

Communities and networks
The contemporary notion of the “network organisation” and decreasing Internet costs appear to present an opportunity for smaller players to access resources from and to compete within global networks. However, using the reduction on transaction costs delivered by ICTs, larger firms can restructure to enter niche markets yet still draw on their wider resource base. New locational strategies allowed white collar work from the US mainland to be relocated off-shore to the Caribbean as far back as the 1980s, and "front office" tasks in prestigious locations have been divided from "back office" tasks relegated to the more local periphery of outer suburbia. Less developed regions find themselves increasingly in competition for such lower value work, and their infrastructure is likely to be developed primarily to support it. At the same time, potential
consumers with limited economic resources are less able to influence the direction of development of technologies, artifacts and services which are targeted at the most lucrative component of global markets. Across the new networked economy as a whole research and development, raw materials sources and routine manufacturing, final assembly, markets and after-market support, are increasingly co-located. The emergent global system is one of complex inter-penetration of peripheries and cores and these terms now refer to competence in the underpinning information and communication infrastructure, rather than physical location.

ICTs are critically important for participation in the global economy but they have been created and driven from within the most developed economies and regions. They carry assumptions about levels of both resources and skills. Many locations have very limited access to the key technologies driving globalisation. These inequities fuel current debates over the nature of the “digital divide”, but despite the reality of division, many marginalised communities have appropriated available ICTs for their own purposes. For example West African communities, in Ghana and Nigeria, use World Wide Web technologies to distribute craft products to a global marketplace by a route which provides its own audit trail safeguarding intellectual property and demonstrating authenticity which adds value to the product. Business centres in the suburbs of West African cities offer phone, fax and email connection to overseas family members and partners in the overseas diaspora (see Little, Holmes & Grieco, 2000).

The twenty-first century has been identified as one in which the large scale movement of civil populations, whether for economic or environmental reasons is likely to be a major feature (Castles and Miller, 1993; Collinson, 1993). This has already been manifested in concerns over “asylum seekers” and “economic migrants”, even in countries such as Australia, which depended on such flows for economic development throughout the previous century.

Many migrant communities seek to reproduce features of their home community in their new locations: the Little Italias, Chinatowns, Little Polands of the United States and Canada. The development of virtual community nets enables migrants to enter once again the discourse and social being of their original community of identity. Miller and Slater (2000) explore the question of local improvisations in the case of Trinidadian diaspora: “Indeed the significance of studying the Internet is the degree to which it transcends dualisms such as local against global. It forces us to acknowledge a more complex dialectic through which specificity is a product of generality and vice versa” (Miller and Slater p. 7). Trinidadians undertake a distinctive set of social activities on the global Internet. What they experience are specific and local practices at a remote location.

Black American members of a more ancient diaspora now have an accessible, authentic, African cultural base which they can access readily. Africa is not a simple recipient of culture across the Internet but rather the location of active shaping of both the cultural and policy content (see the Ghana Computer Literacy & Distance Education site: http://www.ghaclad.org).

Africa has seen a major renaissance in the celebration of its indigenous culture and art, both traditional and modern, through the new communication technologies. Local African radio (JOY FM from Accra, Ghana) is available globally through the Internet; African dance can be viewed globally through the same mode. The texts and tales of oral legends and beliefs are now available on line and all serve the perpetuation of an Africa base to identity in the African diaspora (see http://www.geocities.com/margaret_grieco/kentecon/kente.html).

In Bangladesh the Grameen Bank (http://www.grameen.org/) has extended communication technologies to poor village women as part of their empowerment : communication technologies give these women an ability to check on market prices and to better organise their finances and
production. In India, the Self Employed Women's Association (SEWA) has made use of the new information communication technologies to promote its cause of advancing the interests and improving the situation of poor women (http://www.sewa.org/).

Similarly, indigenous African business is making use of the Internet for conducting commerce, most particularly the marketing of craft goods and the organisation of tourism. In the area of industrial relations (http://www.cosatu.org.za/) African unions are connecting up both internally within Africa and globally in the advancing of the interests of labour (http://www.geocities.com/unionsonline/). They are originators of action as well as receivers of the industrial relations agenda: the global coordination enabled by strategies such as ‘web’ or ‘union rings’ permits local determination in the context of global synchronisation.

**Building and sharing a skills base for virtual common ground**

The “digital divide” is only one aspect of the uneven distribution of and access to resources within the emerging global economy. Nevertheless, we have seen that a number of innovations from well resourced locations can be applied effectively in less well resourced conditions.

In Japan, the Internet has been widely used for political (see http://www.jlgc.org/; http://www.kobe-airport.gr.jp; http://www.agora.stm.it/politic/japan.htm) as well as economic purposes, for example, Business to Business technologies for East Asia (http://www.ecplaza.net). The Japan Local Government Center has set up a site through which it links with local governments globally in the search for solutions to new urban problems (http://www.jlgc.org). It is designed to open up the interaction between Japan and other agencies, most particularly in the United States. In the same frame but from a different political perspective, alternative and oppositional groups in Japan are also making use of the Internet to influence internal Japanese politics by attracting external allies to their cause. A good example of such a case is the campaign to oppose proposed developments at Kobe airport (http://www.kobe-airport.gr.jp/); while the bulk of the site is in Japanese there is an English translation facility which provides the opportunity to sign on to the campaign electronically.

Providing grassroots access to the ICT domain can be used to cut the costs of health and educational servicing (as with the current planned expenditure in the U.K. National Health Service: Cross, 2002). However, in order to improve economic performance through e-commerce modes, the channels for new forms of bargaining are created. The transaction costs for the least powerful to gain visibility are also greatly reduced.

The research described in this paper represents a series of interventions aimed at the dissemination of skills permitting both the voicing and participation of users at the margins.

The Odyssey Group (http://www.geocities.com/the_odyssey_group/) is an open network of organisation researchers who meet in physical and cyber-space to discuss and enact the implications of the current generation of Information and Communication Technologies. The group examines the nature of technical skills and resources in the context of collaborative development of an electronically mediated form of design participation that can be accomplished without physical co-location. The Odyssey group conducts workshops involving both physical and virtual participation. An individual may be present at a particular event via either or both modes.

The group developed the Virtual Journey as a means of accessing aspects of the Odyssey Group workshops without co-presence. The use of web technology to capture key aspects of an environment or a pathway through an environment allows virtual participation in workshops and discussion. Such a journey consists of a web page (or small set of pages) containing images
gathered during the journey and links to relevant web-sites discovered either on route or subsequently.

The use of images in conjunction with hyperlinks to communicate both explicit and tacit understandings in a Virtual Journey can be regarded as an electronic equivalent of the role of storytelling in organisation.

Recent interest in storytelling reflects the need for shared tacit knowledge in complex organisations (Denning, 2001) and in design processes (Lloyd, 2000). Stephen Denning, who was the World Bank’s Program Director for Knowledge Management has published his experiences of the power of stories in leveraging tacit understanding through concrete examples:

“A springboard story has an impact not so much through transferring large amounts of information, as through catalyzing understanding. It can enable listeners to visualize from a story in one context what is involved in a large-scale transformation in an analogous context. It can enable them to grasp the idea as a whole not only very simply and quickly, but also in a non-threatening way. In effect it invites them to see analogies from their own backgrounds, their own context, their own fields of expertise.” (Denning, 2001, pp. xviii–xix)

Virtual Journeys may be constructed in real time, during a workshop, to communicate immediate experience across the virtual group. They may be re-constructed subsequently, as a means of archiving social practice and experience. They may be constructed as a reflection on experience triggered by events and discussions during the meeting.

The group met in Ithaca, New York in August 1999 and developed some initial sites. “On the Road” (http://www.re-skill.org.uk/odyssey/road/ontheroad.htm) is a virtual journey to Rochester New York, “Image Capital of the World”. It represents the perceptions of four members of the group gained over two journeys between Ithaca, NY and Rochester, the city in which George Eastman transformed photography from a craft to an industry.

Township Transport (http://www.geocities.com/township_transport) is a Yahoo-Geocities free-server site constructed by members of the group who visited South Africa jointly and separately in the space of a year. It is intended to develop through further contributions from fellow travellers to become a resource or tool kit which will further participative planning and organisation of transport in South African townships.

A third Odyssey meeting was held in Ghana during August and September 2001. The Odyssey Group of organisation theorists, drawn from a number of U.K. and European Universities, worked with a set of Ghanaian partners from the University and NGO sectors. The Centre for Social Policy Studies (CSPS) at the University of Ghana were the hosts in exploring the potential and affordances of electronic modes of communication for African development and identifying current and emerging practices in this arena. The immediate aim was to develop theoretical perspectives and their practical applications.

During the Ghana workshop a number of web sites were constructed, including one for the recently completed Ghana Social Index (http://www.geocities.com/csp_s/maps). This site contains a set of maps showing social indices for each region of the country. These can be downloaded in stages, and have been designed for the slow connection speeds prevailing in West Africa. Making data created inside Ghana available both inside and outside the country is a significant move way from the situation (common in developing countries) of dependence on external sources of information about local conditions.
These sites can be accessed and maintained from any of the numerous Internet cafes which are available in the suburbs of Accra: a clear demonstration of the need to consider access separately from ownership (see http://www.geocities.com/odysseygroup2001/vj/gallery03.html and http://www.geocities.com/odysseygroup2001/vj/environ.html).

Sustainability is a key objective for these sites. This is achieved by creating simple HTML pages with links and JPEG images. These are composed using the on-line text editors provided by services such as Geocities. Simple HTML templates showing sample hyperlinks and image placement can be shared. Basic HTML commands allow simple on-line maintenance without specialist software and maximum compatibility with basic machines and software. This is in preference to the generation of HTML from word processors or other software, which can result in over-complex and opaque code. These techniques are described on the Odyssey site (http://www.geocities.com/odysseygroup2001/sharing/index.html).

An on-line toolkit is under development at http://www.geocities.com/the_odyssey_group/toolkit.html. Instructions on how to set up a Yahoo-Geocities web site are available at http://geocities.yahoo.com/home

The same philosophy and techniques can be seen in a site, maintained by the Moor Park community in a collaboration between the Moor Park Community Centre and the Odyssey Group at http://www.moorpark.freeuk.com/

A framework for social learning
Sproull and Kiesler (1991) demonstrate that a process of organisational learning is needed to move beyond the technical effects of direct substitution of information technology for manual processes. The work described in this paper suggests three levels at which such social learning can facilitate design participation though the use of web-technologies:

**Level 1 Collaborative design of web sites**
Design can be conducted as a virtual process supported over the web. For discrete, individual design interventions, a community presence can be provided, whether the community is of shared interest or location or of practice. This form of participation fits within a well established paradigm, (e.g. Cross 1972).

A number of sites have been developed collaboratively between libraries. For example, the Centre for Social Policy Studies librarian now maintains a web-site at http://www.geocities.com/cspslibrary/

Support can be provided through the sharing of passwords within the group. The use of a U.S. based site allows access from locations with higher access speeds outside Ghana.

The CSPS Library site contains links to other libraries, including the Open University Library and the Safari (Skills in Accessing, Finding, and Reviewing Information) on-line resource that allows students to develop skills on electronic information and document retrieval (http://sorbus.open.ac.uk/safari/signpostframe.htm). This represents a significant leveraging of the on-site resources.

**Level 2 Web-supported problem definition and articulation**
The identification of discrete projects implies problem formulation around multidisciplinary “wicked problems” (Rittel and Webber, 1973), so a need for network of skills, virtual team
building. The CSPS web-site aims to identify areas for direct intervention and an on-line “action auction” of research project proposals was one of the first components developed for the web site. The Moor Park Explore Club at http://www.geocities.com/moorparkexploreclub/ highlights a range of issues, many amenable to relatively simple design solutions, which reduce the effectiveness of public transport service delivery. These include bus shelters with no information on service routes or timetables. Metro stations with Park and Ride facilities but poor access for passengers trying to get there by bus. A major regional hospital site with feeder bus routes which stop a significant distance away.

The CSPS site contains an “action auction” page which consists of a set of research proposals in search of funding (http://www.geocities.com/cspsghana/actionauction/index.html).

For example, Domestic Organisation and The Environment is a proposal based on observations that households compensate for infrastructural deficiencies in the developing urban context by the use of children's labour. Inadequate infrastructure therefore increases the task burden of children and increases their exposure to health risks. The project proposes the development of an Information, Education and Communication campaign directed at achieving a re-distribution of such tasks.

Building District Level Information Management Capacity for Development Planning and Resource Management is a proposal reflecting a government policy of decentralisation which places great responsibility on each District Administration machinery to identify its development needs and the resources available locally and externally to enable it adequately plan and implement development programmes. The project aims at building up the capacity of each district administration to be able to collect, process and disseminate information and network with other districts.

Level 3 Policy monitoring
The expressed desire of the British government for “joined up government” implies closing the feedback loop at policy levels. North East Action on Transport (NEAT) has experimented with real-time on-line monitoring of public transport service provision.

In the low income areas of the North East of England low car ownership is often partnered by low levels of public transport provision. Although communities are clear that they are experiencing public service failure, petitions, consultations, letters of complaint, requests for more socially balanced services or bus designs which can accommodate young mothers with pushchairs, older persons with restricted mobility or disabled persons are not resulting in public transport improvement. Policy has focussed on getting motorists out of their cars. Ensuring either an adequate range of social and leisure services locally, or an adequate level of mobility for all in accessing of services now located at considerable distances from low income residences is not a visible concern.

The monitoring of public transport systems has traditionally been conducted by professionals who have rarely given the feedback to communities. The advent of the World Wide Web and the availability of new Information Communication Technologies (ICTs) can enable communities to monitor public transport and other public service provision and performance and make transparent that performance beyond their local arena.

In Lemington, in the West End of Newcastle, on the 25th and 26th September 2001, a real time community monitoring of the performance of the Stagecoach bus routes and services was undertaken. Stagecoach, as service provider, joined in with this community monitoring as did members of the Newcastle Disability Forum. Technologies used for this exercise included digital cameras, digital video, on-line surveys, wireless laptops, Global Positioning Systems (GPS)
monitors and Wireless Assisted Protocol (WAP) telephones. The results are archived at http://www.newnet.org.uk/neat/monitor/default.htm

**Conclusion**

This paper has described some of a number of related activities conducted by a loose network of U.K. and overseas-based academics. These are aimed at the collective and collaborative development of virtual forms of design collaboration, at the level of individual web sites, and in the wider engagement with project formulation and policy evaluation.

The on-line version at http://www.geocities.com/knowledge_links/commonground.html provides live links to sites that demonstrate the techniques used in this research and the outcomes from a continuing process.
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Building better relationships between design research, design research education, government, industry and the design professions

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Abstract

Governments and major industrial players regard successful innovation as one of the most significant factors in improving economic and social outcomes. Designing is the process by which new knowledge is transformed into innovative products, systems and services. Research into designing provides the foundation for improving designing and improving how innovation processes are managed.

Stakeholders in design activities have relatively neglected design research. This paper focuses on the role of concepts and terminology in multidisciplinary design fields in supporting or inhibiting relationships between design professionals, designs researchers, design research educators, government and industry organisations.
Building better relationships between design research, design research education, government, industry and the design professions

Introduction
Most developed national governments such as Australia, the UK and the US, regard innovation, the generation of new knowledge and its transformation into real products, services and systems as a key element of their policies for economic and social development (see, for example, Canadian Agri-Food Research Council, 1997; Commonwealth of Australia, 2001; Dept of Industry Science and Resources, 1999, pp. 3, 9-10; Innovation Summit Implementation Group, 2000; National Science Foundation, 2001, 2001, 1998; Sara, 2000; The British Council, 2001; The Chief Scientist, 2000; Whitney, n.d.). It is designers that transform the new knowledge from basic research and convert it into these real world products, systems and services that are the physical manifestations of the widely sought after innovative outcomes (Langrish, 1987).

Many Western nations have neglected the roles that designers play in transforming knowledge into economic and social benefits. This neglect is evidenced by, for example:

- The omission of designing, designs, the education of designers, the design field, and research into improving design processes in policy and strategy statements about innovation and the development of a knowledge nation issued by the Australian government in recent years. Similar neglect is apparent in government documentation from other countries.

- The relatively insignificant levels of government support and research funding aimed at improving the efficiency and effectiveness of design activities.

- A lack of understanding by government (and by many businesses) of the importance of improving the efficiency with which new knowledge is converted into real outcomes, and the importance of managing the effectiveness of transformation, by designing, of new knowledge into designed outcomes to align with government and business’ strategic plans.

- Unlike other industries, there is as yet little attempt at national levels to map out the different resources in design expertise available within national economies (this of itself would be a useful project that there would be strong justification for government funding on grounds of improving national strategic planning).

- Design education aimed at developing highly competent professional designers for participating in complex innovative multidisciplinary design projects has been neglected at a tertiary level. The training of most technical designers consists of minor elements in degree programs of traditional disciplines. This is evident in, for example, the fields of engineering, information systems, and education.

- The management of research funding for improving the efficiency of the conversion of new knowledge into real world designed outcomes, in Australia, the UK and the US at least, is managed by minor government research bodies that are significantly under funded compared to similar research bodies that manage the research funding for other disciplines. For example, in Australia, compare the Creative Arts panel of the Australian Research Council with the Science panel; in the UK, compare the Arts and Humanities Research
There are many reasons for this neglect, some of which lie with government, some of which are political, and some of which lie with design practitioners and the sub-fields of design research. These include:

- Intrinsic weaknesses within the design research because terminology and concepts are fragmented and discontinuous on the sub-discipline boundaries. This is in part due to the structure of tertiary education, and in part due, in many design fields, to an over emphasis on the information that designers use as the basis for defining designing (e.g. engineering information rather than knowledge about appropriate best practices in designing).

- The discourse relating to design research, for the field, within disciplines, across disciplines, with sponsors, with clients and with government agencies is confused and poorly defined. The central, mainstream and peripheral concepts used in discussing designing, design problems, design solutions, user interactions, government strategies and sponsor criteria are not only used imprecisely, they are often used with multiple meanings and not explicitly or implicitly defined by context.

- The literature of business and innovation research almost completely neglects the role of design and hides its role by placing primary emphasis on entrepreneurial business units. The design function is passively subsumed within the business model and the importance of maximising and aligning the designing activities and outcomes with business strategies, vision and objectives is neglected or ignored.

- A dislocation between undergraduate and postgraduate education in designing in many disciplines. For example, in technical disciplines such as engineering, design research at a postgraduate level almost exclusively focuses on developing models of objects’ physical properties, i.e. it reverts to an engineering paradigm of applied physical modelling that is only incidental to its information provision role in designing. Similar but opposing phenomena are found in appearance-based design disciplines of the Art and Craft school traditions in which design research at a postgraduate level becomes refocused on the paradigms of Fine Art and Social Science. This can be seen in the strong interest for designed artefacts to be a substitute for research, and where research into the use of actualised designs is refocused as anthropological research.

- Core concepts in the fields of design and design research are confused and conflated with each other in the design literature and in the minds of practitioners and researchers. This appears to be due to a lack of strength across most, if not all, design fields in epistemological issues.

- Designing and design research is epistemologically more complex than many other disciplines. In part, this is because designing is interdisciplinary and in almost all situations must simultaneously address qualitative and quantitative factors in technical, social, ethical and environmental realms.

Taken together, the above factors point to many situations in which the relationships between stakeholders in design research are problematic. Developments in the disciplines and sub-disciplines of design have not yet led to a satisfactory level of mutually beneficial interrelationships between design researchers and those organisations and professions who would be expected to gain
most benefit from the findings of design research. This is in spite of the multidisciplinary field of Design Research having: strong international networks of academics, researchers and practitioners that span the very broad range of disciplines in which designing is undertaken; a broad range of international and national peer reviewed journals, conferences and other means of knowledge dissemination; and having been established for several decades.

In most countries, design research and the education of design researchers, is on the periphery of awareness of most government funding agencies, industry bodies and businesses, neglected by many design professions and professionals, and its outcomes are under utilised by individuals, organisations and governments.

This paper focuses on the ways that terminology, and concepts of design research contributes to these problems, especially through the lack of alignment between:

- Terminology and concepts specific to particular 'design disciplines'.
- Terminology, theories and concepts of other disciplines.
- The integrating conceptual and symbolic representations with which human knowledge is codified.
- Terminology, theories and concepts used by researchers, leaders and managers in business and government organisations.

The problems of these mismatches can be seen in, for example, the factors that result in large-scale funding and higher levels of government and industry awareness of the 'engineering' aspects of Engineering Design, and the much smaller funding and government and industry awareness of the 'designing' aspects. This paper argues that many of the problems lie in the lack of ease of communication between individuals in different disciplines, and that these problems are exacerbated where design disciplines do not maximise their use of concepts, theories and terminologies that span disciplines.

The paper takes a pragmatic instrumentalist position: in most cases, the outputs of designers are functionally defined. That is, in most cases, designers produce output according to instructions from others (e.g. project sponsors, managers, clients). They are rarely 'totally free artistic agents', nor in most cases would it be helpful for them to be so. From this position, theories about designing and designs are conceptually tied in two directions:

- To common languages of symbolic representation and theory used across many disciplines for representing the different aspects of the store of human knowledge.
- To restricted personal concepts and terminology of individual designers.

Tying the terminology and concepts of design research in all sub-fields of design practice to the already established languages of symbolic representation and theory is important to enabling and supporting cross-disciplinary research and the education of designers who will later work in multi and cross-disciplinary design teams. This by itself will help address the problems of terminological confusion and conflation in the design literature. Resolving the problems of terminology is central to resolving many issues of improving the way that the design field can more effectively contribute to national economic and social development.

Occasional need for localised 'designer' concepts and languages may arise when designing pushes the bounds of what is known and hence, it is possible that existing concepts, terminology and theory may be insufficient. Of concern, however, is when this occurs where designers or design
researchers have insufficient understanding and knowledge of already existing terminology, concepts, and theories, and are terminologically and conceptually ‘reinventing the wheel’.

**Constituent orientation relationships**

Constituent market orientation theories provide an effective tool for understanding relationships between stakeholders in design research, identifying improvements to the efficiency and effectiveness of individual and organisational processes important to design research, and identifying key situations in which terminological problems impact adversely on relationships between constituents. Extensive research by Tellefsen and others (Tellefsen, 2001, 1999, 1995) has indicated that orientation of members of an organisation towards other constituents (stakeholders) is a major factor in achieving satisfactory outcomes. Tellefsen’s research was based on a wide variety of organisations (235 CEOs, 244 market managers, 188 purchasing managers, 163 personnel managers, 179 union representatives, 154 PR managers, and 175 lobbying managers) and indicated that CMO findings are applicable independent of organisational type, size or discipline area and hence are well suited to proving insight into the situation of design research and its stakeholders.

Human beings cannot hold all and everything in mind, and whatever lies outside their orientation is ignored or neglected. There is strong evidence that where managers’ constituent market orientations are aligned with those constituents that have primary influence in the organisation’s value chain, this maximises efficiency and effectiveness of the organisation’s business processes and maximises quality of outcomes.

Tellefsen’s findings point clearly to significant advantages being gained where organisations involve multidisciplinary teams in which high levels of communication and learning are found. The organisation and teams benefit by teams being composed of heterogenous individuals with a wide range of expertise in different discipline areas, and where high levels of communication and learning activities exist between team members.

Constituents in relation to design research are:

- Sponsors of design work
- Organisations in which designing is undertaken
- Organisations that use outsourced design services
- Industry associations
- Managers and leaders of organisations
- Government organisations
- Governments
- Research funding agencies
- Other design researchers

There is anecdotal evidence that design researchers, like designers, have not adequately addressed constituent market orientation issues, and research and practice seems to have primarily focused on design problems, solutions and artefacts. There is some evidence, particularly from the graphic design field, that market orientation is either inadequately considered or faultily conceived with respect to some constituents. This is evident in survey findings indicating poor relationships with users, sponsors/clients, and managers in the same and other organisations (see, for example, IcoGrada, 2002, 2002, 2002; IcoGrada, 2002).

The constituent market orientation of designers and design research managers towards research funding agencies is obviously very important and is problematic. In theory, design research is funded under the aegis of Arts and Humanities research funding bodies. Many design researchers,
however, undertake research that is highly technical and the lack of fit with the Arts and Humanities research funding bodies means that, in practice, many design research projects submit their funding applications to more technical research funding bodies. This means that they are inappropriately competing against the sorts of research projects for which the technical research funding bodies were originally established. This is a consequence of confusion about what designing and design research involves and is at root a problem of terminology. The problems are due to difficulties with terminological and conceptual confusion about whether the term ‘design’ (and hence, design research) refers to an artistic or scientific pursuit, when in reality it involves both. The consequences are serious in two ways: inadequate scientific exploration of the activity of designing; and faulty reconceptualisation of the activity of designing in terms of object properties or information flows in which design research is inappropriately viewed as either engineering research or information systems research.

Another dimension of the constituent market orientation of design research is the problematic relations between design researchers. Design theories have been developed in different disciplines almost independently of each other. This has resulted in limited and parochial definitions of key terms such as ‘design’ that are directly tied to design practices in these disciplines (Love, 2000). Most general definitions are limited in scope: either because they include too much, or they exclude aspects of designing that other disciplines would include. Anecdotally, there remains political tension between the engineering design fields and the design fields whose origins lie in the art/craft traditions (graphic design, typography, industrial design, fashion etc): members of each regard the work and research of the other as ‘not really design’. At present, newer design fields (e.g. policy design, social program design, mathematical representation design, experience design, learning systems design futures design, ethical environment designing) are neglected and relatively isolated from the more established design fields. The nature of contemporary multi-disciplinary design work and design research means that these are deep and serious problems. They not only reduce the inefficiency and effectiveness of research and practice, they result in contradictions in upstream and downstream constituents’ views of designing and design research, effectively seriously reducing the effectiveness of constituent market orientations. By compromising the ‘brand and image integrity’ of the design field, it weakens the definition of designing being distinct from other disciplines and compromises requests for research funding on those grounds. Again this is a problematic issue that increased conceptual and terminological integrity would help resolve.

Constituent market orientation issues with regard to management have been defined by a neglect of managerial issues in design research and by a lack of attempts to integrate theories about designing with theories of business function, management and marketing. Again this is at root closely tied to the definitions of key terms such as ‘design’. Few definitions of ‘designing’ locate the activity within commercial contexts involving management issues whilst at the same time defining designing as distinct from other commercial activities. A notable exception is Galle’s definition that defines ‘design’ in a manner that is dependent on a commercial sponsor (Galle, 1999).

The constituent market orientation of design research as a field towards government and its agencies is perhaps the one of greatest significance because to a large extent it defines the prominence or otherwise of design research in the research funding community and in the general academic research community. Currently, the constituent market orientation of the design research community to governments has been relatively ineffective. There has been limited government funding by the UK Engineering and Physical Sciences Research Council (EPSRC) for Centres of Excellence and funding by National Science Foundation in the USA mainly delivered under the rubrics of engineering research and small business innovation research. In Australia, the research discourse is in place by the ARC (Sara, 2000) but this has not yet emerged as strong contribution to design research as distinct from science, engineering and business process research. In each of these
countries, it appears that government-funding agencies believe they are funding design research. Again, this points to terminological and conceptual confusion in which major upstream constituents with engineering, art, entrepreneurship and business management conflate ‘designing’

Constituent market orientation relationships with other constituents are similar to those described above. In each case, the confusion in design research relating to its key terms and concepts emerges in weakened constituent relations and is compounded and compounds constituent relationship problems between others, for example, between designers, users, sponsors and managers of design projects.

**Role of terminology in relationship problems**

This section draws attention to terminologically problematic situations potentially implicated in relationship problems between stakeholders in design research.

1. The design research field is split because different disciplines regard what they do as ‘design’ and try to own the term.
2. The art-craft high profile ownership of ‘design’ has meant that other disciplines such as engineering give precedence to ‘engineering’ as a ‘mathematical modelling’ over ‘design’, which is assumed to be easy and potentially automated by engineering processes.
3. Lack of an adequate definition of the role of designing in business processes.
4. Lack of an adequate definition of the role of designing in software production.
5. Lack of an adequate definition of the role of designing in education processes.
6. Lack of an adequate definition of the role of designing in leadership and entrepreneurial activity.
7. Lack of an adequate definition of the role of designing in investment practices.
8. Lack of an adequate definition of the role of designing in architecture and planning (conflicts with structural ‘design’ and civil engineering).
10. Conflict between concept of designing as a special ‘different’ activity/skill and concept that designing is similar or identical to sketching or producing artefacts. The contradiction becomes more evident where designing is assumed to take into account stakeholder attitudes, needs etc.
11. Confusion as to whether designing is an internal or external human activity.
12. Confusion as to whether designing is a human activity or one that can be automated and hence be ‘not-human’.
13. Lack of clarity about differences between designing and other closely associated activities such as calculating, information gathering or drawing.
14. Lack of clarity about the definition of a ‘design’.

15. Lack of clarity about the difference between design research and other research disciplines.

16. The identification of specific value addition due to designing is not evident in the terminology of design research.

17. Lack of clarity about the differences between designing and creativity.

18. Lack of clarity about the differences between creating a design and creating a product, system, service, theoretical construct, or an experience.

Some issues are specific to problems between particular sub disciplines of designing, and as a result are implicated in inhibiting interdisciplinary, cross-disciplinary and multidisciplinary designing. Some cause problems between designers and users, designers and sponsors/clients, design researchers and research funding bodies, and with potential research sponsors. Together they allow government policymakers to believe that if they fund business, technical disciplines and art organisations then they will by default have funded designing and design research.

Conclusions and implications
The previous sections point to a direct connection between terminological problems and problematic relationships between stakeholders (constituents) in design research. This is particularly evident in relation to the international status of design research and the funding of design research projects. Poor terminological and conceptual foundations are strongly implicated in systemic difficulties in design research and design practice.

Much of the terminological and conceptual confusion is a result of design disciplines’ conceptual isolationism and parochialism, and a neglect of epistemological issues (see, for example, Coyne, 1997; Love, 2001, 1998; Tovey, 1997). Resolving these issues may be possible by identifying conceptual common ground and redefining key terms and concepts to reflect the underlying similarities in the physiological basis of human activities in designing.

Ways forward include addressing this problem formally through a cross-disciplinary association such as the Design Research Society. Other alternatives include continuing pressure in the design research journals by individual researchers whose work is adversely affected by the lack of coherent conceptual and terminological foundations and by adverse comment by professionals in other fields (including government) about the problems involved in relationships with design researchers and designers.
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Are ‘the reflective practitioner’ and ‘learning cycles’ suitable foundations for theories about designing and design cognition

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Abstract

This paper challenges the use of the concepts ‘reflective practice’ and ‘learning cycles’ as a basis for analysing designing, for building coherent theories about human designing, and for developing design methodologies. It develops the argument via two paths: a review of the original formulation of the concepts of ‘reflective practice/practitioners’ and ‘learning cycles’; and an analysis of the implications of recent findings in the areas of brain and neurology research for building theories about designing. The paper suggests researchers have over extended the use of the reflective practice and learning cycle concepts: concepts that were devised as relatively coarse structural formulations bringing together some of the more obvious macroscopic characteristics of individual human functioning for business consultants and educators. It argues that new micro-level understandings of design cognition emerging from brain and neurological research offer a better basis for building theories about designing.
Are ‘the reflective practitioner’ and ‘learning cycles’ suitable foundations for theories about designing and design cognition

Introduction
In the design research literature, concepts of reflective practice and its close associate ‘learning cycles’ have been widely used as the basis for building design theories (see, for example, Craig & Zimring, 2000; Dorst & Cross, 2000; Dorst & Dijkhuis, 1995; D A Schon, 1992; D A Schon & G, 1992; Stumpf & McDonnell, 2002; Valkenburg & Dorst, 1998). This paper asks whether these concepts are epistemologically and practically sufficient as structural foundations for developing design theories that provide full explanations of the human activity of designing and how humans interact with designed objects. It argues that the theoretical foundations of design research reach much deeper, and that the concepts of ‘reflective practice’ and ‘learning cycles’ are in fact peripheral, and relatively superficial, models. The paper suggests that models of reflective practice, learning theories and learning styles essentially model the external phenomena only and are thus not epistemologically well aligned in purpose with modeling an activity such as designing that is intrinsically an internal human process. It suggests that the justifiable use of these concepts of experiential learning does not extend beyond their roles as aids to developing educational programs, as accessible constructs for students of design practice and design management, and presentation aids for consultants involved in improving design management.

Brain research is now offering direct insight into the actual internal human processes of designing. This is a significant change in the design research field. Until recently, design theory making has been severely limited because research-based understanding of core aspects of human activities in designing could only be inferred by observations of external behaviours of designers and externally observable phenomena. The consequence has been that theory making efforts have been deflected into building theories about designing in terms of the structure and sequencing of externally observable activities; the properties of objects (forms); information used by or transferred between those involved in designing; models of social interactions; and human cognition, itself described in terms of these factors. What has been neglected is the essential core of the field: the human internal processes of designing, i.e. how humans design.

Trying to model the human activities of designing is difficult: the human processes are complex. Attempting to take theoretical shortcuts to avoid this complexity by focusing only on superficially accessible information about the external attributes of the phenomena and the human behaviours raises similar epistemological and practical problems as trying to infer the internal electronic circuits and software code of a calculator by observing the contents of its display, or trying to infer the program code of a word processor from the content of documents that have been produced using it.

The paper has five parts. In the next (second) section, the reflective practitioner, learning cycle and learning style models are briefly reviewed. In the third section, research findings about the key roles that feelings play in cognition and hence designing are outlined in terms of new findings about the physiological mechanisms by which feelings, emotions, cognition and actions are actualized. In the fourth section, the issues raised in sections two and three are discussed in terms of the construction of sound foundations for design theories. In the final section, the conclusion, a new structure is outlined that repositions the reflective practitioner and learning cycle/style models in design theory, design research and design education.
Reflective practice and learning cycles/styles

Schon’s theories of reflective practice, reflective practitioner, and reflection in action originate in his research into experiential learning and experience-based action undertaken in the 1970s with Argyris (see, for example, Argyris & Schon, 1978, 1974; D A Schon, 1983; Donald A. Schon, 1973). The primary purpose of this research into individual and organisational learning was the aim of improving the effectiveness of managers and consultants offering services to increase organizations’ performance. The theory base of action/experiential learning/reflective practice goes back, however, at least to Dewey’s (1933) work on experiential learning.

Schon (1987) focused on two kinds of practical reflection: ‘reflection-in-action’, in which the reflection is undertaken during a task; and ‘reflection-on-action, in which the reflection is done away from the task. Schon differentiated between:

- Espoused theories – the theories that people say underpin why they do things
- Theories in action – the theories that actually underpin why people do things
- Reflection – theory that gives feedback into either theory and experience

In exploring the theory aspects of how people best gained from their experiences, Schon focused on five processes:

- Undertaking an action
- Reflections on experience of that action
- Using a theory
- Reflections on using that theory
- Reflections on the idea of reflecting about a theory of e.g. action (meta-theoretical reflection)

Kolb and Fry developed an alternative approach to experiential learning in the mid-1970s (Kolb, 1975). From this research, and that undertaken earlier by Lewin (e.g. Lewin & Cartwright, 1952; Lewin & Lewin, 1973), emerged the Kolbian learning cycle of ‘concrete experience’ > ‘observation and reflection’ > ‘forming abstract concepts’ > ‘testing these abstract concepts in new situations’ > ‘more concrete experience’ etc. As Ekpenyong (1999) inferred, this can be seen as an unpacking of the simple behaviourist stimulus-response (S-R) theory to provide room for a theory of learning. The experience of Kolb and other educators and consultants in applying the learning cycle in educational and consultancy situations indicated that individuals performed better and were more enthusiastic about some parts of the learning cycle than others. This pointed to potential benefits from categorising individuals in terms of learning styles predicated on their preferred part of the cycle. These he called Convergers, Divergers, Assimilators, and Accommodators (Kolb, 1985: 61-95). Kolb’s learning styles sit between axes on the learning cycle. Alternative learning style categories by Honey and Mumford (1982) (Activists, Reflectors, Pragmatists and Theorisers) locate learning styles on the cycle axes. Like the Myers-Briggs and personality types, the cultural roots of Kolb’s (and presumably Honey and Mumford’s) ideas on learning styles were Jung’s personality types (Kolb, 1985:78).

These theories about reflective practice, learning cycle and learning styles are grounded in observation of the behaviour of individuals, groups and larger organisational arrangements. These observations were made and theories developed alongside a conceptual backdrop of models and theories from education and psychology. The discourse within the material indicates that the development of these theories is marked by four significant, but often tacit, factors:
• Theory is built on a stimulus - response focus on observable behaviour rather than an understanding of causal mechanisms.
• Theories tacitly assume and presume models of internal human functioning such as cognition. Where explicit these are also predicated on observation of external responses rather than knowledge of internal processes.
• Epistemology of new theories, and new theories themselves, drawn relatively uncritically from fields of Psychology and Education.
• Theories built on simple mathematical relationship models, e.g. linear relationship, feedback relationship, circular relationship, oscillatory relationship.

Neurology and physiology as foundations for design theory

Theories of affective cognition model the ways that feelings, body states, conscious and subconscious thoughts, attention and memory processes influence, or ‘cue’, the formation of new thoughts and the processes of successive thought development and management (see, for example, Bastick, 1982; Damasio, 1994; Love, 2000; Mosca, 2000; Ridley, 2002).

Unlike the above simple models of reflection in action, reflection, learning cycles, and learning strategies and styles, a physiological understanding of how humans design is complex. The complexity is not born of obscure medical and biological concepts: it is that the processes that go on inside human’s brains, neurological, hormonal, visceral and other physiological systems are intrinsically much more complicated, even when the description is limited to understanding them in terms of the embodied information flows. For example, viewing brain and body processes at a general level, Damasio (1994, pp. 127-164) describes more than a dozen different neurological and hormonal pathways and at least ten feedback systems involved in an individual’s perception of an emotion (not including the cognitive processes such as visualising, bringing out memories, judging, creating new thoughts, or deciding on actions).

When designing, designers convert problem statements into internal problem gestalts and draw on their experiences, bodily perceptions (feelings), emotions and external information to generate multiple partial solutions to these problem gestalts, compare them imagically ‘in their mind’s eye’, and communicate these partial design solutions and their associated ‘design worlds’ to others. It is this level of analysis that is needed for design researchers to have a sound understanding of how people design, and how people understand, and learn to utilise, designed artefacts, products, services and systems. Understanding designing and creating the foundations of design theory in reality requires an understanding of the dozens of separate physiological, neurological, informatically embodied feedback systems.

In terms of physiological systems, there are several processes / responses that offer a basis for the reflective practices described by the experiential learning theories of Schon and others. Cognitive neuroscience models differentiate between two affective system pathways, one of which passes through the frontal cortex and one that does not. For those aspects of affect that pass through the frontal cortex, some may be available to conscious attention as ‘body states’, i.e. feelings or quale (John Dewey, 1895), whilst others come into consciousness as pre-conceptualised entities or cognitive artefacts (objects in the mind’s eye) realised in the imagenic aspects of the brain.

Each of these form a causal foundation for reflective or experiential learning by which the human organism responds and learns. The differences between these can be seen, for example, in the potential responses from an individual putting a finger too close to a candle flame:
1. **Subconscious primitive learning mechanisms resulting in near instant removal** – in which ‘reflective’ processes do not pass through the conscious mechanisms of the frontal cortex but instead involve subconscious primitive that result in a faster/stronger ‘instinctive’ response next time a similar situation happens.

2. **Response based on the individual’s conscious perception of their somato-sensory body-based feelings:** whether direct feelings as in ‘hotness of the fingers’ or of the kineasthetics of movements, or other body state parameters such as palpitations and muscular tension.

3. **Response based on the individual’s attention to the situation as expressed in terms of cognitive artefacts:** (such as ‘flame’, ‘finger’, ‘heat’ and ‘candle’) that are, in whatever way that they are individually conceptualised, available to the individual’s thinking from their prior learning.

4. **Secondary somato-sensory grounded reflective feedback:** due to the individual’s perception either at the time or later of the above three processes.

In working situations, the above somato-sensory ‘reflective’ processes combine with other information-based reflective processes. Consider a situation in which a professional in their normal activity undertakes a task involving an aspect of reflection. Key elements are:

- The actuality of the task
- The gestalts and contexts within which the task is undertaken
- Their access of memories of previous similar tasks, gestalts and contexts
- Their access of memories of outcomes of those tasks and gestalts
- In some cases, their access of memories of situations and gestalts prior to undertaking those similar tasks
- Their access of memories of their reflection on the tasks, gestalts, contexts, prior considerations and outcomes
- Their access of memories of their judgement as to the quality of their reflective processes
- Their access of memories of their decisions, judgements and heuristics that they developed as a result of the prior reflective processes
- Their analysis of differentiating factors
- Their judgement processes that support the professional choices they make in identifying guidance from these past analyses that influence current behaviour
- Their access from memories of the reflection and reflection processes

For each of these information processes, one or more of the four responses in the previous list may apply. The combination indicates the number of aspects of a simple practical reflective task that need to be included and addressed by an adequate theory of reflection.

For reflection relating to the human activity of designing the situation is considerably more complex than that described above because it also has to include a description of the ways that reflection activities influence the complex processes associated with the generation of new thoughts: including the simultaneous (or almost so) processing of technical, social, environmental, ethical and aesthetical information with all its necessary reflection and brain-body/feeling-thought processes. In addition, alongside these issues must also be added the processes and physiological pathways associated with designers’ communication of their partially conceived problem statements, ‘design worlds’, gestalts, partially completed solutions, and the relative evaluation of
those solutions between designers and other stakeholders. Together, they indicate that a reflective practice model that satisfactorily explains sufficient of the real human processes to provide a full explanation and model for improving the outcomes of design activities is considerably more complex than ‘reflection’ theories based on external observations of individuals’ behaviour.

Discussion

The development of coherent design theories requires that they are grounded on epistemologically sound foundations capable of supporting required analyses. All forms of theory about designing explicitly, or tacitly, assume and presume particular underlying theories of human functioning. Theories derived from the external characteristics of objects, here including human behaviour, cannot, by their nature, definitively explain or model the internal workings of the objects or, in this case, the internal human processes. The layered nature of theories; in which individual theories provide assumptions for less abstract theories and depend on more abstract theories; means it is not possible for theories that depend on or presume an internal human mechanism of designing to explain that mechanism.

Four core issues that a body of theory about designing and designs must address are:

1. The explanation of how designing occurs inside an individual.
2. The modelling of how users’ internal processes shape their interactions with design products, services and systems.
3. The creation of new thoughts.
4. Closure, i.e. the internal human conscious and unconscious automated processes that stop, start, continue or redirect human external and internal activities.

The sketches in the preceding section also point to a more complex view of learning and reflection processes than that described in the reflective practice and learning cycle/style literatures. Human activity at an individual and social level is more complex than the reflective practice/reflection in action and learning cycle/style models indicate. Schon’s theories of reflection, action and practice, Kolb’s learning cycle and the learning styles of Kolb, Honey and Mumford have major limitations as foundations for building design theories because of their grounding in external observation of practice, rather than an understanding of what happens inside humans whilst they are involved in designing. They are unsuited to being foundational to theorising about designing because do not provide the data or theoretical means to infer and model deeper underlying processes of human functioning by observing the superficialities of behaviour and practice. This is a limitation that Schon was well aware of from early on (D. A. Schon, 1987). He identified that what was really needed was a model of human cognition derived directly from an understanding of human cognitive processes and not based on observing behaviour. One way of seeing Schon’s theories of reflective behaviour is that they are an approach that aims to make the best of a difficult situation limited by the lack of information about human internal processes, and an attempt to maximise the theory making potential available from external observations and individuals’ subjective perceptions of their own thoughts, experiences and feelings.

Another way of viewing this situation is in terms of theorising about the internal functioning of a ‘black box’: an approach widely used in systems analyses. (A ‘black box’ being one that nothing is known about its internal functioning. A ‘white box’ is one in which everything is known about its internal processes. A ‘grey box’ is somewhere in between.) The models of Schon, Kolb, and Honey and Mumford regard humans as a ‘black box’ and do not look inside the box. Their theories model the relationships between humans’ inputs and outcomes rather than trying to understand the feelings and thoughts and internal human processes that are the causal basis of the humans’ ‘outputs’. In epistemological terms, these are theories about the behaviour of objects rather than theories that
explain why human behaviour occurs. The use of ‘black box’ systems theories as tools for
developing predictive and explanatory models is however always limited by lack of knowledge
about the processes inside the ‘black box’. The data about inputs and outputs that is collected, by its
nature, cannot be used to formulate theories about why the behaviour occurs or why and how the
underlying processes and mechanisms are likely to produce other sorts of outcomes. In essence, the
theories are at the level of explanations such as ‘pressing harder on the brake results in the vehicle
decelerating more’ rather than an explanation of how the brake system works and why pressing on
the brake pedal will result in the consequent changes to the vehicle’s speed.

The essential foundational aspect of designing, the creation of new thoughts, the management of
gestalts, the communication of partially completed design possibilities between designers and other
stakeholders in design processes, the interpretations and understanding of function embedded in
designed artefacts, systems and services all depend on underlying human embodied processes.
These can only adequately be explained in terms of the physicality of human processes, i.e. the
moment-by-moment, conscious and unconscious events and processes that result in doing and not
doing particular activities, thinking and not thinking particular thoughts.

The above analysis also points to the weakness and, at this point, failure of traditional rationalist
theories of cognitive science in explaining human designing and the ways that humans interact with
actualised designs. Epistemologically, practically and pragmatically, the only ways to establish
sound foundations for building theory about how human beings undertake designing, and how they
interact with designed products, systems and services is to focus on the internal processes revealed
in the physiology of real humans.

As a postscript to this discussion, it is necessary to acknowledge that theories about reflective
practice, learning cycles and learning styles have been attractive to design educators and
practitioners. In most cases, it appears that the reasons are because they offer political benefits
rather than because they provide sound theory foundations. The most obvious benefits are that they
align well with ideas that:

- Design learning as a master/apprentice relationship
- Design critique and evaluation should be based on designers ‘explaining’ their designs or
  that designs should ‘explain’ themselves
- Experiential learning supports arguments that design education should be based on craft
  skills training modalities.
- The learning cycle echoes simple models of design process in which a practical design
  problem is explored, some ideas for solutions are conceived, these ideas are investigated and
  tested, and eventually a plan is chosen or confirmed as a new idea/design.
- The segregation of professional expertise into categories indicates that designers are a
  unique breed. The learning style divisions fit well with customary biases that designers must
  by nature be divergent and free thinking, whereas theoreticians are assimilators building
  models of things, engineers and scientists are convergent appliers of models, and
  professionals such as managers and manufacturers work with models in concrete, real
  environments.

If uncritically viewed, the learning cycle also provides justification for a description of designing in
which the designer/practitioner starts off from a concrete situation, reflects on the situation, and as
a result of that reflection, produces ideas, and then experiments with them to create new knowledge:
a description that can be interpreted to imply that design practice should be viewed as identical to
research.
Conclusion

Building sound underlying theories about the activities of designing and the ways that humans use designed outcomes requires a different and more fundamental approach than that available through theories of organisational and action learning such as the theories of reflective practice, learning cycles, and learning styles described earlier.

The development of foundation theories in the areas of designing and the use of designed products services and systems must go deeper than theories about individual’s reflective practices, sequences of learning, or simple categories of learning styles. In epistemological terms, these latter models lie alongside design theories rather that offer foundations for them. Theories based directly on the underlying human physiological mechanisms of designing, and the embodied mechanisms that underpin how individuals interact with designed products, services and systems and other aspects of their external environment offer a sounder foundation for a body of knowledge on designing and designs. This has not yet been adequately developed in the design research field.

At a pragmatic level, contemporary brain research is beginning to offer simple heuristics on which to build higher-level design theories. Evidence is emerging that supports some socio-psychological theories such as the role of attention in Constituent Market Orientation theories, and points to weaknesses in others as described above. It also offers direct causal explanations (Damasio, 1994) for anecdotal concepts such as:

1. Light complex, innovative fast modes of thinking are associated with positive, happy, relaxed body states.

2. Slow, repetitive, limited thinking – associated with tense, negative, painful, distressed body states

In summary, theories of organisational psychology and experiential learning (such as reflective practice, learning cycles and learning styles) offer consultants and managers models that indicate that if certain things are done then certain consequences are likely to result. For educationalists, they indicate that some educational approaches are more likely to be effective than others in specific situations when assessed against particular criteria. For those involved in managing organisational learning processes in commercial organisations, they offer both. Their use as theory foundations is, however, epistemologically unjustified.

For design researchers wishing to build theory on sound foundations, the human physiological mechanisms that underpin human creative thinking, feeling, values, judgement, decision-making and motivation are more appropriate.
References


The Æsthetic of precision in virtual design
What are the implications of precision in the use of computers in the modelling of architecture and interior design?

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Abstract

It is suspected in design education, that the use of computer representations of design, especially 3D modelling, tends to limit design outcomes in some ways while at the same time appearing to offer greater opportunities to explore new ideas in others. Virtual space in design becomes a province of isolation, often noted for its limited view of design. Precision itself is a style of argument (rhetoric) for design, conventionally accepted in such pictures as working drawings. The precision of the drawing itself is denied in order to make way for precision in the concept. The return of the æsthetic of representation as an æsthetic of precision is the result of the denial of pleasure of drawing. It is a drive to find pleasure in the concept itself through precision of representation as measurement of the design as material; an æsthetic of precision.

The computer model, which simulates the design within its simulated Cartesian space, becomes the most precise place for the design to exist. Within an æsthetic of precision, this becomes the best, most complete version of the design. It is therefore a conceptual precision modelled rather than a perceptual precision, that is seen. The phrase "more real than real" expresses the character of computer modelling and image making, as it is regarded within the æsthetic of precision. The computer produces a representation of intelligence that is offered as a reality. For design this means that the material purposes of, for examples the physical body, lose their intensity. Thus a new formal virtuosity is possible.
The Æsthetic of precision in virtual design
What are the implications of precision in the use of computers in the modelling of architecture and interior design?

Introduction
It is suspected in design education, that the use of computer representations of design, especially 3D modelling, tends to limit design outcomes in some ways while at the same time appearing to offer greater opportunities to explore new ideas in others. Anecdotally, this seems to be shown in student work where computers have been used, especially for modelling architecture and interior design in three "dimensions". Virtual space in design becomes a province of isolation, often noted for its limited view of design. Work produced using virtual modelling seems to all have the same "look". This effect is usually thought to be caused by the complexity of the software and/or the prefigured nature of the default actions possible in that software. It seems that the limitations of the equipment are appearing in the work that it represents.

This argument is of the same kind that says that architecture is rectilinear because drafting equipment makes orthographic drawing easier than curvilinear or free-form drawing, especially in terms of measurement.
The argument presented visually, goes like this:

Figure 1: Diagram of the argument that presentation influences design. (Image prepared by the author)

The shape that is expedient in the representation process is that which tends to occur in the final design.

This of course is a generalisation. There have been many buildings before computers, that have curves that are notoriously difficult to draw. For example, the Sydney Opera House, conceived using models cut from spherical sections (the orange slices). These buildings have been extraordinarily complex to draw and can often only be determined from models. Even the invention
of curves such as the Bezier curve, have not made the process of manual representation that much easier.

Computing has made, it seems, complex building shapes involving, for example curves, far more accessible, even easy to represent, in a way that is measurable and build-able. It has made the three dimensional visualisation of buildings as two dimensional images, as in free-hand perspective sketching, unnecessary. Computing it seems, has made the measurement of almost any shape possible in a fast, precise and reliable way.

The computer though, is the expression of a Cartesian spatial concept. This concept is that space is a measurable void, defined according to dimensional axes. The definition of locations is made using "Vectors" which are locations according to the dimensional axes. These Vectors are made in relation to an 'Origin', that in the computer has become completely freed from any actual locality. Vectors are now place-able at any point within the conceptual space. Combinations of vectors have made objects which have the same freedom of location, including freedom from gravity. Has, in the virtual world of the computer, Cartesian space been fully realised? Is this an abstracted Euclidean dream. If so what does this mean? Is this the completion of a cycle that predestines a profound change in thinking, especially in design?

It is not intended here to examine the historical relationship between the technology of representation and the production of built work with which it was associated. That the rectilinearity of buildings and the technology of the drawing board are part of the flux of Cartesian thought is not questioned here. The measurement of the degree of precision within which computers can work and the extent to which that degree is asserted as measurement of quantity itself, while having bearing on the discussion is not the primary focus either. Neither is it the purpose here to examine examples of rendered images from computing models in an attempt to find the golden egg within the dissected corpse of a digital goose. The influence of communication technology on design is assumed. What then, is the focus of the paper? The primary focus is the consequences of a specific form of representation

If computing is to become the primary mode of communication, what would this mean for the fleshy human constellation? The question of precision is used as a focus for this issue because precision is the argument by which the computer is gaining or has gained ubiquity in design.

The æsthetic of representation
The æsthetic of representation has been the target of certain branches of philosophy of art during the 20th century. This æsthetic had been the mainstay of western philosophising about art since the Greeks. The articulation of art as "picture" in which an opposition between representation and abstraction has been made throughout western philosophy from Aristotle but only really became fully determined during the European Enlightenment. Perhaps Immanuel Kant has, in his Critique of Judgement [1], best summed up the European position for the æsthetic of representation and indeed the universality of beauty as taste (sensus communis) [2]. Conversely, the self criticality of modernism, in which the "æsthetic life" becomes pride in one's self conscious dignification of humanity through "dis-interested" curiosity, is best expressed in 1863 in the French poet and writer, Charles Baudelaire's, "Painter of Modern Life". [3]

In Kant's model, representation equals presentation of the visual sensation of a natural thing in a simulation. The recipient of the sense of a thing is a passive (disinterested) recipient if the sense of the thing is to be sensed clearly. Thus representation and by inference, art, can only mimic nature and thus cannot add to knowledge, unlike science. Art is "fine" because it is judged and science is true because it is reasoned. [4]
The business of representation then, is to, through careful observer neutrality, make more and more precise judgements about the sense of things, thus bringing about better art. Thus "fine art", as Kant calls it, pursues precision. In this model beauty is in the sense of the thing and is the same beauty that is found in nature and is not arguable as such, merely sensible.

We may generally call beauty (whether natural or artistic) the *expression* of æsthetic ideas. [5]

Taste on the other hand, is arguable due to it being about judgement. The following from Kant explains his position,

“As we have frequently shown, there is an essential difference between what we like when we merely judge it and what gratifies us (ie, what we like in sensation). The second is something that, unlike the first, we cannot require of everyone”. [6]

It is this second thing, taste, that is "argued" for in representation, which perhaps explains it tendency to the grammatical, from which, for example, perspective gains its "truth". As Hubert Damische writes in *The Origins of Perspective*,

Its [perspective's] function as a paradigm extends much further, or deeper, providing painters with a network of indexes that constitutes—I posit this hypothesis again—the equivalent of an expressive apparatus of sentence structure, ... [7]

For design, it is what Damische calls *Perspectiva Artificialis* [8], that is to say the constructed simulation of three dimensional image of a concept in which the design ideas are "expressed", as Kant would put, takes place, but also in which precision is the means by which design is more accurately *argued* for through that precision. Precision itself has become a *style* of argument (rhetoric) for design, conventionally [9] accepted in such pictures as working drawings.

In the drive for accuracy in the prediction of the flow of reality, precision has become an abstracted goal in itself. In drawing and especially drafting, it has developed according to its own æsthetic of precision, in which an special form of reductive abstraction has found a home.

Drawing for the purposes of construction exhibits a certain style readily adopted by designers but with a certain reservation; that it is drafting for draftsmen [10] and is within the tradition of the drawing office. The style of lettering of hand drafting for example, is *de rigueur* for architects, who seem to be perfectly willing to use the style even though in most other aspects of their practice they assert originality and independence. It is as if the style of hand lettering is a badge or sign of that independent tradition, a paradox to be sure, when it is put like that.

The ubiquity of an architectural style hand-lettering is evidence of a universality of thought, if one regards handwriting as a significant form.

The precision with which the system of hand lettering of orthographic and in particular, "working drawings", is adhered to fiercely by architects and is now also used by interior designers is now far beyond the needs of communication of material meaning. The establishment of computers in drawing offices has left the tradition of hand lettering largely unaffected. It has though, meant that it is no longer the practice among draftsmen.

The beauty of drawing has been found, for the draftsman in the precision achieved in and for the drawing itself. The traditions of the design for decorative art and craft show the same need to satisfy an æsthetic idea in the representation of design. The result of the "craft" approach is that there is a desire for æsthetic unity in the representation and the product itself. The craft of representing is the expression of the truth of the design as an aesthetic experience. The shading and linework are an attempt to represent the actual physical presence of the object.

Figure 3: The Aesthetic unity of craft and design in representation, from Cliff, S, (date unknown), *The English Archive of Design and Decoration*, Thames and Hudson, London, p91. The drawing is from the "set of albums in the collection of the Victoria & Albert Museum, London, believed to be the production records of Messrs. Hartley Greens & Co....1802." (p64).
The precision of the representation works within the same tradition of design, not against it or in an attempt to re-figure the tradition in an avant-guardist way, in this approach. Colour for example is described by "actual" colours, for example gouache or water colour, rather than the written notes one finds in the representations of early 20th century design. The extension of this text representation is the use of colour systems where colours are defined according to codes, as are supplied by paint manufacturers. The precision of the drawing itself is denied in order to make way for precision in the concept.

Figure 4: "The Modulor", from Le Corbusier, *The Modulor*, Faber, (1963: 237, fig. 100)

It is in the early 20th century industrialised modernism that the æsthetic of representation changes from unity to divergence (from the design), according to the "break with the past" that is usually characterised as modern or avant-garde. This break is shown by a break with the craft aesthetic in which there is a denial of the pleasure in the making of the image.
The suppression of pleasure in the representation of design, along the lines of all repression results in a return, in some other form.

In Baudelaire's essay the "painter" becomes proud of the curiosity that he self-consciously directs toward his fellow man and thus reduces his life to an æsthetic image of himself as a good person, interested in humanity. The universality of beauty becomes a means of attaching value to oneself. Instead of entering communitas, communitas becomes the object of observation and thence possession for the disinterested subject. It seems as though the adoption of purely æsthetic sensibility deprives one of a motive for morality and ethics. In this kind of approach, art becomes a process of representing without engagement or commitment and a purely private pleasure in the consideration of the public object. Precision becomes a matter of mechanical reproduction for the purposes of pleasure, thus opening the way for objective industrialised design and a determination for the æsthetic of precision within the concept. LeCorbusier's design concepts would not have gained ground without the dissociation of the public self from æsthetic pleasure; one was not allowed to say the design was ugly if it could be shown to have an arguable concept.
The Bauhaus and illusion
For the Bauhaus [11], representation, according to the Kantian tradition, was found to be a bad thing. It was thought to be "Illusion". The intriguing thing about this is how representation of the natural world became associated with illusion and how illusion became a kind of 19th century decadence, rejected by the remaking elite of early traumatised 20th century Europe.

The concept of "illusion" as a thing to be avoided, was elevated in the Bauhaus, perhaps a legacy of or a relation to Russian Constructivism through the arrival there of Laslo Moholy-Nage [12]. Representation, especially in colour, was the means by which illusion found a home. It was the Kantian "Genius" of production that the Bauhaus was pursuing rather than the mimicry that representation implied. It was the objects that could stand alone as beautiful, not due to what they might represent they were after. As Kant wrote:

"Judging beautiful objects to be such requires taste; but fine art itself, ie, production of such objects, requires genius". [13]

In the drive to assert a distinct way of being through industrialisation, the Cartesian subject-object binary model was stripped of its ambiguity. Two dimensions were to be only two dimensions and three were only to be three.

The Genius was to be a machine for designing. "Everyone is equal before the machine" said Moholy-Nage [14]. Percept and Concept [15] became entirely separate entities within the opaque Formalism of the second Bauhaus, thus marginalising the work and ideas of Kandinsky and others. The insistence on positivistic materialism resulted in the relegation of spiritualism to an occult, "spiritualistic" function, not associated with the "real world", but with the 19th century mysticism, mediums and seances. Paradoxically, it seems, it was the formulation of concepts as "real", material things, as percepts that was the main interest of the Bauhaus. Moholy-Nage was determined to assert the "surface", the thing as a truth in itself, no depth in painting and one meaning for all things; the material meaning. It was the assertion of a concept over perception itself, all under what Walter Gropius called the opaque formalist "Great wing of architecture" [16].

And so it is the concept of form itself that replaces the percept in this idea. It is in this context that the pleasure of representation is regarded as deviant, even criminal in some of the more shrill declamations from De Stijl theorists at the time:

"We have given colour its rightful place in architecture and we assert that painting separated from the architectonic construction has no right to exist". [my italics] [17]

In many of the drawings from the Bauhaus, there is a certain self-conscious incompetence in representation, despite the æsthetic of the design. The "Engineer's Æsthetic" [18] seems to involve the loss of drawing skills as if these are the mark of the flesh; a flesh that must be eschewed in the drive to be like a machine, or at least a part of it.

Drawings intended as the pattern or "direction" from which reality is given its "reality", have developed according to this machine-like denial of incarnation. It has become an æsthetic of denial, in which the pleasure returns under the conditions of materialism: measurement. From measurement comes the elevation of the value of precision; the orthographic projection is the most valued image in this æsthetic because it tells no dimensional lies, it is perfectly flat and conforms to the physicality of the object itself through its scale.
Orthographic drawing has thus developed its own need for precision apart from that required to satisfy the processes of manufacturing and construction. The æsthetic of this kind of drawing has its own philosophical orientation apart from what it may be representing in design. This must have a bearing on the perception and reception the design itself.

In summary, the return of the æsthetic of representation as an æsthetic of precision is the result of the denial of pleasure of drawing. It is a drive to find pleasure in the concept itself through precision of representation as measurement of the design as material; an æsthetic of precision.

This being the case, what the consequences of the æsthetic of precision are when computing takes that aesthetic to a new level, a new extreme?

**Precision and the computer**

The computer has enabled the manifestation of an æsthetic of precision in its most complete form yet, especially in the creation of "photo-rendered" images made from electronic models and the precise measurement of those models. The precision though, is also extended into the calculation of the means by which the design will be made; quantities and processes. The measurement of the concept only possible in the orthographic projections (plans, sections and so on) is now possible in the *perspective* drawing itself. Measurement is now possible of lighting models, sun and shadow charts, colours, scale, textures quantities, assembly, manufacture and even maintenance and usage of design of all kinds, within the perspective image through the electronic simulation of Cartesian space. [19]

It is the satisfaction of the need to *see* the concept as *quantity*, that the computer gains its power. The visualisation of a concept called a "design", as an *image*, means that the design is not actually entering the negotiated world in which the senses are brought into focus by the gathering of a self into a body, but rather the concept is made *visible* only, as an image of its post negotiated form. And yet this is measurable and therefore a form of truth! In this form, it conceptually needs *no body*, only an electronic simulation! This though, in its form as truth, is only possible when one is prepared to believe that the visible alone is "real".

Design is made in the computer from which drawing projections are measured, from which measurements of all kinds are made. The computer model, which simulates the design within its simulated Cartesian space, becomes the most precise place for the design to exist. Within an æsthetic of precision, this becomes the best, most complete version of the design.

For most of us though this is not the case; we need to imagine that we can touch, smell, hear *as well* as see the thing for it to really *be* a thing. When sound is added to an image, as in the cinema, the difference between hearing and sight gives us a negotiation with to bring a body and ourselves into focus and so make a "thing" and a "self" just that bit more real. As Merleau-Ponty writes in his last book, *The Visible and the Invisible*:

“...my synergic body [...] assembles into a cluster the "consciousnesses" adherent to its hands, to its eyes, by an operation that is in relation to them lateral, transversal;...that it is sustained, subtended, by the prereflective and preobjective unity of my body. This means that while each monocular vision, each touching with the sole hand has its visible, its tactile, each is bound to every other vision, to every other touch; it is bound in such a way as to make with them the experience of one sole body before one sole world...” [20]
An idea, the Real, is made from the negotiation between what Merleau-Ponty calls the "five notes" and the "family of sensibles we call lights." [21]

Virtual reality offers a completed visible reality, one that precludes the body of the observer. The touch of virtual reality is solely the fingers on the keyboard or the hand on the "mouse", that has a distant and strained relationship with sight, not like a body at all. This is of course why virtual images remain unreal, no matter how realistically imitative they become. The negotiation is already done and the body is not required, at least that is how it seems. The computer offers the appearance of pre-negotiation but in fact it offers a monocular vision presented to each eye related to a touch of the keyboard as a form of body-world. Its argument within the process of negotiation need take not account of the flesh, thus allowing precision in a more achievable setting.

To make a very precise visible image is therefore to assert a visible truth very precisely without the body, a truth that relies on that electronic digitisation of precision for its true-ness (not the eye and the ruler, even). It is therefore a conceptual precision modelled rather than a perceptual precision, that is seen. Even in the most limited tolerances of industrialised manufacture (the extended or supplemented body), are exceeded in precision by the modelling possible in the computer.

Within the computer a complete simulation of the "real" is now possible, at least for buildings, that goes well beyond naturalistic representation. The phrase "more real than real" expresses the character of computer modelling and image making, as it is regarded within the aesthetic of precision.

This "Super-reality" is taken as a more precise version of the truth of design than the final made object, exactly because it is more precise. Computer simulations satisfy a conceptual need that has been present in design work from its inception; that need is to make visible the concept itself. The character or identity of that concept is part of that need. It is precision that is the central character of the need for conceptual expression in computing. This need for precision is an end in itself in this. It is the end towards which the philosophy of subject-object metaphysics has made its way through science.

Æsthetic precision is pure expression through representation, of the pure thought of the concept; the establishment of Res Cogitans [22] as natural. It eliminates percepts from which concepts are constituted [23] through the simple belief that one has all the information within the concept itself, or at least its representation, modelled in the computer.

The mind is separated from the body as a form of perfection, but perfection as a (re)presentation of perfection as a concept. Thus precision is the end of the body as a reality. The way is open for fantasies of disembodiment and dislocation; the body becomes an object that can be discarded and replaced with the more perfect machine. The identification of the body as a person though, is a twist of the proverbial Deleuzian rhizomic web. It is both of the web and yet a knot within it. The body is a self while simultaneously it is of a species, while it is matter, and chemistry, and genetics, and race, and a nationality and so on. The self exists also as a point of focus within which linguistic acts drag being into matter, giving things their thingness; their "Dasein", their being-ness. Thought is the circumscription of events within the given language of the senses, that focuses being. The body is a product of thought finding its self in perception. The body then, is thought.

If precision is denying the body, it is cutting off the means of thought from the mind. To make it work it must replace the body with a "thinking" machine; the computer. The computer though, only produces the representation of, or a sieve-like image of thinking, with electronic bytes separated out into their relative sizes and shapes according to the requirements of the digital grid. Thought is then
replaced with the *image of thought* just as action is replaced with the image of action on television. The computer produces a representation of intelligence that is offered as a reality.

Is this the image of the thought-body replacing the perceived body?

The image of thought, because it is a reflective state rather than an entered embodied state carries an agenda of dislocation. It is thus through computed precision, as an ideal, given representation in the machine, that humanity will be excluded from its own perception and thus its own designs, its own body. It is only in the mass manufactured precisely designed industrial objects of hygiene that can approach the precision of the electronic machine, that will still be open to humanity as a body; the tooth brush. Their reality will seem strange, like the images of alien space craft seem strange in science fiction. Thus there is no room in the computer for a fleshy percept. In order to exist within precision, a self comes in which the machine is the flesh.

The feeling of everyday becomes a feeling of the machine. The hard surfaces of the senses become unreal. The self-world formed as a negotiation between the senses becomes less "real". The modern strangeness that Louis A Sass compares to schizophrenia in *Madness and Modernism, Insanity in the Light of Modern Art, Literature and Thought*, [24] becomes the everyday state for those in virtual space. In virtual space that is valued for its precision, this strangeness of the sensory percept will be more extreme, making the virtual world seem safer, more complete, more real. In this context design tends to be less related to the fleshy functions of the body; movement, scale, enclosure, surface texture, sound and shifts to the virtually conceptual; form without significance, contour without texture, dimension without scale. All this was possible without the precision of the computer, which designers, especially architects are first to assert. The architects Frank Gehry and Renzo Piano have both asserted that their complex and curly recent work has relied on the physical model. In Piano's case it is the material of model making from which the formal ideas come. In the case of Gehry, it is the imagined material relationship with form that is emphasised, [25]. In all cases though, it is the precision of the virtual model that enables the building of the work.

Figure 6: Denton Corker Marshall, Art and Design Building, Melbourne Australia, 2000, from DCM Website: http://www.dcm-group.com/Web/DCM_Folio_A.htm, 2001
So it seems that design, especially architecture is about to enter a new phase of virtual virtuosity. The qualities of electronic space will be made visible through its application to and measurement of the materials of architectural design. The following text from Renzo Piano can perhaps be understood as the beginning of that time:

“In Padre Pio’s church, stone will be used not just for the paving and roofing, but as a structural material as well: the main span of over fifty metres will perhaps be the longest supporting arch ever built out of stone. This is not an attempt to get into the records books; it is simply desire to find out what can be done with stone today, almost a thousand years after the Gothic cathedrals were built. Technical virtuosity is not an end itself, but meets the needs of a precise formal choice. [my italics] The church at San Giovanni Rotondo springs out of the stone of the mountainside. Walls, parvis, supporting arches, and covering of the roof will all be made of stone. We have deliberately insisted on a single material as the expressive key to the design” [26].

His single material is coincidentally, one which can be fully modelled electronically. Renzo Piano also writes:

“I want to stress another point: a good building is not just beautiful, it is also good. A modern building today must be sustainable from every point of view, human, technological, energetic and economic”. [27]

Sustainability, as Piano indicates, is a quality that should be measured accurately within each of the categories he describes. This is now possible thanks to electronic modelling, it seems. The return of pleasure through the aesthetic of precision tends to place the design more completely in virtual space. The design tends to be more suited to virtual space than the sphere of matter. Designs, in this context are becoming less concerned with enclosure and more concerned with abstract form or what might be called opaque virtual formalism. Issues of space become de-scaled and disembodied. Measurement though, makes them more “buildable” in the real world, the realm of “trades” and “materials”, but an imperfect world in which the design is less fully manifest than in the computer. Bilbao Guggenheim for example looks alien, de-scaled, as if it were more properly within a computer, even the materials seem alien, as expensive, perfect in conception, representation but tedious in manufacture.

The theoretical work of Peter Eisenman can be seen as proto-precise in that its theoretical intent described in text with drawn images can be more fully and completely understood in computer modelling. In the final images of this presentation, space becomes an abstraction so purely represented, that it is impossible to build, despite being perfectly measured and imitated, which, it seems to me, suggests that architecture is on a cusp between the perfection of Kantian representation and a rediscovery of the fleshy constellation of architecture.

The following images from diagram diaries are drawn in a conceptual space perfectly suited to the technology of the computer.
Figure 7: Eisenman, P, 1999, "Inversion Slippage, House VI", in *Diagram Diaries*, Thames and Hudson, p50

Figure 8: Eisenman, P, 1999, "Shifting Repetition, Aronoff Centre", in *Diagram Diaries*, Thames and Hudson, p50
The fact that Eisenman has presented them as either "plans" or orthographic "3D" drawings such as axonometric projections suggests a rhetoric of precision more accessible within the highly sophisticated virtual projections of the computer. To illustrate this, a number of computer models have been made of Eisenman concepts, from the drawings shown in *Diagram Diaries*.

Thus the aesthetic of precision has found its way out of the exclusion from representation of design forced by modernism, and into the computer where it is enabling and yet also determining or defining a new virtuosity. It is this new virtuosity that now appears, as is seen in the examples of The Bilbao Guggenheim and in many other projects already built, both profoundly developed and yet exclusive. Design is tending further away from the multiplicity of locale to a new level of the universality of the machine within which the claim of the an individual can be argued as univocal truth.
Fig 10: "The Sleep of Reason Produces Monsters". The title of an etching by Francisco Goya in his book "Caprices", as shown in Collings, M, 1999, *This is Modern Art*, Weidenfield and Nicolson, p80
References

[2] Kant, Immanuel, 1987 (first published 1790) (trans, Pluhar, Werner S), *Critique of Judgement*, Hackett Publishing Company, Indianapolis Cambridge, p160. The text is "shared" to which the translator adds "[by all of us]" but this is not necessarily clear. It could be that Kant meant that "sharing" is a characteristic by which taste becomes taste. Thus it doesn't matter how many share it, just that it is shared.


[9] "Convention" is used here in its full sense in which a con-vention is formed through the use of linguistic practices in order that the linguistic practice can be confirmed.

[10] While the term "draftsman" is clearly gender specific, it is used here to indicate the male stereotyping of the practice of drafting, as it remains today. This stereotyping is primarily in architectural, building design and engineering practice while female stereotyping has been common in some government institutions in Australia, especially in the area of two dimensional or graphic design.

[11] The effect that Bauhaus had on western design is well documented and so will not be argued here.


[15] Even the most cursory reading of René Descartes' work shows the over simplification this makes.

[17] De Stijl", Manifesto V: — _ + = R4, 1923, as quoted in Conrads, U. (Ed), Bullock, M., (Trans), Programmes and Manifestoes in 20th Century Architecture, Lund Humphries, London, 1964, p 66. While De Stijl split with the Bauhaus because it seemed unproductive and so an enemy of the state, they remained of one kind when it came to the principles of abstract architectonic formalism.


[19] Perspective drawing in computing is actually the use of electronic modelling from which "projections" are made.

[20] Merleau-Ponty, Maurice, 2000 (©1968 in English, 1964 in French), The Visible and the Invisible, Northwestern University Press, p141-p142, This text was in draft form at Merleau-Ponty's death with the end section remaining incomplete. It contains explorations that indicate an abrupt divergence from his other works such as The Primacy of Perception and his main text, The Phenomenology of Perception.


[22] I would like to point out that while the separation Res Cogitans-Res extensa is usually attributed to René Descartes, in his section titled "An Explanation of The Human Mind or the Rational Soul. Which Explains What It Is And What It May Be" from Descartes, René, (Translated by Desmond M. Clarke), 1998, Meditations and Other Metaphysical Writings, Penguin London, p 185-186, Descartes says "Those are mistaken, therefore, that claim that we [he] necessarily conceive [s] of the human mind, clearly and distinctly, as really distinct from the body" His idea is that there is a realm of mind and a realm of body "intertwined" as Merleau-Ponty would say in "The Chiasm" from Merleau-Ponty, Maurice , 2000, The Visible and the Invisible, Northwestern University Press, (©1968 in English, 1964 in French), p130-p155

[23] The Deleuzian analysis of Spinoza, from which this idea comes, is found in Deleuze' lectures series of 1978 at Vincennes, four lectures on Spinoza. These lectures were found at the following web address in march 2002 (are currently off the internet):
Deleuze: Sommaire
I - Sur Spinoza: Vincennes - Deleuze: 24/01/1978: Version Espagnole; English Version. ...
www.webdeleuze.com/spinoza.html - 4k - Cached - Similar pages
Deleuze: Sommaire
III - Sur Leibniz (2ème série): Vincennes- St Denis
- Deleuze: 16/12/86: Version Espagnole. Vincennes ...
www.webdeleuze.com/leibniz2.html - 3k - Cached - Similar pages

[25] No doubt both architects would be horrified to be summed up in such a way. Architects are profoundly resistant to other people explaining their work. Perhaps this is due to the avant-garde proprietorship that they feel for it. This can at times seem like pure contrariness.


Websites:


Deleuze: Sommaire

Deleuze: Sommaire
III - Sur Leibniz (2ème série): Vincennes- St Denis - Deleuze: 16/12/86: Version Espagnole. Vincennes ... www.webdeleuze.com/leibniz2.html
Dialogue in participatory design

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Abstract

The study of participatory design has been an active research field for several decades (Cross 1971; Sanoff 1973) an acknowledgement that direct involvement in the design and decision making of physical environments has a positive influence and that there is continued value, new insight and knowledge from its investigation. During this time there has been a maturation of the subject and subtle shifts in the field: recognising participatory design as a process with many approaches and techniques, rather than a particular research method and the flexibility of participatory methodologies. Sanoff's (2000) continued involvement and development of the field have shown that participatory design techniques can be used for different scales of project, different units for analysis, to design and develop communities as well as individual buildings.

Sanoff's (1988) extensive research in this area stems from the methodological concept of action research (Lewin 1946) which integrates theory and practice. In this way the diversity of views expressed by people during the design decision-making process can influence the final outcome of a project. The democratic principle underpinning participatory design is demonstrated through the involvement of different users during design dialogues and their potential equal contribution to the design outcomes. The egalitarian, non-discriminatory principles of participatory design are common with an 'inclusive' approach for the design of environments: which should not discriminate on accessibility.

This paper will draw on interview data gathered during conversations between an architect and the users of a future building to comment on the language used during the design dialogues and its effect on a participatory design process.
Dialogue in participatory design

Introduction
This paper draws on current research using data gathered from interviews to comment on the dialogue between the architect and building user early in the design process and how user needs and preferences can be part of that process. These data are used to illustrate some of the themes that emerge from the architect-user conversations that are part of the briefing process and questions whether participatory design approaches have potential to enrich the dialogue and the exchange of information between the architect and building user.

Participatory design research, originating in 1960s, has evolved progressively, expanding beyond the design of a single building to the design of communities; the dwellings as well as engaging the people of the community in the process. In this way participatory design is more than a collection of design methods to influence the built form, it also has a human dimension and can engage the people who form the community in the process. The participatory design approaches are considered to reflect design as a social process, illustrating that the sphere of the design activity extends beyond the designer. As part of a participatory design workshop the people who attend are part of the social process of design and play an active part in the issue/problem raising, discussion and decision making processes that are part of the early design stage of a project. The people who are commonly known as the 'users' are active participants in the design process and the boundary between 'designer' and 'user' becomes blurred. This has similarities with Hill's (1998) research that recognises that a building user's presence in a space will change the properties of that space; making their own alterations, decoration and through the act of occupation they change the space. He acknowledges that through occupation the user is designing space. This position challenges the finality of the design process as well as the role of the 'architect'. He explores this concept further; playing with the legal definition of an architect, he introduces an 'illegal architect' into the picture, a non-architect designing space.

Returning to Professor Sanoff's work, his position as a frontrunner in participatory design (PD) is recognised (Teymur 2002) because of his continued application and refinement of PD methods. He clearly grounds the methodological basis for participatory design in the action research methods of Lewin, (1946) where the engagement of the test participants (I'm consciously avoiding the term test subjects as the approach belongs to the interpretive, not functionalist paradigm) allows new knowledge to be created. The process is iterative and knowledge and understanding emerge as a consequence of the verbal exchange of ideas, the social process that is critical during the early concept, pre-briefing stages of design.

There are two main reasons for considering the application of Sanoff's PD methods to a current project; firstly because the study focuses on the iterative, verbal exchange of design ideas and secondly, digging deeper, because of the underpinning philosophy of PD. Sanoff's work clearly articulates that PD methods form part of the broad democratic philosophy of participation of people in decision-making processes, politics etc. This aspect is of particular interest to the project described as it parallels the principles of participation advocated by disability theorists (Finkelstein 1993) that people with disabilities should be in an empowered consultative position in more aspects of their lives, the design of environments being a key area of concern. The social model of disability view, that environments disable people and that some consultative processes are placatory not emancipatory (Imrie 1999) are part of this argument and discussed within (Luck 2000).
The project briefing and data collection process

The project described within this paper uses interview data gathered from people with a range of disabilities to illustrate the themes discussed and the range of ideas exchanged verbally during the early design stage. The project is a multi-functional building at the University of Reading, being designed following inclusive design principles, where the accessibility, use and experience of the building should not be influenced by a persons' abilities. The project is described more fully within Luck et al. (2001) and the method for gathering interview data based on (Taylor 1999).

The interviews were conducted with future building users as part of the briefing process, to develop a written project brief and to understand their user's wants, needs and expectations from the building. The number of people interviewed was small, just six. Amongst this user group people with a range of disabilities; two people with hearing impairments, one person with mobility impairment, a wheelchair user and a visually impaired person were interviewed. Two others, with no impairments, were also interviewed as they interact with a range of people with disabilities.

The design of the briefing process was considered in detail; the aide memoire prompts used to gather user need information, the structure to the decision-making process for filtering process the ideas generated from the interview consultation process and how these would be taken forward within the written brief. The briefing process had distinct stages and the findings from one stage feed into the next. The stages were; semi-structured interviews - for gathering data, the feasibility study - producing a document with the views of all the people consulted (there were conflicting ideas and suggestions within this document) using this in the third Steering Committee stage - to discuss which ideas would be taken forward when preparing the written brief. Documenting the process meant that a decision could be reviewed and revisited at a later stage. In this way the briefing procedures reflected an iterative decision-making process (as occurred in reality) rather than a post-hoc, smooth sequential process. The method used for the briefing design stage has been discussed in more detail within (Luck, Haenlein et al. 2001). Other advantages of this approach were that the briefing process was informed by the needs of actual building users rather than generalisations from a non-representative group and that the architect wasn't designing on behalf of people with needs beyond their own experience. This fits with the emancipatory, participatory model advocated by disability theorists.

Semi-structured interviews

The method used to gather information was to individually interview respondents using a semi-structured approach and a checklist of headings to steer the discussion. The checklist of headings was developed through experience in architectural practice, developing an understanding of the information needed to design different types of projects (Luck, Haenlein et al. 2001). The headings link to aspects of a building and prompt the respondent to generate ideas for the building being designed. The headings also prompted comments on other buildings and their experience of other environments, as well as qualitative judgements on the relative merit of these environments. It was this rich information which was invaluable knowledge for the architect and impossible to quantify.

The interviews were conducted using the same checklist for each person interviewed. This allowed consistency across the sample of people interviewed but didn’t impose a structure as to how an individual should respond. The responses were the unprompted, unbounded ideas of the person interviewed. This approach generated rich data of personal perceptions of their experience of buildings and suggestions for improvements to the built environment. Interviewing people individually had the advantage that their ideas were personal and not affected by group pressures and influences.
A key issue explained to each respondent was that there was no correct response. Each response was an expression of their personal wish list for the building based on their own experience. In this way the response was individual and was not assumed to represent the needs of one type of disability. The comments were considered to be personal perceptions of the built environment rather than representing a larger percentage of the population.

**Analysing the interview data**
The interviews varied in duration and took between 1 hour and 2½ hours to complete. The interviews were taped and transcribed into a text document. The sample size, the numbers of interviews conducted were small, so the analysis was manual rather than using the qualitative data analysis software, Nudist or Atlas ti. The method used to analyse the text was thematic content analysis (Smith 1992) taking a grounded theory approach (Strauss and Corbin 1997). This approach was appropriate for this study of the language use as the method allows text to be grouped according to themes that emerged from the data, then comparing the groups of responses and commenting on any themes within the data. This meant that the researcher had to become familiar with the data, the participants’ interpretation of the prompt and their response; the texts were re-read several times. The response was in the interviewee’s own terms, using phrases and vocabulary they were familiar with.

**Some language-use themes emerging from the data**
The participants’ responses are used to illustrate the different interpretation of prompts that occurred during the interviews. Some of the themes discussed have been grouped according to the aide memoire prompt and are shown in Table 1 below.
Table 1: Semi-structured interview comments, grouped according to interview prompt.

1. **Comments from people with the same disability**

The lighting within the future building was discussed by only two of the people interviewed, both people had a hearing impairment.

“I prefer natural lighting. I don’t like of strip-lighting…. Lighting mustn’t cast shadows.” (Person 5)

The second person with a hearing impairment also thought “shadows should be kept to a minimum.” (Person 4)

These two were the only people that discussed noise and vibration within the building. They both gave insight into the importance of vibration to deaf and hard of hearing people as an alerting mechanism for movement, when someone is approaching and their heightened sensitivity to physical vibration.

“Movement and vibration within the building should be minimised. Hearing impaired people are more conscious of vibrations than most and use this as a method for sensing when someone is approaching.” (Person 5)
“The building should have a solid floor to reduce vibrations within the building. The disturbance caused by Concord and people walking within a building should be kept to a minimum.” (Person 4)

These two quotes illustrate that people with the same disability can make common observations and may cite the same problem. People will have common experiences but generalisation from value judgements must be treated with caution. Even observations made by people with the same disability cannot be extrapolated to represent the views of a broader population, as described below.

2 Contradictory preferences from people with the same disability
These quotes illustrate that the views expressed by people with the same disability didn’t always present a coherent picture.

“An issue for deaf people is knowing whether they should stop working and be involved when new people arrive in a space. Working in a glazed open space can be distracting. This uncertainty results in lost concentration and effective working. An allied confusing situation is when people just appear and you haven’t been notified, which can be quite distressing”. (Person 5)

“I’d encouraged the use of glass. Deaf people need to be able to see and access people. The shape is not so important but transparency and visual links with others are important.” (Person 4)

“Use of glass and lighting will have an effect on deaf peoples' ability to lip read. The idea of using glass to divide spaces within the building is appealing, so there is visual contact over long distances. People will be aware of others within the building and can acknowledge each other over those distances. Signing often occurs over these longer distances.” (Person 3)

These quotes illustrate that extrapolating information from interview data concerning user needs of a particular disability group is not always an effective way to make generalisations about user needs. One of these quotes was from a hearing person working with deaf people, who in everyday situations interacts and observes the behaviour of many people with a hearing impairment. His comment was similar to the view of one person, who thought the transparency of glass would make it a useful material to separate spaces for people with a hearing impairment, but did not reflect the view of the other person. This illustrates the problem of ‘presumptive’ designing, assuming a knowledge of a user group and also the fact that people’s preferences are not always predictable or constant.

3 Different use of space and spatial preferences
The people interviewed were asked to describe how they use space and to describe the space they’d like to work in.

“Fixed areas for specific functions are preferred to temporary ones. There is a need for barriers between spaces but these may include a visual link of activities. In a public space you’re always keeping a watchful eye for people trying to attract your attention.” (Person 5)

“Open plan, hot-desking could be encouraged by having points throughout the building so a computer can be connected to a network. Separate partitioned quiet rooms with vision panels and windows to see whether people can be disturbed are needed.” (Person 4)
“A decision needs to be made whether the building will be organised so firms work autonomously within the building or whether similar functions and activities, e.g. ‘office space’ could be linked together. We could group activities according to the level of noise generated by each person. It should be similar and kept to a minimum.” (Person 4)

The responses were again diverse. One person had a distinct preference for a fixed space of their own, a view they defended by describing the disturbance they experience when others wander near to where they're working. It would be interesting to understand whether this personal preference, ‘work space construct’ was held because of the type of activities their work involves or for other reasons. Person 4 was conscious of people’s differing needs and preferences and suggested a problem solving approach to group activities together. To understand user needs it is more appropriate for personal preferences to be given, rather than a solution as it is restrictive and may provide only a limited design answer, often at the expense of innovation (Fisher, Bowman et al. 1999).

4 Revealing tacit knowledge

This approach, using dialogue to better understand user needs, has been successful for revealing tacit knowledge (Polanyi, 1996) for an individual to share their personal perceptions, and based on their experience give the designer insight into the issues that influence a disabled person's experience of an environment.

“Loss of balance is a common problem for those with a hearing impairment which can be easily assisted by the inclusion of strong horizontal features within spaces, horizontal bands of tiling etc.” (Person 4)

This information may assist the designer when specifying finishes to decorate a space.

The comment that:

“Different disability groups tend not to mix”, (Person 3) was particularly revealing. The designer may want to verify this by asking other people or observing the use of space in buildings shared by people with different disabilities. The use of this information may have a strong influence on people's satisfaction with the completed building. Designing the layout of spaces to encourage interaction between people with different disabilities, e.g. sharing amenities within the building may make people feel uncomfortable. This comment may raise other questions; of validity, the need to investigate the cause, establish a satisfactory separation distance and other fundamental environmental psychology questions.

Revealing tacit knowledge through dialogue was an intention and major advantage of this approach. This information is based on personal experience, which without dialogue wouldn’t be available to the designer.

5 Metaphors, descriptive narrative and conjecture

The flexibility of use of the new building prompted a different style of response.

“A good model is the Californian Centre for Deafness where there are outer perimeter rooms which don’t have windows. The central room was sunlight from overhead. What’s the ideal height for the concourse area? We’d like a height so the space has a buzz and activity but don’t want the effect of a chimney. The concept of a cyber cafe is appealing, people working in an interactive environment.” (Person 3)
The description of buildings or environments they had visited that had left strong impressions was encouraged. Narrative and metaphors were considered positive language use for this exercise to illicit tacit knowledge and allow the designer to gain insight into the mindset of the user. Here Person 3 described a central, sunlit space which they enjoyed and within their narrative questioned the best height for the space so it doesn’t have ‘the effect of a chimney’.

> “An open plan building will appeal to the user groups in different ways. The building’s acoustics may need special consideration, absorbing surfaces to counter act the effect of a big space. Perhaps visually impaired people would prefer smaller spaces. Is there a way of giving more immediate local information within a large open space.” (Person 6)

The prompt, 'flexibility of use of space', was interpreted by many as meaning an open-plan spatial arrangement. These quotes illustrate that people also considered and rationalised the needs of others, sometimes for people with different disabilities, in their response. The need to provide blind people with local information to navigate through this space was a concern expressed by people with hearing impairments. This again raises the issue of assuming an understanding of the needs of another person. Tacit information, when a person gives insight into their particular experience of the world with a disability was of great value to the designer. Expressing concern for the needs of people with another disability may highlight an issue and bring it to the designers attention but is presumptive conjecture, less valuable information.

6 Interpreting a prompt differently
Several prompts provoked different interpretations of meaning from those interviewed. This was an accepted characteristic of this approach to allow people to interpret the prompt in their own terms, with the intention that the priorities that were most important to them would be represented and others, significant to a different person, may be represented during a separate interview.

Illustrations of this were the responses to the prompt 'The environment'. The prompt was deliberately non-specific. Person 2 discussed an individual's ability to locally regulate aspects of the internal environment to suit each individual.

> “There should be the opportunity to control the internal environment from one zone to another. Those with a disability are less active and need different environmental conditions. We need testing equipment to monitor the physical and emotional effects of the internal environment and consider other aspects of the environment that need to change, as well as the temperature and humidity”. (Person 2)

Another person discussed the environment in terms of the effect that many people occupying the same space had on their ability to concentrate.

> “It is often difficult to concentrate when there are many activities within a room. It is easier to concentrate when there are just 1 or 2 people within a room, perhaps we need areas for sole working.” (Person 5)

7 Inability to articulate personal preferences
The people interviewed were prompted using the word 'aesthetics' to give their thoughts and preferences on the appearance of the final building. These comments gave insight into people's perceptions of the environment and the visual appeal of buildings.
Several people interviewed were conscious that a purpose built ‘accessible’ building shouldn’t be linked with a ‘futuristic’ appearance, conventional buildings can be used by people with differing needs as well.

“Building needs to be relatively traditional, whatever that is. Should be attractive and appealing, achieved through relatively traditional styling rather than futuristic, so that other people would feel they could design a similar building, have sympathy and feel comfortable with the building.” (Person 2)

A similar view was expressed; “The building can be modern, using new technologies, but its appearance shouldn’t be too outlandish. The design fires others to realise that accessible design is not out of the ordinary and is achievable.” (Person 6)

“It is essential that the design is not unusual, to show that you can have accessible environments in normal buildings. Accessibility doesn’t require a lot of money. It should be an attractive aesthetic statement without being extreme.” (Person 1)

Other people interviewed favoured a modern ‘futuristic’ appearance; “The building should be a ‘futuristic’ design rather than something traditional. ‘Futuristic’ in the sense that it is innovative and forward-looking. The building should represent an international cause, different cultural backgrounds”. (Person 5)

“Building that blends into the landscape but reflects the 21st century, something a bit different. The Louvre is modern but has a resonance with the surrounding buildings”. (Person 3)

In these dialogues the users' descriptions of a building’s appearance were limited to one ‘construct’, the traditional-futuristic polemic and most peoples’ view was at either extreme. Here the vocabulary used was limited and the participants' understanding and familiarity with the language of architecture meant that they couldn't articulate their views on the appearance of buildings.

These comments illustrate not only differing views amongst those interviewed, which unsurprisingly were unrelated to a person’s disability, but also some difficulties for participants to verbally articulate their views and to share these with another person. Some terms used were ambiguous, without precise definition, ‘traditional’ and ‘futuristic’. One of the people interviewed was conscious of the deficiency but didn’t attempt to explain his interpretation of the term ‘traditional’. This observation highlights that dialogue and the exchange of concepts between designer and user can be limited by the use of common terminology, interpreted in the same way by all parties to the dialogue. A common vocabulary isn’t enough to share meaning, the constructs of the dialogue should be similar, demonstrating a level of understanding that extends beyond semantic correctness. This view parallels recent thinking in discourse analysis that the context of the dialogue has a bearing on the meaning of the exchanges as well as linguistic correctness (Jaworski and Coupland 1999).

A theme to be explored in greater detail by the author is the issue of 'common vocabulary'. The view of the author is that there are several 'languages' of architecture that can be used by an architect; architectonics, developed from semiotic theory (Mitchell 1999) the language of architectural form and also a 'coded language' used to discuss architectural theory. Although in linguistic terms architecture is not a language, the two 'languages of architecture' described won't be 'languages' the architect can share with most building users. The notion of an architect discussing a building with a future user using a common language is limited to everyday vocabulary and
mediating a meaning for specific terms through dialogue. This position will be developed further and is considered to parallel the doctor-patient model where there is also a knowledge and power imbalance and complex medical conditions are explained using 'everyday' language and a vocabulary, words with particular meanings, are developed through dialogue.

**Conclusion**

This paper has drawn on interview data to observe the discussion of user needs during the dialogue between the architect and building users. The social process of dialogue facilitated the exchange of information and enhanced the designer's understanding of the needs and expectations of future building users. Several themes emerged from this review;

- That generalisation, extrapolating user preference to a broader population, should be approached with caution.
- Tacit knowledge, giving insight into user experience of an environment, can be revealed through discussion.
- Descriptive narratives and metaphors can reveal tacit knowledge.
- Users suggesting 'solutions' can limit a design solution.
- In some situations, discussing the appearance of the building, language use was limited and the absence of a common vocabulary or architectural language, limited the discussion to very basic constructs.

These observations of language use when gathering user need information have highlighted many factors associated with knowledge transfer between the user and designer, issues that prevent the extant transfer of knowledge. These observations are sympathetic with those of (Gill 1994) that design knowledge cannot be completely represented in a propositional, non-contextual form.

In epistemological terms different forms of user requirement knowledge has been revealed, created and exchanged (Polanyi 1966) (Nonaka 1994) during this process. The semi-structured interview revealed explicit and tacit knowledge through the social process of discussion. Explicit knowledge is readily available to designers in design codes and guides but the revealing of tacit knowledge is of particular value to the designer, knowledge that otherwise wouldn't be available. Without the ontological, social process of dialogue this knowledge would not have been transferred from the user to someone who may be able to use this knowledge for the users' benefit.

The last bullet-point observation is of particular interest as it illustrates that some concepts are difficult to discuss. Different knowledge and 'languages' used by the user and architect are suggested as reasons for the need to mediate the definition of specific terms through dialogue. Based on these observations more detailed discourse analysis, where the context, the social dimension and the situational meaning of a concept are considered is proposed for these data.
References


A product design process model that can redefine business strategies

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Abstract

Manzini pointed out that “traditionally, ideas follow organizations; in the future, organizations follow ideas.” In a highly competing business environment, a company’s innovation capability defines its sustainability and good new product ideas are a key ingredient to company success. Industrial design deals mainly with new product development, in which innovation ideas are central. Designers view themselves as idea creators. But, why should future organizations follow the ideas proposed by designers? If designers’ ideas are to be followed by organizations, then a different design process thinking that can redefine company goals or suggest different business strategies is necessary.

As a response, a business centered design process model is proposed, which consists of five steps: (1) Identifying new product ideas with attractive design potential from a user’s viewpoint, (2) Selecting appropriate company goals as design goals from a business perspective, (3) Defining new product concepts to reach the desired goals from a customer’s standpoint, (4) Specifying key design elements for less development efforts from a producer’s prospect, and (5) Translating design elements into physical entities or products. For verification, a product design workshop class taught by the author was employed. From students’ works, it can be asserted that the new procedure can be feasible and effective in developing new products that can meet market satisfaction and redefine business approaches. For illustration, a redesign work done by a student is demonstrated as an example. For further verification, theoretical analyses are conducted, resulting in supportive conclusions.
A product design process model that can redefine business strategies

A need of new design process thinking
New product development (NPD) is essential to all business organizations. The new product may be tangible objects or intangible services. A good new product can not only increase market shares and profitability but also lead to new business opportunities and establishment of new core competence. New product derives from innovative ideas. “What is a good idea worth?” According to Robert Cooper (1986: 67), the answer is “everything.” In a fast changing business competition environment, idea quality largely defines company success. Manzini (2001: 2) pointed out that “Traditionally, ideas follow organizations; In the future, organizations follow ideas.” Since innovative ideas are precious, business organizations should adapt themselves to cope with challenges from NPD works. “To ensure the leadership of tomorrow,” said Lew Platt, former chairman of HP (Tushman and O'Reilly 1998: 274), “we are willing to give up everything we have achieved today.”

Industrial design deals mainly with innovations or new product ideas, which are a key ingredient for company success. Designers, of various kinds, view themselves as idea generators or creators. If Manzini’s notion can be sustainable, then designers should be leaders in NPD works or in business organizations. This can be true because designers know how to define and develop new products with a strong focus on target customers and can foresee the scenario in which new products will be used. With a good sense of market and a comprehensive perspective on new product works, designers should be able to propose quality ideas for organizations to follow.

However, the reality shows a different story. In many NPD projects, designers are basically followers or downstream workers. Due to their inclinations of making changes to existing systems, designers are often seen as troublemakers. In addition, high-ranked managers or decision makers are largely from engineering or business backgrounds, rarely from design. All these facts reveal that designers remain distant from being quality idea initiators or managers. How come and why?

To answer, two fundamental questions should be explored in depth. The first one deals with the goals and strategies that drive design processes. As a rule, new product projects are proposed based on company goals or needs. Following predefined project objectives, design goals and strategies are developed and accordingly design processes are activated. Company success is mainly determined by business performance, which can be achieved if and only if new products can be satisfactory to target markets. This rationale is basically from a product designer’s point of view. From a business management perspective, only through appropriate business goals and strategies can company success be attained. Since both paths can reach business success, then what is the relationship between goals and strategies of design and those of business? If the concept of “organizations follow ideas” is right, then a capable design process should function to define business goals and strategies, or even company goals. Yet, none of existing design processes do.

The second question concerns the adopters who buy new product ideas. Generally, there are two types of idea adopters - intermediary and end. Development of an idea from abstraction (concept) to reality (product) undergoes two major steps. First, it must be attractive to a producer or company. In order to be an invested project, the value of an idea should be conveyed in terms of business benefits or company goals. Otherwise, an idea remains an abstraction. Secondly, it must be appealing to its potential customers and target users. Without compelling reasons to buy, an idea stays away from commercialization. Products that can meet market satisfaction are successful developments, which can contribute to business success and company prosperity. Essentially, both
producers’ and customers’ needs are equally important and should be well taken care of. In terms of NPD procedures, company needs are prior to customer needs and producers are the first layer of idea adopters, hence with higher priorities for adoption decisions. If the notion of “organizations follow ideas” stands, then the ideas proposed by designers must show reasonable attractiveness, in meaningful ways, to both the intermediary and the end idea adopters. Nevertheless, almost all industrial designers are educated to be user-centered, with a strong emphasis on needs of the end idea adopters. As a result, the value of an idea, or of a new product design, is often measured by user benefits or customer satisfaction, less meaningful to business management.

From the above analyses, it can be posited that to cope with future challenges in new product works, a new design process thinking is needed, which requires designers:

(1) To put an emphasis on business performance and company needs in design goals;
(2) To integrate design solutions into business strategies or company goals;
(3) To view both companies and customers as substantial idea adopters, and;
(4) To express design values or new product idea benefits in business terms.

With clearly specified business goals and strategies, most existing design processes are effective in delivering incremental innovations, characterized by marginal benefits and low risks. However, in current and future business competitions, radical ideas, frequently associated with high profitability and risk, have increasing influence on the success of a business, the fate of a company, or the prosperity of an industry. Yet, most design process models are impotent in, or less capable of, dealing with radical innovations, for they often involve redefinition of business strategies or company goals.

In light of the significance of radical ideas, this paper proposes a new design process model that can implement the essential design process thinking listed above and function to turn incremental ideas with marginal benefits into radical ones with great profitability and strategic advantages.

**The new model**

As an answer to the two basic questions, a business-centered product design process model (briefly as “new model”) is introduced, which consists of five major steps: (Figure 1)

![Figure 1: The Business Centered Product Design Process Model](image)

Step (1): Identifying attractive ideas from a user’s viewpoint:
Through conventional user observation techniques and design analysis methods, innovation, or product improvement, ideas can be easily perceived. Ideas may be generated and adopted internally or externally (Dean 1968). To identify potential ideas, an effective screening model is necessary. Product success is mainly defined by end users. Hence, users’ perspectives are a focus at the outset.
Since this paper concentrates on design process model and a screening model proposed by the author (Luh 2000: 1-20) can be effective for more innovative ideas in early development stages with an emphasis on end idea adopters’ viewpoints, new product project evaluation and selection issues are not addressed herein.

Step (2): Selecting desired company goals as design goals from a business perspective:
In general, new product projects are driven by company goals, which may fall into one of the following eight categories (Thomas 1999: 14.44): (1) establishing long-run competitive advantages, (2) reinforcing or changing strategic direction, (3) enhancing corporate image, (4) improving financial return, (5) increasing research and development effectiveness, (6) improving utilization of production and operations, (7) leveraging marketing effectiveness, and (8) effectively utilizing human resources. For easy selection and portfolio management, a “benefit matrix” tool (Luh 2001: 370-381) is introduced to help designers to align their efforts with company needs in early design phases. (Figure 2)

According to an idea’s development potential or innovation attributes, goals that can be attained and attractive to a company are chosen as design goals. This step is most critical. Because once design goals are specified, the space that an idea can be strategically developed lessens.

Step (3): Defining new product concepts to reach design goals from a customer’s standpoint:
This step can also be described as “positioning new product ideas.” This procedure further reduces the design space by providing designers with clearer market pictures about the new ideas in development. Markets are driven by life patterns, which can be expressed in form of circles. People in a same life circle share similar values or needs. From intimacy to strangeness, four basic life circles can be identified - personal life, family life, work life and non-direct life. Through which, a “life hierarchy” model (Luh 1996: 88-91) is established, which can be applied to represent market types. Personal life, for instance, indicates the market type that new products are essentially made for personal uses, with closest relationships with the end idea adopters. Non-direct life refers to the market type that new products have least or no direct connections with the general public. Pencil is a product example for the former market type and power loom is another for the latter.

As a rule, the more mature (or less innovative) the technology a new product employs, the more likely its market type can be targeted at the core circle (personal life), which denotes the largest market base. Normally, radical ideas are associated with advanced technologies, new product categories, new markets, or shifts of life circles. Targeting at a different life circle implies creation of a new product category. With the general market evolutionary pattern (non-direct -> work -> family -> personal), an idea’s market type can be positioned, strategically.

Step (4): Specifying key design elements for less development efforts from a producer’s prospect:
Based on attributes of competing products in target markets, key components of new product design are analyzed and further defined. The “product stratification” structure (Luh 2001: 479-486) can be employed as an analytical framework for specifying design focus, which has four components: senseware, humanware, functionware, and systemware.

Senseware indicates concerned product appearance factors that are associated with the attitudes or perceptions of an adopter towards a product. Humanware refers to product-human interface that enables people to manipulate a product efficiently, effectively, comfortably and/or safely. Functionware infers product constituents, together or as a part, which can generate major functional quality of the product or provide essential service for the adopters. In many circumstances, a product is merely a subsystem to a larger system (keyboard, for instance) and the larger system is supported by an infrastructure, an even bigger system included in an environment. Systemware represents the conglomeration of the larger systems with which a product is involved.

Generally, the development pattern of new products with innovative technologies can be briefed as follows: Initially, establishment of technological standard is central and design efforts concentrate on systemware constituents (basic system) or functionware components (core technology), depending on the wholeness of a product in development; As technologies improve, product paradigm becomes pivotal and design endeavors shift to humanware factors (usability); With emerging market segmentation, design attentions move to senseware elements (aesthetics). With the product evolutionary pattern, design focus can be consensually agreed by NPD participants for facilitating teamwork and synergy.

Step (5): Translating design elements into physical entities or products:
When both the company’s needs and those of the target customers are met, i.e., the idea in design shows significant benefits to both the intermediary and the end idea adopters, the process moves on to the last step to deliver real products. Otherwise, the process may choose to go back to the first step to re-select ideas for development, or to the second step to redefine design goals that are more appropriate for further development based on the key design components specified.

For projects entering into the last design procedure, new product ideas become increasingly concrete and design elements are specified to a great extent, ready for implementation. Through a standard design implementation process, i.e., laboratory verification of theory or design concept, demonstration of application, full-scale or field trial, and commercial introduction (Starling 1988: 532-533), abstract ideas can be smoothly translated into real products.

A product design example
To demonstrate how the new model can work, a product design case is employed as an example. This case is merely one out of many in the product design workshop class (Spring 2001) taught by the author at the department of Industrial Design, National Cheng Kung University, Taiwan. Sophomore students were asked to play as in-house designers for famous companies they chose. Each one of them was required to apply the new model to redesign a simple product with which he or she is familiar.

The student work that redesigned the glue stick product by 3M company is selected for illustration. Due to limited space, details of the design work and concerned processes are omitted herein. Since most redesign projects are highly confined by predefined company goals and/or business strategies, the design goals initially set for each design work were basically specified as “operation utilization” and/or “human resource utilization” in terms of the eight strategic goals.
Through conventional behavioral observation techniques and design analysis methods, a key problem for design improvement is identified: users do not know when the glue will be used up, i.e., uncertainty about glue consumption. (Table 1)

<table>
<thead>
<tr>
<th>Design process</th>
<th>Iteration 1</th>
<th>Iteration 2</th>
<th>Iteration 3</th>
<th>Iteration 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Potential idea</td>
<td>Visible glue consumption</td>
<td>Concise shape and “lure” for next purchase</td>
<td>Comic icons and “lure” for other (new) products</td>
<td>Collectible toys and platform for major cartoon figures</td>
</tr>
<tr>
<td>(2) Strategic goals</td>
<td>+ competitive advantage</td>
<td>+ R&amp;D effect</td>
<td>+ corp. image</td>
<td>+ marketing effectiveness</td>
</tr>
<tr>
<td>(+: additional)</td>
<td>+ financial return</td>
<td>+ strategic direct.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Market position</td>
<td>Work life mainly</td>
<td>Work life + family life</td>
<td>Personal life + family life</td>
<td>Personal life (global markets)</td>
</tr>
<tr>
<td>(4) Product element</td>
<td>Humanware basically</td>
<td>Humanware + senseware</td>
<td>Senseware + humanware</td>
<td>Systemware mainly</td>
</tr>
</tbody>
</table>

Iteration 1
Focusing on the key problem, an improvement idea that inserts a colored glue component in form of a power consumption icon is proposed. This idea can make glue consumption visible and gain extra strategic effect: competitive advantage (the process technology for the tinted core). Since the new design can be effective in enhancing work efficiency and considerable current products are consumed at work places, the market type of “work life” can be appropriately positioned for the new idea. To reach the predefined design goals, current product appearance may remain. Uncertainty about glue consumption is essentially a perception or usability problem. Concentrating design efforts on humanware improvement is reasonable.

Examining its potential benefits, the new design can save trouble for users and remind customers of preparing a new one in advance; the producer can receive patent protection and gain competitive advantage. Nevertheless, production cost concerns require further design efforts for simplification in manufacturing.

Iteration 2
To solve the emerging problem, a betterment idea is suggested. A battery shape (Figure 3) is applied to the glue component design, which can greatly ease manufacturing complexity and reduce production cost. In addition, a brief promotion message (“lure”), such as “50% off for next purchase,” can be printed on the stand where a glue component sits. These ideas together can help enhance R&D effectiveness and contribute to maintaining or increasing financial returns, two different strategic goals not specified in the beginning. The “lure” idea can help to lock customers in and to attract the market type of family life, for money-saving is a critical factor in their decision-making. Besides, it adds new elements for senseware design.
In terms of idea benefits, the new idea can save some trouble in use and some money in purchase for the users, and can economize production cost and gain a tool for customer loyalty for the producer. With the lure element, customers are likely to purchase another glue stick product before or after one is used up. Sales volume may increase positively. It is a better idea. But, is it the best?

Since products can be strategic tools, better financial performance should be anticipated. It is possible if further design endeavor is granted. Noticeably, although the new idea can target family users, the battery icon is less meaningful, or attractive, to the most frequent users in a family – school children - who use it for their homework regularly.

**Iteration 3**

To deal with the new issue, two design changes are suggested (Figure 4): replacing the battery icon with two comic figures and promoting all concerned products by the company (other stationery products by 3M in this case). The former design change has multiple advantages: (a) The product becomes more attractive to young customers (less instrumentalism); (b) It provides new tools (comic figures) for customer loyalty; (c) It facilitates to double the sales volume (either ends can be faced up); (d) It adds entertainment ingredient (interesting transformation process) while retaining good usability, and; (e) It may lead to faster consumption speed and higher purchase amount (curiosities for figure transformation and for “promotion lottery”). Additionally, the latter design change may contribute to promote sales of associated offerings and to enforce brand loyalty.
Obviously, the new design can enhance corporate image and change strategic directions, two new design goals not previously defined. With properly designed comic figures, the market type of personal life can also be targeted, suggesting a much greater market base or profit space. Design focus shifts from humanware improvement to senseware creation. Benefits for both types of idea adopters are multitudinous and multivalent.

Nevertheless, the former design change requires introduction of different design talents, development of complex process technologies, and establishment of new marketing channels, to name the most significant ones. All of which may result in increase in cost. To solve or ease the accompanied difficulties, further design effort is necessary.

**Iteration 4**

If the comic figures can be appropriately designed, the new product can be a collectible toy in a sense. Hence, it can be employed as a platform for promotion of cartoon figures by all major entertainment companies, serving multiple clients while sharing development costs for the expensive process technology.

Since all potential client companies are well established and have strong marketing networks, the new design thinking can not only enhance marketing effectiveness for products by the producing company but also solve the needs for design talents and for building new channels. Individual customers can be targeted and market space can be expanded globally. To gain the new business opportunity, systemware design becomes a focus. Benefits of the new idea are numerous and there is no major shortcoming (management complexity may be one, but easily solvable), suggesting that the design process may precede to the last step for realization.

From the design example, it can be posited that the new model is able to focus on business performance and company needs, integrate design solutions into business strategies or company goals, consider needs of various idea adopter types, and communicate design values in business terms. The four design ideas in the example can be seen as four design strategies for four new products, or as four strategic tools for a new business strategy, or as a series of business strategies (from short-term to long-term) for a new corporate strategy. Hence, the new model can also be seen as a process model for strategic planning.
Theoretical analyses

Basically, Step (1) is a typical idea screening process and Step (5) a standard idea implementation process, requiring no emphasis. The ones in between are core design processes, deserving further exploration. Through which, the relationships between goals and strategies of design and those of business become clear. First, business goals are subject to company goals, which can be defined, or developed, through the benefit matrix tool, and the eight generic company needs are ultimate goals for any design activities. Secondly, key elements of strategy (direction, timing, and extent) are already embedded in the core design processes, enabling design strategy to function as business strategy. With the benefit matrix, design goals that can satisfy company needs can be defined, providing concerned participants with a clear direction for development of new product project and for synergy. Through the life hierarchy, a new product idea can be timely positioned to meet dynamic market needs. By using the product stratification, the extent of change that needs to be made to a new product can be revealed and design efforts can be concentrated for effective implementation.

Technology, aesthetics, and business are three essential elements in Industrial Design works. Examining the development history of which, two professional education approaches (“engineering” and “marketing”) are characteristic. The engineering approach integrates aesthetics into technology, centering on the sciences and techniques for mass production. Fundamentally, designers are trained to be engineers solving manufacturing problems. New products are seen as problems in a sense. The marketing approach introduces aesthetics into business, focusing on the knowledge and skills for mass consumption. Designers are prepared to be stylists, whose tasks are mainly for market segmentation and product promotion. New products are viewed as marketing tools. Intrinsically, both approaches obey predetermined company goals or align with current business strategies.

If designers’ ideas are to be followed by organizations, then a product design process that can redefine company goals or suggest different business strategies is necessary. By comparing the two design approaches, a strategic ingredient of the new model becomes distinct. (Table 2)

<table>
<thead>
<tr>
<th>Approach</th>
<th>Engineering</th>
<th>Marketing</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>Problem-solving</td>
<td>User-centered</td>
<td>Profit-driven</td>
</tr>
<tr>
<td>Design goals</td>
<td>Identified</td>
<td>Predefined</td>
<td>Evolving</td>
</tr>
<tr>
<td>Design effort</td>
<td>Technology</td>
<td>Market</td>
<td>Benefit</td>
</tr>
<tr>
<td>Designer role</td>
<td>Engineer</td>
<td>Stylist</td>
<td>Strategist</td>
</tr>
<tr>
<td>Main concern</td>
<td>Mass production</td>
<td>Mass consumption</td>
<td>Strategic Performance</td>
</tr>
<tr>
<td>Design focus</td>
<td>Process model</td>
<td>Product model</td>
<td>Business model</td>
</tr>
<tr>
<td>NPD driver</td>
<td>Producer</td>
<td>Customer</td>
<td>Both</td>
</tr>
<tr>
<td>Major NPD Process</td>
<td>Product idea</td>
<td>Product idea</td>
<td>Product idea</td>
</tr>
<tr>
<td></td>
<td>Design strategy</td>
<td>Product strategy</td>
<td>Business strategy</td>
</tr>
<tr>
<td></td>
<td>Design strategy</td>
<td>Design strategy</td>
<td>Product strategy</td>
</tr>
<tr>
<td></td>
<td>Product</td>
<td>Design strategy</td>
<td>Product</td>
</tr>
</tbody>
</table>

Typically, the engineering approach focuses on problem-solving activities. From an abstract product idea to its physical outcome, solutions for identified technological difficulties, i.e., design strategy, are most critical in its NPD process. Essentially designers are engineers concentrating, in relative terms, on process models. Normally, the perspective of a producer drives the NPD process. For designers applying the engineering approach and in terms of the redesign example, the design
process is likely to be ended at the second iteration, resulting in a better design in usability and manufacturability at most.

The marketing approach is inherently customer- or user-centered. In addition to solving technical problems, issues on product positioning in selected markets, i.e., product strategy, are also crucial to designers. For products with matured technologies, designers are often seen as stylists focusing on product models. Opinions from the end idea adopters drive the NPD process. For designers employing the marketing approach, the design case in example is less likely to proceed to the fourth iteration, due to pre-determined business strategies and company goals.

The new model is business-centric. Design goals and associated business models evolve while design processes proceed. Designers are strategists in essence, concentrating on strategic performance for maximal benefits. Both the producer’s concerns and those of the users drive the NPD process. However, unlike existing design process models and design evaluation systems, in which producer concerns are over emphasized and placed up-front in the process, the new model equally values both types of concerns and alternatively introduces them, starting with a users’ and followed by a producer’s. Theoretically, such arrangement is able to reach higher success probability in new product development (Luh: 2000).

According to studies by various scholars (Maidique and Zirger 1984: 192-203; Montoya-Weiss and Calantone 1994: 397-417), success factors for NPD can be approximately divided into two groups: process-related attributes (controllable factors) and selection-related attributes (less controllable factors). The process-related factors capture the nature of the new product success and how the project is undertaken. Eleven factors are concluded most critical, briefly: (1) a unique superior product, (2) a strong market orientation, (3) sufficient predevelopment works, (4) sharp and early product definition, (5) focus and sharp project selection decisions, (6) quality of execution, (7) the correct organizational structure and climate, (8) planning and resourcing the launch, (9) the role of top management, (10) speed, and (11) a multistage, disciplined new product process. The selection-related factors describe the new product project process and its situation. Five elements are identified as most crucial, namely: (1) market potential, (2) competitive situation, (3) product life cycle (PLC), (4) synergy or leveraging core competence, and (5) familiarity. Of the two sets, process-related factors have by far the strongest influence on new product success.

In terms of the process-related factors, the new model is strongly market-oriented and a multistage, disciplined new product process. It can directly help to form early product definition, to suffice predevelopment works, to provide focus for project selection decisions, to generate a unique superior product, to increase overall NPD speed, to shape an organizational climate for successful NPD, and indirectly facilitate enhancement of the quality of execution, to plan and resource future launch, and to influence the role of top management in project evaluation and selection.

In terms of the selection-related factors, the new model can be applied to estimate market potential. In addition, the life hierarchy obeys PLC principles and can be used as a strategic tool for advantageous competitive positioning. The product stratification can help identify key design elements for less design effort and greater project familiarity. The benefit matrix provides a comparison basis for design goals in various natures, which help leverage core competence.

Above all, the new model furnishes with the function of redefining company goals and/or business strategies, a unique and powerful characteristic never seen in existing approaches. Evidently, the business approach is most advantageous and the new model is superior in many aspects.
Conclusions

From above discussions, it can be asserted that the business-centered design process model emphasizes business performance and company needs in design goals, integrates design solutions into business strategies, balances perspectives among various idea adopter types in new product development works, and expresses design benefits in business terms. Through the redesign example of 3M glue stick, the new procedure can be verified as innovative, feasible, and advanced in comparison with other approaches, and the following conclusions can be drawn:

(1) The new method can be a useful and effective tool for developing new product ideas that future organizations might seriously consider to follow.

(2) Defining business strategies or company goals should be one essential and critical activity in design processes.

(3) The new process demonstrates a different design logic that refreshes the way that design is viewed and valued.

(4) The new system introduces useful tools (benefit matrix, life hierarchy, and product stratification) for strategy making (direction, timing, and extent, respectively).

In general, new product projects are driven by company goals, which can be reached via business strategies. Design goals and approaches should therefore be aligned with business goals and associated strategies. Business orientation and strategy-centeredness are a key development thinking that all design approaches should follow. Designers are strategists in this context and strategists are normally ranked at higher levels in an organizational structure. However, current industrial design education and associated professional training do not prepare, or aim to prepare, designers to be strategists. As a result of adopting conventional approaches, designers are largely positioned as product engineers or stylists, remaining in lower status in a new product development team. To promote Industrial Design, to enhance quality and effectiveness of new product development, and to improve overall performance of any business organization, reorientating educational goals of Industrial Design and redefining designers’ professional roles are not only necessary but also urgent in the new era.
References


Integrating the world’s most effective creative design strategies

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Abstract

The paper examines the broad range of methods, tools and strategies available to designers and attempts to distill the best of each in a bid to generate a coherent, ‘systematic creative design’ philosophy. Although using the Soviet-originated Theory of Inventive problem Solving, TRIZ as its foundation, the proposed design method also encompasses elements of, amongst others, QFD, Design for X, Value Engineering, Axiomatic Design and Robust Design. The paper describes the ongoing process of integrating these methods and reviews their deployment on a broad spectrum of real engineering design case studies.
Integrating the world’s most effective creative design strategies

Introduction
The world of creative design is currently served by a range of tools, methods and strategies that many might conclude is bewilderingly large. Their individual and combined effectiveness and usability is similarly a matter of concern for many designers and design managers. Taking a broad sweep across the complete menu and matching them to the different essential elements of the design process – here segmented as definition, generation, evaluation and capture – a study conducted specifically for the paper has concluded that there is also a considerable mismatch between the importance and the efficacy of the tools available to support each stage. The primary objective of the work carried out for the paper, then, has been to establish ways and means of resolving some of these issues.

In reviewing a range of tools that encompasses QFD, Robust Design, Axiomatic Design, Design For X, TRIZ, Value Engineering, Kansei, FMEA, Multi-Criteria Decision Analysis, and a host of lesser others, the paper suggests that there is a large and potentially confusing surplus of assistance in the design process areas of definition, evaluation and capture, and a distinct dearth in the area of generation – with many of the methods reliant on brainstorming when the ‘now generate some ideas’ part arrives.

Whether these tools, methods, strategies and philosophies can be integrated together to form a sum greater than the sum of the individual parts has been a matter of some debate. What does appear clear from the analysis carried out, however, is that there are opportunities for the creation of a unified, confusion eliminating, higher level system embracing and distilling the most effective qualities of all. For the sake of providing this higher level system with a label, the paper proposes the term ‘systematic creative design’.

Further analysis has revealed that TRIZ is the only one of the considered methods to explicitly tackle the idea generation part of the design process. The paper discusses TRIZ in this context, and reports the finding that its effective deployment offers significant opportunities for a more systematic creative approach on condition that the earlier definition process is conducted in a manner that takes best advantage of the opportunities afforded by TRIZ. In other words, the distillation of best design practices that form a significant part of TRIZ show that the most effective design solutions start from a distinctly different definition than has traditionally been the case.

While it was far from clear that any designer would actually want a seamlessly integrated creative design system, what emerged from the study conducted for the paper was their desire to be able to mix and match an array of methods to suit both individual taste and the demands of a particular design task. The paper describes the process of assembling just such a system.

This paper is divided into three unequal parts. The first part describes ongoing work on the development of TRIZ as the core of an integrated systematic creative design ‘system’. The second, longest, part of the paper examines how the main ‘other’ creativity tools, methods and philosophies have been integrated into this TRIZ-based ‘systematic creative design’ picture. To varying degrees all of these other tools, methods and philosophies are shown to have something to enhance the efficacy and efficiency of TRIZ. The final part presents a review of recent case study examples of the current integrated system being used to tackle real-life design challenges in a way that fundamentally achieves a stronger outcome than would have been possible without the integrated methodology.
TRIZ – Ongoing evolution

The future of TRIZ (Altshuller, 1988. Salamatov, 1999) has been the subject of significant discussion in recent times (Savransky, 2000, Vertkin, 2001). Opinion differs as to whether it is still at the beginning or has reached the limits of its evolutionary potential. The conflict can be both understood and resolved if TRIZ is recognised as just a part (albeit an important one) in a much bigger system. For the sake of providing this bigger system with a label, the term ‘systematic creative design’ is proposed.

TRIZ places great importance on the existence of evolutionary S-curves. In these terms, the difference between the s-curve for TRIZ (actually, bearing in mind the different TRIZ proponents and variations, such a TRIZ s-curve should be seen as the average of a cluster of subtly different s-curves) and an average curve that might be constructed for ‘systematic creative design’ is illustrated in Figure 1.

![Figure 1: ‘Systematic Creative Design’ Evolutionary S-Curve](image)

The conflict between ‘is TRIZ a mature system or an immature one?’ is thus explained by the point marked on the figure illustrating the current evolutionary state. The point suggests that TRIZ is at the mature end of its evolutionary potential (thus concurring with Vertkin’s comment that ‘there hasn’t been a single new concept introduced into TRIZ in the last 12 years’), but that TRIZ and the current position are still at the relative beginnings of the over-riding ‘systematic creative design’ curve.
In terms of systematic creativity it is evident that there have been many new concepts emerging in the same period. This paper discusses the emergence and integration of some of these concepts as they build on the four philosophical pillars of TRIZ – evolution towards increasing ideality; maximum use of existing resources; the importance of function; the systematic elimination of contradictions as a fundamental evolution driver – and their distillation into a complete problem definition/solving process and wide-ranging selection of tools (Figure 2).

![TRIZ Philosophy/Method/Toolkit Hierarchy](image)

**Figure 2: TRIZ Philosophy/Method/Toolkit Hierarchy**

The idea that TRIZ is one s-curve (system) inside a bigger system for now called ‘systematic creativity design’ emerges from the concept of recursiveness in systems. Recursiveness as discussed in the Viable System Model, NLP and other emerging texts on, not just creativity, but all system evolution is an example of a concept which has not previously existed in classical TRIZ. The current prevailing view is that recursion will be an important element in the successful realisation of a ‘systematic creative design’ s-curve.

The idea of TRIZ representing one s-curve inside a higher order s-curve explains the s-curve figure constructed by Savransky, which suggests that the next stage of ‘TRIZ’ evolution (but actually to give some credit to the mass of other creativity research outside the current scope of TRIZ, ‘systematic creativity’) will involve the integration of different methods.

Examining, now, ongoing work on the development of TRIZ it is possible to show that, although the system is relatively mature, there is still scope for significant improvement and extension.

If Vertkin’s statement about the absence of new concepts in TRIZ in the last 12 years is correct, it should not be taken to also mean that there has been no new work in TRIZ over the same period. The success of www.triz-journal.com, for example, should provide ample evidence of the spread and expansion of TRIZ in recent times.
Much of this ‘new’ work on the other hand may be seen as refinement and re-arrangement of knowledge that is largely the same as that extracted through early TRIZ analysis of scientific and patent databases. One of the consequences of this is that TRIZ tools like the Contradiction Matrix and Inventive Standards are often inadequate (Mann, 2002a) and in some cases fail to handle certain types of problem altogether. One of the underlying problems discovered here is that the world has moved on significantly since the original analysis was conducted. One manifestation of this progress is that the Matrix, for example, often sends users looking to solve software or electrical problems in directions that are significantly different to those being used by the most successful inventors of the last 15 years. The world was a much more ‘mechanical’ place when the initial analysis was happening.

An extensive programme of work was instigated at the beginning of 2000 to begin to rectify this situation. A team of researchers is now undertaking a patent-by-patent analysis of invention disclosures over the period 1985 to 2000. The aims of this research are to:-

- update the Contradiction Matrix in terms of both its form (updating the list of 39 parameters for example) and content. Initial results suggest that in several key contradictions, inventors are now using significantly different strategies to those of their pre-1985 predecessors.
- identify the emergence of new Inventive Principles
- identify the emergence of new trends of evolution. In this regard, it is believed that at least ten trend patterns not previously found in TRIZ have been uncovered.
- identify the emergence of new Inventive Standards.
- generate upgraded versions of the psychological inertia tools based on incorporation of external tools and findings from psychology research.

In line with an increasing tendency for individuals and organisations to not patent their good solutions, and in order to extract strong solutions from fields not involved in patents (e.g. architecture, business/management, industrial design), a programme of systematic search of other knowledge sources has also been initiated. The overall idea is to ensure that users can be offered access to the most effective solutions from wherever they occur.

### Evolving ‘systematic creative design’

The decision to base a ‘systematic creative design’ method around TRIZ was made in line with the comprehensive range of problem solving strategies contained within the method. It was noted that, where most other methods relied upon brainstorming techniques during the idea generation stage of a problem solving process, TRIZ had successfully identified a wide ranging array of much more systematic strategies. The decision to base the systematic creative design method on TRIZ was further justified because awareness of the problem solving tools within the method causes users to define problems in often considerably different ways than they would normally. Beyond that decision, it was clear that several other tools, techniques and methods still had much to offer to enhance the TRIZ process. The other available methods that the research has indicated are best able to complement and help deliver the higher order systematic creative design model are those shown in Figure 3.

To varying degrees all of these other tools, methods and philosophies may be represented as systems with their own series of s-curves. Rather than attempt to position such s-curve approximations relative to TRIZ, the paper focuses only on their role in serving the higher order systematic creative design s-curve development. All of these additional methods have already been the subject of some form of work to explore the benefits of integration with TRIZ. The paper now briefly reviews such work and projects how and why such integration should progress in the future.
TRIZ and function analysis/value engineering

The function analysis/value engineering methodology initially developed by Miles (1961) is probably the method most closely linked with and integrated into TRIZ. Park (1999) is probably the first text to talk about both function analysis and TRIZ in the same place (albeit the understanding of TRIZ is woefully inaccurate). It does not make any mention, for example, of the simple but profound conceptual addition to function analysis made by TRIZ – that of using the function analysis to describe the harmful, ineffective and excessive functional relationships in a system as well as the useful ones drawn in classical function analysis. This simple shift in thinking transforms a method that is useful into one that offers an extremely effective means of both modelling complexity and defining problems. Dewulf and Mann (2001) describe how the current TRIZ addition to function analysis is being further evolved by incorporation of new concepts such as modelling of system attributes, time-variant problems and transition between problem definition and the selection of the most relevant tools to help solve the problem. Of all the methods considered, the integration of function analysis/value engineering into TRIZ is to date the most comprehensive and complete. Future evolution thus looks set to occur at the detailed implementation rather than conceptual level.

TRIZ and QFD and robust design

The integration of the ‘holy trinity’ of TRIZ, QFD and Taguchi methods was the subject of Terninko, Zlotin and Zusman (1997). Theoretically, the three complement each other very well; QFD is about capturing the voice of the customer and translating it into design specification; TRIZ is about generating solutions that fit the specification; and Taguchi/Robust Design tools are about optimising the implementation details of the solutions offered by TRIZ. The practice is currently seen to be some considerable distance away from the theory for the large majority of users. The biggest problem encountered by users involves the usual failure of QFD to accurately capture that customer voice. Customers are frequently unable to describe what it is that they want other than in
terms of ‘better’ than the thing they already have. Few if any customers would ask for a digital camera given a conventional film camera and a request for ideas on creating a better solution. This is an area where TRIZ – and particularly the technology trend prediction elements – is emerging as a more effective start point than QFD. Integration of QFD and Robust Design techniques into TRIZ looks set to continue. At least one significant conceptual level integrative step remains unexploited at this point in time. That step sees its roots in the inadequate ability of TRIZ to handle problem non-linearities. The strengths of Robust Design in this area and their integration into TRIZ is the subject of Apte and Mann (2002).

TRIZ and design for X (DFX)
Design for X, and more specifically the most developed of the X’s, DFMA shares the same problem as a good number of the other tools and methods described here, in that it contains what can be seen from a TRIZ perspective as the ‘insert miracle here’ moment. DFX is very good at defining problems and even better at quantifiably evaluating solutions, but between the two, it offers users little more than the suggestion ‘now generate some ideas’. That being said, the method does have something to add to TRIZ. The already mentioned solution evaluation capabilities – basically providing a framework allowing users to benchmark manufacture and assembly times for an object and thus provide quantified improvements between ‘before’ and ‘after’ situations – are a useful addition, as are the questions developed within DFMA for identifying whether parts are actually needed in a system. This part of DFMA is closely linked to the ‘trimming’ trend ideas contained in TRIZ. Combined together, a problem solver is offered a more comprehensive list of questions to ask when considering the simplification of technical (or indeed business) situations. There appears little scope for additional high level conceptual integration between TRIZ and DFX. The creation of combined DFMA plus function analysis plus trimming tools appears to offer benefits in terms of use-ability.

TRIZ and axiomatic design (AD)
The integration of AD and TRIZ has already been discussed by Mann (1999). TRIZ can be used to show that the AD ‘axioms’ have some very meaningful exceptions, and that they are thus not axioms, but nevertheless, axiomatic design still offers designers a series of useful rules to help define and achieve ‘good design’. The likely future complementarity between AD and TRIZ currently appears to be restricted to the incorporation of these ‘useful rules’ into the solution evaluation part of TRIZ, although the AD scheme for correlating the functional requirements of a system to the selected design parameters to the subsequent method of manufacture may offer some additional benefits to TRIZ.

TRIZ and Viable System Model (VSM)
Stafford Beer’s Viable System Model emerged from the study of organisation structures and resulted in two very important conceptual findings. The first involved the identification of five essential elements that a system had to contain if it were to be ‘viable’. The second involved the idea of recursiveness – and the discovery that the five element viability test still applied at different hierarchical levels of consideration of a system organisation structure. Mann (2001a) describes how this first finding contradicts the TRIZ definition of ‘system completeness’ and how it ultimately therefore provides a stronger definition of completeness than TRIZ (interested readers might also like to examine CREAX (2002) – which provides an alternative perspective on the Law of System Completeness). The second concept of recursion is still only just being introduced into TRIZ (and the higher order ‘systematic creative design’ system proposed in this paper), and is believed to offer significant scope for fundamental conceptual evolution of systematic creativity.
TRIZ and Multi-Criteria Decision Analysis (MCDA)
There are a growing number of available methods for enabling problem solvers to make legitimate, recordable and reproducible ‘apples versus oranges’ comparisons between different systems. Several such techniques – most notably the logarithmic scaling techniques of Lodge (1981) – offer the potential to enhance the solution evaluation aspects of TRIZ. Software implementations of integrated TRIZ/MCDA can be expected to appear in the very near future.

TRIZ and Six Sigma
As described by Domb (2001), Six-Sigma is more a decision than a method. At a detailed level, there are a number of potentially useful tools and techniques contained in (but not necessarily created by) Six Sigma. These tools centre mainly around the process of problem measurement, and specifically variants of Shewhart/Deming based statistical process control techniques. They offer the potential for some small beneficial advance once incorporated into the problem definition elements of TRIZ.

TRIZ and Theory of Constraints (TOC)
The process of integration of Eli Goldratt’s Theory of Constraints into TRIZ has also begun (Mann, Stratton, 1999). The Theory of Constraints matches TRIZ in its recognition of the importance of defining and eliminating contradictions and while it offers less in terms of strategies to overcome contradictions, it does offer the Evaporating Cloud tool which does offer increased richness in terms of increasing problem understanding and entry points for breaking the contradictions. Related to this, but also a much more important area where TOC can be expected to enhance TRIZ comes with its emphasis on modelling causes and effects inside systems. This area looks set to be the main conceptual enhancement to TRIZ, but several other important TOC ideas (identification of bottlenecks, strategies for overcoming bottlenecks for example) can be expected to find their way into future TRIZ/’systematic creativity’ models.

TRIZ and De Bono
The work of Edward De Bono is both extensive and widespread in its use. Many of the strategies identified or uncovered by DeBono have direct equivalents in TRIZ – for example the idea of working back from an ideal rather than working forward from the known solution (albeit DeBono has nothing as extreme as the Ideal Final Result strategy in TRIZ), the importance of function, the need to shift from either/or to win/win thinking, the trend for systems to evolve in a manner which sees complexity increase before it can decrease, and the concept of psychological inertia and tools to overcome all exist in some form in both pieces of work. Elements of Dr DeBono’s work that have no direct equivalent in classical TRIZ include the Six Thinking Hats™ concept, water logic versus rock logic and the ‘flowscape’ tool, the ‘po’ operator, and ‘sur/petition’ concept. The thinking hats concept – and specifically the idea that different modes of thinking are treated very differently in the human brain and so should be segmented – is particularly useful in the context of applying more complete TRIZ processes like ARIZ to more potent effect (Mann, 2001b).

TRIZ and NLP
Although instigated more recently than TRIZ, Neuro-Linguistic Programming has evolved from a very similar philosophical startpoint. Both TRIZ and NLP have been built on the study and abstraction of ‘excellence’. In the case of TRIZ, the global scientific and patent databases provided the basis of method development; in the case of NLP it was cognitive science research into linguistics, psychology, cybernetics and anthropology. Both have sought to study ‘creativity’ from the perspective of modelling known successful creative personalities. Latterly, NLP has drawn additional knowledge from psychotherapy – including Gestalt and Hypnotherapy. Perhaps these latter two extensions have tended to draw NLP away from the mainstream somewhat, and certainly...
exploitation of NLP in business or scientific practices for example is practically non-existent in most fields of endeavour. This is undoubtedly a pity as NLP offers significantly greater richness than TRIZ in many areas. Initial research to understand the areas of common ground and opportunities for mutual benefit (Bridoux, Mann, 2002) between TRIZ and NLP have highlighted a significant number of high level concepts that exist in one or the other but not both. By way of a simple example, Reference 20 discusses the 9-window or ‘system operator’ scheme in TRIZ and how NLP can be used to extend its essentially two-dimensional space and time perspective into a third dimension which might be called ‘interface’ or relationship. Figure 4 illustrates this new three-dimensional operator as an example of a concept that does not exist in either TRIZ or NLP, but emerges purely from the integration of the two. The benefits of this integration are discussed in more detail in Mann (2001c).

![Figure 4: Extension of TRIZ System Operator into 3-Dimensions Using NLP](image)

The integration of TRIZ and NLP tools, methods and philosophies (both rightly claim to feature such hierarchies of application) is very much at the beginning of what may be expected to be a long and fruitful road, along which several important conceptual advances can be expected to emerge.

**TRIZ and Kansei**

As TRIZ extends further towards industrial design, architecture and the arts it becomes apparent that issues like aesthetics are not well handled by current models. The idea that it is possible to systematise those elements of design that relate to the things we describe as ‘x-factors’, ‘the mysterious wow’, and other labels implying that we don’t understand what makes one design better than another one, is positively offensive to some. Kansei engineering on the other hand represents an attempt to achieve exactly this kind of understanding of why people prefer one artifact over another one. Kansei is undoubtedly also at the beginning of its evolutionary potential. It is already possible to embody a number of Kansei principles and strategies into a tool integrated into the TRIZ/’systematic creativity’ framework, but too soon to speculate on whether the integration of the two will create new high level conceptual benefits. All that can be said with any degree of certainty, is that TRIZ is weak on aesthetic issues and that Kansei is currently the best available tool to explore as a suitable foundation for integration.
Review of case study applications
A number of publications have been published in the last two years describing the application of the evolved systematic creative design method to a broad spectrum of problem and opportunity situations. Notable amongst these studies are the following:-

Wind-Turbine Design – Mann (2002b) summarises a study to try and overcome the inherent inability of commercial wind-turbines to operate in very high wind conditions. The paper describes how the key to successful design in this situation is the fundamental need to depart from traditional design trade-off design paradigms. The paper suggests that the wind-turbine is incapable of operating in high wind conditions because current design practices force the designer to find a compromise between two conflicting requirements; on the one hand to make the turbine strong, and on the other, to be able to make it light. The paper highlights a situation definition process which first seeks to find the ‘root contradiction’ (as opposed to root cause – which requires substantially more data and drives users towards optimisation rather than innovation) of the problem, before applying a range of the contradiction-elimination strategies uniquely contained within TRIZ.

Evolution of Bearing Systems – Mann (2002c) reports the application of TRIZ-based technology trend prediction methods to identify the evolutionary limits of existing bearing and lubrication system design paradigms. The paper then goes on to explore the unused evolutionary potential contained within the trends in order to identify future design opportunities and match them to current and anticipated future shortfalls of bearing systems as may be seen from the perspective of their end-users.

Process Design Applications – Mitchell (2002) and Winkless (2002) respectively report the systematic creative design capability being applied to coated paper and food manufacture process applications. Both cases build on the importance of functional modelling and root contradiction analysis as key problem definition stages. The two papers then show the deployment of conflict elimination and trend evolution strategies to overcome limiting contradictions within those processes.

Design for Sustainability – Mann and Jones (2001) discuss the application of hierarchical space-time-interface modelling strategies, and the deployment of trend prediction and resource maximisation tools to derive novel design solutions to a variety of mobile power generation equipment challenges. The paper concludes by suggesting that far greater levels of sustainability may be achieved through more holistic design approaches.

Consumer Goods – Mann (2002d) examines the application of the systematic creative design process to the paradigm-shifting conception of novel consumer products in which aesthetic requirements play a significant role in determining the success of one design solution over another.

Further ahead
We have speculated here that TRIZ is but one component of a higher level creativity capability we have chosen to label ‘systematic creative design’. We believe that it is fundamental to the evolution of such a ‘systematic creative design’ model is that it will emerge – initially at least (as detailed by Savransky (2000)) – from the integration of the different tools, methods and philosophies that currently exist.

There are several emerging creativity models that have not so far been explored in the context of their place in a bigger ‘systematic creativity’ picture. These include game theory, chaos theory, spiral dynamics and general periodicity. Work to explore the relevance and potential benefits of integrating these models into the TRIZ-based model described here (or, indeed, the other way around) has barely begun at this point in time.
In the meantime we all have problems to solve, and opportunities we wish to explore in inventive ways. Some people may want just a few tools or strategies to help them, others may be looking for a higher level start-to-finish process, and still others are looking for a higher level creativity philosophy from which they hope everything else might emerge. In other words, we are all different, work in different ways and want different things. There is currently no single ‘creativity’ entity that will satisfy every individual desire. If there ever is, one thing it will have to encompass is due recognition of individual difference, and (to introduce a TRIZ concept) be self-adapting to accommodate those differences. At a practical level, this might simply mean that person A likes DeBono, TRIZ and QFD, while person B uses NLP and TOC and doesn’t like TRIZ and that both can still work effectively together. The aim of the systematic creative design framework is to achieve this kind of flexibility. As with a ‘systematic creativity’ s-curve, it is still early days. Our hope is that we’ve at least realised a framework that offers users the prospect of tangible benefit now.
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A ‘social model’ of design: issues of practice and research

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Abstract

Compared to the “market model,” little theorizing has been done to produce a model of design for social need. This paper discusses a process of social service intervention that can address the product needs of vulnerable populations. This process follows a problem-solving approach whereby a professional or professional team works collaboratively with clients to improve their quality of life. A number of options for how product designers might work with such an intervention team are explored. The authors then outline a program of research. A multi-faceted approach to address questions related to social design would include survey research and interviews, content analysis of archival data, the development of case studies, participant observation, and research that centers on the development and evaluation of socially responsible products. Questions related to the education of a social designer are also considered.
A ‘social model’ of design: issues of practice and research

Introduction
When most people think of product design, they envision products for the market, generated by a manufacturer and directed to a consumer. Since the Industrial Revolution, the dominant design paradigm has been one of design for the market and alternatives have received little attention. In 1972, Victor Papanek, an industrial designer and at the time Dean of Design at the California Institute of the Arts, published his polemical book *Design for the Real World*, reissued the following year in paperback. In that book he made the famous declaration that “[t]here are professions more harmful than industrial design, but only a very few of them” (1973: 14). The book, initially published in Sweden, quickly gained worldwide popularity with its call for a new social agenda for designers. Since *Design for the Real World* appeared, others have responded to Papanek’s call and sought to develop programs of design for social need ranging from the needs of developing countries to the special needs of the aged, the poor, and the disabled.

These efforts have provided evidence that an alternative to product design for the market is possible but they have not led to a new model of social practice. Compared to the “market model,” there has been little theorizing about an alternative model of product design for social need. Theory about design for the market is extremely well developed. It cuts across many fields from design methods to management studies and the semiotics of marketing. The rich and vast literature of market design has contributed to its continued success and its ability to adapt to new technologies, political and social circumstances, and organizational structures and processes. Conversely, little thought has been given to the structures, methods, and objectives of social design. Concerning design for development, some ideas have been borrowed from the intermediate technology movement, which has promoted low-cost technological solutions for problems in developing countries, but regarding the broader understanding of how design for social need might be commissioned, supported, and implemented, little has been accomplished. Nor has attention been given to changes in the education of product designers that might prepare them to design for populations in need rather than for the market alone.

The field of environmental psychology has attempted to respond to the environmental needs of the vulnerable. Those working in this field use an interdisciplinary approach to research and implement solutions that create better living space for such populations as the mentally ill, the homeless, and the aged (Altman and Christensen, 1990). Architects, psychologists, social workers, occupational therapists, and others have worked together to explore the intersection of people’s psychological needs and the landscapes, communities, neighborhoods, housing, and interior space that increase feelings of pleasantness, arousal, excitement, relaxation and decrease feelings of fear and stress (Nasar, 2000). There has not been a similar effort in the field of product design.

A “social model” of design practice
In this paper, we want to begin a new discussion of design for social need by proposing a “social model” of product design practice and suggesting a research agenda that would examine and develop it in the same way that comparable research has supported design for the market and environmental psychology. Although many design activities can be considered as socially responsible design – sustainable product design, affordable housing, and the redesign of government tax and immigration forms, for example – we will limit this paper to a discussion of product design within a process of social service intervention. Although we base our discussion on the intervention model used by social workers, a similar model could also be applied to collaborations with health care professionals in hospitals and other health care settings as well as to
joint projects with teachers and educational administrators in school settings. The model could also work with teams of experts engaged in projects in developing countries.

The primary purpose of design for the market is creating products for sale. Conversely, the main intent of social design is the satisfaction of human need. However, we don’t propose the “market model” and the “social model” as binary opposites but instead view them as two poles of a continuum. The difference is defined by the priorities of the commission rather than by a method of production or distribution. Many products designed for the market also meet a social need but we argue that the market does not and probably cannot take care of all social needs, as some relate to populations who do not constitute a class of consumers in the market sense. We refer here to people with low-incomes or special needs such as those due to age, health, or disability.

To develop the “social model” we will draw on the literature of social work, a practice whose principal objective is to meet the needs of underserved or marginalized populations. Central to social work theory is the ecological perspective. Social workers assess the transaction that occurs between their client system (a person, family, group, organization, or community) and the domains within the environment with which the client system interacts. Various domains that impact human functioning are the biological, psychological, cultural, social, natural, and physical/spatial (Furr, 1997; Germain and Gitterman, 1986). The physical/spatial domain, which concerns us in this paper, is comprised of all things created by humans such as objects, buildings, streets, and transportation systems. Inadequate or inferior physical surroundings and products can affect the safety, social opportunity, stress level, sense of belonging, self-esteem, or even physical health of a person or persons in a community. A poor fit with one or more of any key domains may be at the root of the client system’s problem, thus creating a human need.

For example, a group of children is acting out in a pre-school. An initial diagnosis blames their parents for having poor child-rearing skills. A social worker is asked to organize the parents in a group to teach them better child-rearing practices. The assumption here is that the parents will apply these skills and their children’s behavior will improve. When the group meets, the social worker learns that the parents are under tremendous stress due to multiple problems: lack of money because of inability to find a job; low wages in available jobs; scarce transportation to get to work in distant places; unsafe surroundings; broken playground equipment on a cement lot; and inadequate and unsafe elevators in their apartment buildings. It is clear that the issues with which the parents are dealing go beyond poor child-rearing skills, thus requiring that other factors, including those in the physical/spatial domain, must be addressed.

Social workers tend to follow a model of generalist practice, a six-step problem-solving process that includes engagement, assessment, planning, implementation, evaluation, and termination. The entire process is conducted in a collaborative manner with the client system. Other human service professionals may be brought in as part of the intervention. In the engagement phase, the social worker listens to the client system and gets a sense of the presenting problem. In the next phase, assessment, the social worker looks holistically at the client system’s interaction within the various environmental domains. The aim of an assessment is not to take a problem at face value but to look more deeply and more broadly at the client system in the total environment to get at the roots of the problem. The outcome of the assessment phase is a list of different needs to be addressed. In the third phase, planning, the social worker collaborates with the client system to prioritize the needs, trying to determine what is most pressing. Then the social worker and the client system brainstorm in order to devise different solutions. They talk about various ideas and collaboratively decide what will work best. Together the client system and the social worker make a list of goals and objectives and decide who will do what by when. In the implementation phase, the intervention is guided by the goals and objectives that have already been agreed upon.
In settings such as hospitals or schools, social workers are members of teams that include other professionals. Among these might be psychologists, speech therapists, occupational therapists, or probation officers. The team works collaboratively to assess a problem, and different team members intervene as needed. The ways in which product designers could participate in a team process with human service professionals are yet to be explored, particularly the designer’s involvement in the physical/spatial domain.

Lawton (1990) describes a research project for the elderly that sought to learn about the deficiencies in the home environment and the way people cope with them. A social worker, an architect, a psychologist, and an occupational therapist visited the homes of fifty highly impaired older people who were managing to live alone. One of the team’s findings was that many of the people they observed had set up “control centers” in an area of their living room that allowed them to view the front door and, through the window, the street. The nearby placement of a telephone, radio, and television also enabled them to have social contact with the outside world. Additionally, on a table within reach were medicine, food, reading material, and other items of use. If a product designer had been on this intervention team, he or she would no doubt have been stimulated to create products that could serve the low mobility needs of this older population.

To advance the discussion of how the product designer might collaborate with an intervention team, we would like to suggest the following options. During the assessment phase, the designer, either as a member of an intervention team or as a consultant, might be able to identify factors that contribute to a problem. In the planning phase, a designer could develop intervention strategies related to the physical environment. During implementation, the designer could create a needed product or work with the client system to design one.

These strategies differ from Papanek’s (1973) proposals for social action in Design for the Real World. Papanek pits socially responsible designers against a commercial market that thrives on the production of excessive and useless products. By harshly criticizing the market economy, he limits the options for a social designer. Papanek argues that socially responsible designers must organize their own interventions outside the mainstream market, yet he gives little guidance as to how this might be done. We believe that many professionals share the goals of designers who want to do socially responsible work, and therefore we propose that both designers and helping professionals find ways to work together. In short, we believe that designers will find many more allies in professions related to health, education, social work, aging, and crime prevention than are evident in Papanek’s analysis.

Nonetheless, Papanek’s book (1973) is extremely helpful in describing the kinds of social products a designer might create. Using as a framework a socially-oriented design office, Papanek provides long lists of products that address social needs. Among these are teaching aids of all kinds including aids to transfer knowledge and skills to those with learning difficulties or physical disabilities; training aids for poor people who are trying to move into the work force; medical diagnostic devices, hospital equipment, and dental tools; equipment and furnishings for mental hospitals; safety devices for home and work; and devices that address pollution problems. Some of these products, particularly medical and hospital equipment, are already produced for the market, but there are certainly many that are not manufactured because a market cannot be identified for them.

A research agenda for social design
Design is most often understood by the public as an artistic practice that produces dazzling lamps, furniture, and automobiles. This is how it is generally presented by the media and the museums. One reason why there is not more support for social design services is the lack of research to demonstrate what a designer can contribute to human welfare.
A broad research agenda for social design must begin by addressing a number of questions. What role can a designer play in a collaborative process of social intervention? What is currently being done in this regard and what might be done? How might the public’s perception of designers be changed in order to present an image of a socially responsible designer? How can agencies that fund social welfare projects and research gain a stronger perception of design as a socially responsible activity? What kinds of products meet the needs of vulnerable populations?

A multi-faceted approach can be taken to explore these questions. Survey research and interviews with human service professionals, designers, and agency administrators can be conducted to gather information on perceptions and attitudes and to solicit suggestions for change. Content analysis of archival data such as journals, periodicals, and newspapers can be used to gain insight into how the media report on issues of social design.

Another research method is participant observation. This entails designers entering social settings either as part of a multidisciplinary team or alone to observe and document social needs that can be satisfied with design interventions. For example, this was done in the research project conducted by Lawton (1990) that we described earlier, except that an architect rather than a product designer was on the investigative team.

There is also research that centers on the development and evaluation of socially responsible products. When designers have ideas for new products, they need to conduct research on how to translate their ideas into a finished design. They also need to evaluate these products in actual situations to test their effectiveness. Finally, there is a need for case studies that document examples of social design practice.

The combined research methods we have outlined are intended to explore a range of questions that extend from the broad social context within which designers work to the specifics of developing a product for a particular client system. The scope of research for social design includes public and agency perceptions of designers, the economics of social interventions, the value of design in improving the lives of underserved populations, a taxonomy of new product typologies, the economics of manufacturing socially responsible products, and the way that such products and services are received by populations in need. Until now, the social interventions of designers have been hit or miss with few successes to point the way towards social support for more of the same.

The education of social designers

Design skills cut across all situations but skills in relating to vulnerable or marginalized populations rather than to a brief from a manufacturer need to be developed by future designers. Students of social design will have to learn more about social needs and how they are currently addressed by helping professionals. They might do an internship with a clinical team in a psychiatric hospital, a community agency, or residential facility for the elderly. They would also require a stronger background in sociology, psychology, and public policy. As far as we know, there are no university programs that specifically train social designers. We can, however, cite as a good beginning the one year certificate program of Archeworks, a private educational institution in Chicago that is dedicated to advancing a socially responsible design agenda. Each year Archeworks introduces a small interdisciplinary group of students from varied intellectual backgrounds to a process of social design that has resulted in a number of projects and studies including a device for people with Alzheimer’s Disease to facilitate their getting into an automobile, a head-pointer designed for people with cerebral palsy, and a new model office environment for the Illinois Department of Human Services. In most cases, projects have been conducted in collaboration with social service organizations or agencies and many have been funded by grants from public and private sources (Archeworks, 2000).
Conclusion
Our purpose in this paper has been to describe a new “social model” of design practice and to suggest a research agenda through which important questions related to the emergence of such a practice can be addressed. A “social model” of design practice is needed more than ever, and we are hopeful that concerned designers, design researchers, helping professionals, and design educators will find ways to bring it about.
References


The design of product/service systems from a designer’s perspective

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Abstract

In the age of globalisation and information technology, corporate strategies are challenged to bring production in line with a complex demand, which requires a substantial shift from production of goods to the provision of knowledge-intensive systemic solutions. Such solutions usually consist of product-service systems, i.e. a marketable set of products and services capable of jointly fulfilling a user's need. Given their strategic relevance, such solutions have rightly been widely discussed in management and marketing disciplines. In the Design discipline instead, the methodological implications of the design of PSS have rarely been discussed even though design components play a critical role in their development.

This paper aims at contributing to the debate about a new role for designers in the definition of innovative PSS. The paper illustrates the design process of a service (an urban telecentre), emphasising the main methodological problems arising in the process and introducing the methodological tools used to understand the nature of the service.

The findings from the research project reported in this paper are expected to provide elements for discussion in the debate about the methodological implications of the expansion of designers’ competence: from the design of industrial products to the definition of the technological, cultural, organisational and social aspects of the design of a PSS.
The design of product/service systems from a designer’s perspective

Introduction
In the new era, markets are making way for networks, and ownership is steadily being replaced by access. Companies and consumers are beginning to abandon the central reality of modern economic life – the market exchange of property between sellers and buyers (Rifkin 2000: 4).

Rifkin’s analysis of the ongoing separation between markets and property is based on the deduction that the main objects of exchange in the new era are no longer material products, but cultural-intensive services. Exchanging goods is less important than sharing access to services and experiences between servers and clients, Rifkin (2000: 52) argues. Such a perspective shift requires companies to re-focus their activities from the production of products to the provision of knowledge intensive systemic solutions (Butera 1990), (Bucci 1992), (Manzini 1993), based on a different mix of products and services. The consequences of such a shift are quite clear to management and marketing disciplines, which have already extended their cultural domains from production to consumption processes (Albrecht and Zemke 1985), (Normann 2000).

Although the relevance of sharing experience between servers and clients emphasises the role of designers in the definition of the value of transactions in the new age, such a large cultural change has rarely been discussed within the design community. One of the reasons for the notable absence of the design discipline in such a debate is the common view that designers’ activities usually deal with material artefacts (whether industrial products, spaces or architectures), rather than on systemic solutions including services. However some scholars such as Manzini, have repeatedly emphasised the need for the design discipline to consider the extension of its domain to include product/service systems (PSS) (Manzini 1993a, 1993b).

The contribution of designers to the definition of PSS would offer a better insight into several aspects, including the technological potentials of PSS focused business and an enhanced comprehension of users’ behaviour and attitudes with respect to new products, technologies and services. Most importantly, the design approach would be critical in the translation of cultural and social needs emerging in the new economic system into a set of concrete elements that characterise the experience to be exchanged by clients and servers in a PSS.

On the other hand the extension of the design domain from product to services implies a cultural change in the design perspective and requires that the designers put themselves in a different position with respect to old competencies (such as technological and cultural competencies) and new ones (such as socio-economic and managerial competencies).

The TeleCentra research project has proven to be an excellent opportunity to explore such a disciplinary shift in the design domain. This paper describes and discusses this project, which focuses on the design of a specific PSS: an urban telecentre.

Product/service systems: what are they? Why they are relevant to designers?
PSS emerge from the need for companies to extend their mission from the production of material products to the definition of knowledge intensive solutions targeted to specific consumption sectors. Goedkoop et al defines a PSS as a marketable set of products and services capable of jointly fulfilling a user's need (Goedkoop, van Halen, Riele and Rommens 1999: 18).

The element of novelty, from the design perspective, comes from the service component of the PSS:
Services do not qualify as property. They are immaterial and intangible. They are performed, not produced. They exist only at the moment they are rendered. They cannot be held, accumulated, or inherited. While products are bought, services are made available. In a service economy, it is human time that is being commodified, not places or things. Services always invoke a relationship between human beings as opposed to a relationship between a human being and a thing (Rifkin 2000: 84).

Because PSS are generated by the convergence of different actors during the use phase the experiential attributes of the PSS need to be thoroughly planned. This makes the design of PSS particularly relevant to designers.

The focus of PSS on the consumption system requires that the traditional domain of design activities, logically located between the domains of technological innovation and management, be extended to new cultural domains, where a thorough understanding of consumption processes is possible (Figure 1)

![Figure 1: Traditional and new domains for designers' activities](image-url)
The new logical location of design activity introduces new challenges:

a) If the relationship between designers and users takes place during the direct contact with the users, the interaction between users and the service needs to be accurately planned, in order to address service needs, this means that a new design management methodology needs to be introduced, to manage the pre-definition phase of the PSS.

b) Users shape the service, as well as designers and service providers do, this requires a better understanding of users’ cultural, social and technological frames

c) If the service is a diachronic event, new tools need to be introduced, in order to control and address the sequence of such events.

The following section reports on the TeleCentra research project in order to provide the elements for a discussion on such challenges.

The case study
The PSS developed in the project is a telecentre, that is a service that provides office space and related facilities to be let for very short periods of time (from an hour upwards) for work activities.

The service is located in a central area of Melbourne, close to the CBD; therefore its potential users are those who visit the CBD from outer urban areas or other cities rather than telecommuters.

The process described in this paper refers to all the phases preceding the commercial phase. At present, the TeleCentra service is not yet available on a commercial basis.

The design process
The design process of the telecentre consisted in an iterative sequence of phases in which problems generated solutions, which in turn, redefined new problems. The process was articulated in the following phases:

Value proposition. Definition of the needs to be fulfilled by the PSS

Definition of target users. Definition of a profile of prospective users

Analysis perceived competitor services. Analysis of the competitor services.

Product/service concept. Definition of the conceptual structure for the PSS

Use-case analysis. Analysis of several conditions of use on the basis of the available research and information. The hypotheses generated in this phase are used to define key functions, requirements and priorities

Prototype architecture. A prototype service is proposed in this phase, on the basis of the indications in the previous phases

Test. The tentative architecture is tested in order to generate use patterns and other indications on the effectiveness of the tentative solution

Final definition. Redefinition of the tentative architecture.
Value proposition
The value proposition is a short synthetic sentence that defines the main function of the PSS in terms of the function it is going to perform and the added value proposed by the new PSS. The value proposition of the TeleCentra is expressed in the following statement:

A system of physical and virtual tools and facilities that support nomadic workers and virtual work teams by providing both an access point to a virtual office and a temporarily inhabited physical space close to the Melbourne CBD.

The service’s added value with respect to existing services of this kind is determined by:

1) the geographical location; unlike other telecentres TeleCentra is located close to the Melbourne CBD; and

2) its characteristic of being a temporarily inhabited space; the concept of inhabiting the space refers to a professional and customisable space, alternative to the traditional office space, in which particular activities can be undertaken, such as isolated work (away from the distractions of the office) and meetings.

Users’ analysis
A survey and a series of interviews helped identify and describe different profiles of potential users. Among them the most interesting profiles were those of telecommuters (i.e. people who divide their work activity between their home office and their corporate office) and nomadic workers (i.e. people working from many different locations).

A profile of those two categories of workers emerges by the interpretation of the data gathered through the filter of a set of criteria, which, according to Bijker (1995.: 122-127), define the socio-technical framework of each group:

Goals, (the needs each group wants to satisfy in relation to specific aspects of their work activities)

Key problems, (the problems to be solved for each group in order to achieve their goals)

Problem solving strategies, (the strategies each group believes to be admissible and effective in solving the main problems)

Requirements to be met by problem solving strategies, (the admissibility and effectiveness criteria for problem solving strategies)

Current theories, (theoretical knowledge supporting the activity of each group in setting goals, identifying and selecting problems and proposing admissible problem solving strategies)

Tacit knowledge, (practice based knowledge upon which each group relies to set goals, identify and select problems and propose admissible problem solving strategies)

Testing procedures, (procedures each group uses to evaluate the effectiveness of each problem solving strategy)
Design methods and criteria, (methods and parameters used for proposing technological solutions to emerging needs)

Users’ practice, (users’ attitudes towards the existing solutions to the present needs)

Perceived substitution function, (products, services or sets of functionalities each group believes to be replaced by the proposed PSS)

Exemplary artefacts (products and services that are used as models in developing new solutions. Often deriving from the perceived substitution function)

The analysis of these parameters reveals specific needs, problems, problem solving criteria and tacit knowledge related to nomadic work (Table 1).
<table>
<thead>
<tr>
<th>Goals</th>
<th>Telecommuters</th>
<th>Nomadic workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better time management for office and personal activities, Telecommuting as a choice.</td>
<td>Compensating physical distance with logical contiguity. Nomadic work as a necessity.</td>
<td></td>
</tr>
<tr>
<td>Key problems</td>
<td>Reducing redundancies and optimising resources when working in two different locations.</td>
<td>Finding dedicated working spaces. Making data and reference material available in every possible location.</td>
</tr>
<tr>
<td>Problem solving strategies</td>
<td>Have adequate facilities to work at home. Large portable memory support (Zip disks, CD ROM) to transfer files. Creating similar environment at home and in the office.</td>
<td>Reducing volume and weight of the material transported in nomadic movements. Use of a laptop or reliance on local Internet connection to retrieve personal files and reference material.</td>
</tr>
<tr>
<td>Requirement s to be met by problem solving strategies</td>
<td>Software, reference material and previously saved files must be available and usable by both home and office computers.</td>
<td>Availability of software, reference material and previously saved files in every work location. When using Internet connection large bandwidth connection is needed.</td>
</tr>
<tr>
<td>Current theories</td>
<td>Telecommuting is an alternative to traditional office work that is suitable for those who cannot commute every day.</td>
<td>There are no theoretical references to describe nomadic work.</td>
</tr>
<tr>
<td>Tacit knowledge</td>
<td>Desktop usage. File transferred using floppy disks or email attachment. Minimal knowledge is required to perform day-to-day information management operations.</td>
<td>Laptop usage as the ideal solution to achieve complete independence. More problems solving capability is required for technical problems when far from the office. Files and personal information are retrieved through the internet using complex file transfer procedures.</td>
</tr>
<tr>
<td>Design methods and criteria</td>
<td>Dedicated space to work at home.</td>
<td>Minimal infrastructure to support nomadic work. Transportable storage (eg small luggage) is needed for paper documents. File storage supports (eg Zip drives, CD ROM) must be compatible with the standard facilities available in Internet cafés, telecentres, airport lounges.</td>
</tr>
<tr>
<td>Users’ practice</td>
<td>Familiarity with those applications that are needed for working in both locations.</td>
<td>Familiarity with the most known applications for managing and exchanging files included Internet-based applications.</td>
</tr>
<tr>
<td>Perceived substitution function</td>
<td>The traditional working environment.</td>
<td>When nomadic work is a necessity, rather than a choice (eg salesmen) there is no perceived substitution function.</td>
</tr>
<tr>
<td>Exemplary artefacts</td>
<td>Office workstations and professional settings.</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: A profile of telecommuters and nomadic workers, according to Bijker's criteria. (Bijker 1995)

**Perceived competitor services**

The perceived competitor services of TeleCentra are chiefly the result of the increasing use of IT as a support to work activities. In some cases these services stem indirectly from this phenomenon. For instance, the increased connectivity between geographically remote locations makes possible the decentralisation of many office-related functions (Morelli 2001).

The analysis of competitors has been undertaken by applying the same criteria used in the user’s analysis. It is assumed, indeed, that technological infrastructures and services included in the
analysis are themselves the result of the interaction between different actors and different socio-technical frames. By applying (where possible) the same analytical filter the researcher aims at gaining a better understanding of the socio-technical frames of the actors who shaped such services (Table 2). Furthermore, this filter makes it possible to comprehend existing models to which TeleCentra customers refer.

<table>
<thead>
<tr>
<th>Competitors</th>
<th>Serviced Offices</th>
<th>Internet Cafés</th>
<th>Neighbourhood Centres</th>
<th>Airport Lounges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>To accommodate medium term office activities and reducing their capital costs</td>
<td>To provide access to the Internet for Web surfing, mail and chat. Mainly designed for tourists.</td>
<td>To provide cheap access to local (not necessarily computer literate) community.</td>
<td>To provide access and basic working space to businessmen, between their flights</td>
</tr>
<tr>
<td>Key problems</td>
<td>Need for medium term temporary offices in central metropolitan areas.</td>
<td>Large bandwidth access. As many workstations as possible</td>
<td>Reduce costs of infrastructure and connection, in order to reduce usage fees</td>
<td>Travels should bring about minimal disruption of working activities.</td>
</tr>
<tr>
<td>Problem solving strategies</td>
<td>Provision of space plus accessory services (e.g. reception, secretarial assistance)</td>
<td>Reduced space for non computer-performed functions.</td>
<td>Second hand computers. Avoid cutting-edge technology.</td>
<td>Computer and working space contiguous to lounge and waiting areas</td>
</tr>
<tr>
<td>Current theories and tacit knowledge</td>
<td>This service increases small and large business’ flexibility</td>
<td>Internet replaces expensive phone calls when travelling.</td>
<td>Need to expand computer literacy and Internet use in disadvantaged communities</td>
<td>Increased connectivity reduces working problems for remote workers, when travelling.</td>
</tr>
<tr>
<td>Design methods and criteria</td>
<td>Shared facilities and services, representative spaces. Computers are not necessarily included in the service</td>
<td>Small cubica to accommodate a computer. (sometimes) coffee area.</td>
<td>Adaptation of spaces and infrastructure designed for other functions.</td>
<td>Cubica for computer-related and private working activities. Meeting spaces contiguous to lounge and waiting areas</td>
</tr>
<tr>
<td>Users’ practice</td>
<td>Use of the services offered as in traditional offices.</td>
<td>Users are supposed to be familiar with basic Internet applications</td>
<td>No particular knowledge is needed.</td>
<td>Users are supposed to be familiar with the basic hardware and software applications</td>
</tr>
<tr>
<td>Perceived substitution function</td>
<td>Ownership of the office space and related office services</td>
<td>Telephone (for communication). Home computer.</td>
<td>Telephone (for communication) traditional office space.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Analysis of the perceived competitor services according to their related socio-technical frames
**Definition of the product/service concept**

The previous considerations provide indications about the needs to be fulfilled by the telecentre, however there is no indication about the actual solutions to be offered with this particular PSS. Furthermore, the above analysis does not provide any indication about what the telecentre could become in the future.

The conceptual definition of the components of the telecentre must be articulated according to such short and long term perspectives. In the short term the project will focus on a simple system of products and services that satisfy the basic demands for support from nomadic workers. Such a system should include physical and virtual elements. The main attributes of each component should also be listed in this phase.

**Use case development**

Use cases are *short stories* about hypothetical users’ behaviours. The behaviour of possible TeleCentra customers was deduced from the analysis of existing telecentres and from the brainstorming sessions in which the value proposition and the PSS definition were formulated. Use cases are employed to articulate problems in such a way that assists in generating a list of specific requirements.

Use cases were described in a standard format including an actor’s name (usually indicated by a common personal name), a short description of a flow of events and some indication about pre-conditions (i.e. conditions that have to be true before the flow of events start) and post-conditions (i.e. conditions that have to take place at the end of the flow of events). The development of the use case generates a list of products and services included in the system. The following section clearly demonstrates the capability of this technique to generate a set of requirements needed in the PSS.

An example of a use case is outlined below.

**Use Case 1**

**Title**: John wants to edit his CV

**Actors**:

John, when using the telecentre to edit his CV  
The receptionist welcoming, informing and billing John  
The room assistant, assisting John

**Flow of events**:

John enters the telecentre  
The receptionist welcomes John  
The receptionist informs John about available workstations  
The receptionist introduces John to the room assistant  
The room assistant guides John to the workstation  
John logs in and works on his CV  
Time spent by John working on his CV  
John finishes his work, saves the file and approaches the billing person (it could be the receptionist)  
The receptionist updates John’s membership card (that helps John keep track of his use of the telecentre)
**Pre-conditions:** John is a registered user of the telecentre (he has a login and password that allow him to access the telecentre’s network and computers)

**Post-conditions** John has a saved copy of his edited CV in his online directory on the telecentre’s server (or on a floppy disk).

A schematic representation of the interaction between users and products and services included in this particular scenario is outlined in Figure 2.

![Figure 2: Flow chart of user interaction with products and services for Use Case 1](image)

Figure 2 represents the service cycle and provides information about:

1)   Processes  
2)   Performer of the process  
3)   Physical location of the process

However the representation in Figure 2 only includes the elements of the service cycle that are visible to the user. A more comprehensive representation of the service cycle includes intangible elements and technical and maintenance services provided to maintain the quality of the service. The blueprint for the service cycle related to this scenario is represented in Figure 3.
Figure 3: Complete description for Use Case 1

Functional requirements for the telecentre (i.e. requirements about product and service components needed for the system to perform the required functions) can be directly deduced by the use case. Figure 4 is a schematic representation of the requirements logically inferred from the use case, representing the main elements, their characteristics and their interaction.
The iteration of several use cases similar to the one described above provides a list of functional requirements and related attributes as in Table 3. Budget constraints and technological limitations require a prioritisation process for the inclusion of components and the improvement of the attributes.
<table>
<thead>
<tr>
<th>Functional Components</th>
<th>Priority</th>
<th>Attributes</th>
<th>Priority</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spaces for computing, including Internet connected workstations</td>
<td>High</td>
<td>Separate enough to guarantee privacy, at the same time; located in a way that makes team work possible, when necessary. Large enough to allow for working with paper documents and other cumbersome working support.</td>
<td>High</td>
<td>Commercially available office furniture was used. The model for this space was the Dex. (DuFy and Powell 1997), ie an interactive but semi-autonomous open space. Settings and colours of the space had to be familiar to the customers.</td>
</tr>
<tr>
<td>At least one separate office (to be used by home based business to meet clients or recruitment interviews)</td>
<td>High</td>
<td>Professional setting, Internet connected.</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Spaces for laptop users</td>
<td>High</td>
<td>It must be equipped with Internet access and access to printers and the local server.</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Graphic workstation</td>
<td>High</td>
<td>Access to scanner, colour printer and large monitor.</td>
<td>High</td>
<td>Advanced graphic design software. Budget limitations, depending on demand.</td>
</tr>
<tr>
<td>Spaces for meeting</td>
<td>High</td>
<td>At least 8-10 people.</td>
<td>High</td>
<td>Multimedia facilities and Internet access. Budget limitations, depending on demand.</td>
</tr>
<tr>
<td>Fax, photocopiers, b/w and colour printers, scanners</td>
<td>High</td>
<td>Located in shared spaces, easy to access and to use.</td>
<td>High</td>
<td>Automated meters and payment systems. Budget and technological limitations.</td>
</tr>
<tr>
<td>Phone Lines</td>
<td>High</td>
<td>Available in every work station</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Desks for casual visitors with their laptop or who do not need a computer</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet-connected server</td>
<td>High</td>
<td>Secure access.</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Technical assistance</td>
<td>High</td>
<td>Available full time</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Memory space for personal files</td>
<td>Medium</td>
<td>Small space, connected to the service.</td>
<td>High</td>
<td>Large, fee-based file and personal management service. Technological limitation, a system needs to be designed for this specific purpose.</td>
</tr>
<tr>
<td>Training room</td>
<td>Medium</td>
<td>Classroom equipped with several workstations.</td>
<td>Medium</td>
<td>Already available, use depending on demand.</td>
</tr>
<tr>
<td>A reception space and service</td>
<td>High</td>
<td>Fast information service.</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Payment system</td>
<td>High</td>
<td>Based on membership. Make it possible for users to keep track of their usage of the service.</td>
<td>High</td>
<td>Automated.</td>
</tr>
<tr>
<td>Devices for large memory support (eg CD burner, Zip drivers)</td>
<td>Medium</td>
<td></td>
<td></td>
<td>Budget limitations.</td>
</tr>
<tr>
<td>Synchronisation devices for palmtops</td>
<td>Low</td>
<td>Based on Infrared or Blue Tooth technology.</td>
<td>Low</td>
<td>Low percentage of laptop users, technological limitation.</td>
</tr>
<tr>
<td>Small Café or water cooler space for casual meetings</td>
<td>Medium</td>
<td>Close to the working area, but separated, in order not to disturb other workers.</td>
<td></td>
<td>Space limitations.</td>
</tr>
<tr>
<td>Small shop for stationery</td>
<td>Medium</td>
<td></td>
<td></td>
<td>Depending on demand.</td>
</tr>
</tbody>
</table>

Table 3: Functional components, attributes and priorities of a tentative architecture

**Prototype architecture**

In this phase the requirements deriving from the use cases and scenario development are translated into a prototype architecture of the service. The generation of a prototype architecture is based on the definition of functional components of the service and their attributes. The choice of building to be occupied by the telecentre was driven by the availability of spaces. The prototype service was
located on the first level of a building and distributed over four rooms, across which the various functions were distributed. The floor plan of the telecentre as designed in this phase is reproduced in Figure 5.

![Figure 5: First TeleCentra floor plan](image)

The reception area and a large training room were located on the ground level. Some of the shared facilities were located close to the working space (e.g., fax, printers, and scanners). Others were placed closer to the reception area to facilitate supervision and access from users who were not using the telecentre’s computer workspaces.

Access limited by membership would preserve the professional characteristics of the environment and to avoid improper use of the service. Membership cards would record customers’ login details and service usage.

Customers would have the option to pay for the card in advance at a discounted price, in order to encourage return visits to the telecentre. Depending on budget availability, the card could be replaced with an electronic card that records all transactions at the telecentre (photocopies, usage, fax, phone calls, etc). Membership cards can be defined as service evidence, i.e., an element that is visible to the consumer, but not critical to the sequence of events that constitute the service. According to Shostack (1982) the role of such elements is essential for the client to recognise and judge the value of the service (like bus tickets).

The economic restrictions imposed by the project budget were not the only reason why the adoption of an automatic payment system was excluded in the first phase of development. In fact, it was also important that new clients found a familiar and friendly environment in which the direct contact
with the telecentre personnel could help in the understanding of the various opportunities offered by this kind of service.

**Test phase**
The telecentre was opened for 6 months to run a test phase. During this period, the telecentre’s service was offered at a discounted price to prospective users. Furthermore, some groups of people were invited to use the telecentre as *testers*, in order to verify some of the functions. Information brochures about the telecentre were distributed in the local area (especially in hotels and serviced apartments) and through some organisations. The test phase focused on some critical design aspects, such as:

- **Facilities usage** (What facilities and functions were used most often?)
- **Performance** (Do all the services offered perform at acceptable levels?)
- **Continuity** (Does the process flow smoothly for each of the services offered to customers?)
- **Communications** (Do clients find all the communication needs they require to work independently?)

The test phase introduced some strategic issues upon which to focus, such as:

- Improvement of the functions in the computer room
- Redesign of the separate office
- Improvement of the facilities available in the meeting room
- A more professional image to be communicated to customers in order to generate an environment closer to the concept of a *club*.
- Improvement of the reception space
- More efficient infrastructure (Internet connection, photocopiers, fax)
- Staff training and coordination
- More transparent billing system
- Improved communication between the functional units
- Design of a computer interface to *empower customer use*, i.e. to facilitate the use of the services offered.

**Final definition of the service**
In this phase the service had been defined to the point where the project team believed the telecentre was sufficiently developed to be launched commercially. Several changes were included in this phase. The main change consisted in moving the telecentre to new premises where technical problems with Internet access, phone network and reception management could be solved. A larger and more comfortable separate office and a larger meeting room were also available in the new location.

The functions of reception, booking and coordination of the working space were unified and managed by the same personnel.
Some features of the new premises (such as a small courtyard and a kitchen) were used to emphasise the character of a stress-free environment, in which users could attend their meeting or get their professional work done in a quiet and relaxed setting.

Such a characteristic required that the value proposition be readdressed, providing a new attribute of the physical and virtual services to be offered. The marketing campaign designed for the telecentre also addressed this characteristic, which seemed to add considerable value to the service.

**Discussion**
In this section some aspects emerging from this case study, which are relevant to the designer’s perspective, will be discussed. The section will focus on three main points:

1) The generation of a design management methodology for the pre-use phase of a service;
2) The analysis of socio-technical frameworks converging in the PSS;
3) The definition of methodological tools to control the flow of events and to represent attributes and components of a service.

**Product design VS service design: a comparison**
To what extent can product design and development methodologies be exported into the definition of a service?

As seen before, products and services are produced and defined according to different timeframes: while products are relatively well defined in their physical structure before they come in contact with the user, services are defined by the interaction with the user. Existing product development methodologies do not focus on post-sale phases, while the development of a service takes places mainly in the use phase that should be carefully planned and managed, as proposed by Ramaswamy (1996) (Figure 6).

![Figure 6: The service design and management process as proposed by Ramaswamy](image)

Furthermore, the existing product development methodology cannot be simply transposed to service design because of the very nature of the service, in which the immaterial component has a critical role. The process described in this paper is an iterative sequence of problematic and propositional phases. The problematic phases aim at acquiring as much information as possible, in order to implement the conceptual and operational structure of the service, while the propositional phases
are temporary configurations of the service. Problematic and propositional phases generate a process of co-evolution, which qualify service design as a design exploration activity (Maher 1996; Maher 1996). Although this case study only refers to the pre-definition of the service, the management phase can be interpreted as the prosecution of such an exploration with the involvement of customers.

![Figure 7: The evolution of the design process in the TeleCentra project](image)

The co-evolutionary approach developed in this project may offer suggestions for the development of innovative product-development strategies. In the age of product customisation the definition of the product is the result of a co-design process involving producers and end-users. Such a relationship, argues Rifkin (2000: 108), is more like that between server and client than a seller and buyer and customisation could be better managed if it were regarded as the contracting of a service. From this perspective, the co-design of products/services should be based on intense feedback and redefinition loops similar to the sequence of analytical and propositional phases of the TeleCentra project.

**PSS and socio-technical frameworks**

The method used to generate a profile of the possible TeleCentra users is based on the assumption that PSS are socially constructed entities, which result from the interaction of the socio-technical frameworks of the actors involved in it.

Once possible users were identified, their profiles were compared with the socio-technical framework of other actors involved in the telecentre, including the system of technological infrastructure and products used. Figure 8 is a graphical representation highlighting actors, technological infrastructure, products and services that contribute to shape the service. Each actor either interacts directly with the service (e.g. telecommuters, nomadic workers) or interacts indirectly by providing products and services.
It is worth stressing that technological products and infrastructure have been considered as active agents in shaping the service, as they transfer the socio-technical framework of the actors that generated them. The limits of Internet applications, the limitations due to security concerns and the problems derived from the building configuration, are explained more clearly through this approach.

This approach is suggested by social construction studies, which introduce the concept of heterogeneous actor network as a methodological tool to understand innovation phenomena implying strong links between social actors and inanimate objects (products and technological systems). Callon (1989) suggests such a conceptual tool to conduct an analysis that in every stage of the development of the PSS focuses on the continuous co-evolution of the socio-technical framework of the various actors. The TeleCentra project approach, focuses on such networks, rather than looking for a clear definition of the PSS as a system, which would imply the definition of the system boundary and environment and further logical and analytical work.

From the designer’s perspective this approach is useful to identify the inevitable social implications of an innovative PSS, without having to borrow the whole complexity of more traditional sociological analysis.

**Controlling events, components and attributes of a service**

The design activity mainly consists in a projection into the future. In fact some languages (e.g. Italian) use the word *project* to denote such activity.
Whilst product design has developed several methods to control such projection, because of the specificities of services, those methods cannot be automatically transposed to service design. It is difficult, for instance, to use product design methods, focused on material qualities, to control some services’ immaterial attributes, related to time and social and cultural relations.

The use case approach in the TeleCentra project was an attempt to control such variables.

This approach is borrowed from computer system studies, where it is used to predict users’ behaviour and represent the interaction between users and the system (Cooper 1999), (Leffingwell and Widrig 2000). Similar methods based on the description of use case scenarios, have also been used by design firms for the development of design concepts (Covington and Hannah 1997).

Use cases are aimed at generating scenarios that represent the possible future configurations of what is to be designed. Once a use case was generated, the next stage in the project consisted in producing a schematic representation of the use case. Such a representation contains indications about material elements of the service (e.g. sequence of spaces, products used) and immaterial attributes, such as time sequences, interaction, actors involved, accessoriel operations.

Such a schematic representation is the blueprint of the service. Indeed such a representation makes it possible to communicate the service concept in a simple way.

The importance of the generation of the service blueprint is clear when some situations are considered, such as franchising, in which the service needs to be replicated in several locations and contexts.

Several representational techniques have been considered in the project, which derived from computer science studies (in particular graphical representation used for use cases in the Unified Modelling Language and the Petri Nets method), from marketing studies (Shostack 1982), and previous design studies (Pacenti 1998).

The representations used in this project contain elements derived from such studies, with the addition of indications that are critical to the designer’s activity, such as information on physical and virtual spaces, perceivable and unperceivable elements and attributes [2].

Because of its focus on design and the capability to represent future scenarios, the use case method can also be applied to broader strategic design studies aimed at representing short and long-term futures. Studies on sustainability for instance, may use this approach to articulate Design-Orienting Scenarios, which are being used to generate and evaluate possible and desirable futures in certain consumption areas (Young 2001), (Manzini 2001).

Conclusions
The description of the design process in the TeleCentra project provides suggestions and tools for the operational aspects related to the expansion of the design domain from the design of products to the definition of new services. It is clear, from this project, that service design implies a multidisciplinary approach in which designers have a critical role in a wider design team. It is also clear that the different nature of services with respect to products challenges the traditional designer’s competencies and requires a new methodological approach, which borrows methods and tools from other disciplines.
This paper addresses some of the operational aspects of such a new challenge for designers. Several aspects still need to be explored by a more extended design practice in this domain. It is clear however, that more thorough research in this area is particularly relevant in a historical moment in which the shift from a mature industrial phase to what Rifkin (2000) defines ‘the age of access’, requires a thorough rethinking of the role and nature of products themselves, and consequently a strategic repositioning of the design profession.

[1] This paper reports on the research activity undertaken for the TeleCentra project. The project was funded by the Australian Research Council under the SPIRT scheme. This project involved an academic institution (RMIT University) and two private partners: CoAsIt and Motile Pty. Ltd. It was coordinated by Dr Nicola Morelli (Centre for Design at RMIT) and Prof Liddy Nevile (Motile Pty. Ltd). The author wishes to thank Prof Liddy Nevile and Michael Abdilla for their critical contribution to this paper and to the project.

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A research into the thinking modes in creative design process

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Abstract

The authors made four design experiments to know how student designers create design solutions in translating goal description to its visual form. Firstly, in experiment 1 and 2, several thinking types were found in the sketches of the subjects, and then confirmed that they could sum up to two thinking modes (Metaphor mode and Form-making mode) depending on the difficulty in translating the goal description to its visual form. In experiment 3, it was found that the subjects took varied ways with changing thinking modes to reach final sketches depending on the difficulties of goal descriptions. Lastly, in experiment 4, the subjects were given a very difficult goal description, and the experimenters analyzed the sketches and words written in the sketches. As the result, some hierarchies of meanings of goal description were found in the subjects’ thinking processes. The subjects seemed to search clues of translating word to form through low-leveled words. Consequently, the author asserted that to make creative design, designers need to go along a thinking path with repeated changes of the thinking modes.
A research into the thinking modes in creative design process

Introduction
Recently, computer seems to become essential tool of design works. However, designer’s creativity is not increased by using computer, but rather seems to be declined. In design education, it is also serious problem. We should pay attention to the human design activity again. In this situation, we focused on the creative thinking process of design.

Finke made famous experiment on the creative cognition, in which they observed how the subjects invent creative things by using given geometrical shaped parts (Finke, Ward and Smith 1992). However, the design process usually started by setting a design goal, and designer has to generate forms fitted to the design goal in his/her thinking process. If the thinking process shown by Finke was a creative thinking, there might be another type of creative thinking in design. Goldschmidt had remarkable study on the designer’s thinking process focused on the designer’s sketches (Goldschmidt, 1994). Purcell and Gero made effort to sum up the recent studies on the relations of designer’s drawings and creative thinking process (Purcell and Gero 1998). Candy and Edmonds presented result of long time survey of certain bicycle designer’s thinking process (Candy and Edmonds 1996). Maher, Poon and Boulanger presented a research on the thinking process of design focused on the thinking path (Maher Poon and Boulanger 1996).

Based on those results, we had several experiments to know the relations of designer’s drawings and creative thinking process from the view points of thinking mode and thinking path.

Experiments
For the purpose of understanding how creative thinking progresses in design process, we made four experiments focused on drawings as important clues.

Experiment 1
Purpose of the experiment 1
The purpose of this experiment was to know how visual image of a new object is created from verbal goal description (key words).

Procedure of experiment 1
About 80 subjects (first year class students of Chiba University) were assigned a task to design two kinds of paperweights, one of which was to give a sense of ‘relaxation’ and the other was to give a sense of ‘excitement’. This experiment was composed of three steps in the entire process. The first step was made for the purpose of giving training of thinking and drawing to the subjects, because they were still in rudimentary stage in the first year design class.

At first the subjects were assigned two tasks. One was to draw the most favorite plant and the other was to imagine an unknown plant and draw it. After a week from this initial training, the subjects were assigned the second task that was to design a paperweight with which gives a sense of ‘relaxation’. After 20 minutes was given for drawing, sketches were gathered and copied for using them to examine subjects’ mid term output of thinking process. Then the subjects were instructed to continue drawings. Color pencils were used for drawing this time. After 30 minutes was given for drawing, sketches were gathered and copied again.

After a week from the last task, the subjects were assigned the third task that is to design a paperweight with which gives a sense of ‘excitement’. The same process as the second task was taken in this task.
Evaluation of the sketches
Methods of evaluation of sketches were made on the basis of following two ways. Firstly, two expert design educators evaluated mid term sketches (at 20 minutes after start) in following evaluating items by 5 steps grading (grade 3 was neutral point) on each. We thought that two evaluators were sufficient number because the evaluation items required not so subjective judgment and the results of evaluation would be not so different between the two evaluators. Moreover, the evaluators were experts in design education and they used to evaluate many students works in every days work.

(1) Whether new form was intended to generate or not?
(2) Whether form of ready-made objects were used or not?
(3) What was drawing skill?
(4) Whether a metaphor was used or not?
(5) Whether intended to make aesthetic form or not?
(6) Whether intended to make funny sense or not?
(7) The number of ideas (normalized score 0 to 5).

The results of averaged grades on the evaluation items were analyzed with using the principal component analysis method. From the result of the analysis, the values of the principal components on each sketch were positioned onto two-dimensional distribution maps (Fig.1 and Fig.2).

![Scattered graphs of PCA](image)

From the component loading value of each principal component, we recognized as axis X (principal component No.1) represented creativity and axis Y (principal component No.2) represented ability of expression.

Based on the two-dimensional distribution graphs, the first quadrant area implies creative and good expression ability, the second quadrant area implies not creative but good expression ability, the third quadrant area implies not creative and poor expression ability, the fourth quadrant area implies creative but poor expression ability.
Examination of thinking process
In next step, we examined on the difference of two kinds of sketches drawn by the same subject, those were rough sketches drawn in first 20 minutes and colored sketches drawn in next 30 minutes in this experiment. Examination was focused on how did the subjects carry their thinking process from the start to the end of the experiment.

As the results of the examinations, several groups of thinking types were recognized. Those were as follows.

1) Type of subjects who drew sketches in evolving and modifying one sketch to get satisfied one. We named this ‘evolving type’.
2) Type of subjects who drew, at first, as possible many drawings as they could imagine, then selected one of them and refined it. We named this ‘diverging type’.
3) Type of subjects who drew only one or two sketches, but elaborated drawing. We named this ‘Adhering type’.
4) Type of subjects who drew only one or two poor drawings. We named this ‘Poor imagination type’.

Typical examples of sketches by those types are shown in Figure 2.

![Typical examples of sketches](image)

Figure 2: (A pair of sketches of divergent type and evolving type)

Analysis of the results of experiment 1
We looked into the relations between the number of sketches in each quadrant of the principal components spaces and the thinking types mentioned above. Firstly, we counted the number of samples of each thinking type in each quadrant of the principal components space. Then calculated proportions of each thinking type in each quadrant. The results are shown in Table 1.
Table 1: (The numbers of types in each quadrant)
The result was shown as follows:

1) The evolving type and adhering type were mostly seen in the first quadrant area of both cases (‘Relaxation’ and ‘Excitement’).
2) The diverging type was scattered over the second, third and fourth quadrant areas but scarce in the first quadrant area in both cases.
3) The adhering type was mostly seen in the first and second quadrant areas in case of ‘Relaxation’, but in case of ‘Excitement’, it was mostly seen in the first fourth quadrant areas.
4) The poor imagination type was mostly seen in the third and fourth quadrant areas but scarce in the first and second quadrant areas in both cases.

From these results we found that:

a) ‘Evolving type’ produced the most numbers of creative drawings, and most of their sketches were abstracted forms with drawings of repeated lines.
b) ‘Diverging type’ produced many idea sketches, and most of their sketches were cartoon like drawings of well-known objects.
c) The number of ideas was not correlated to high creativity.
d) There was some difficulty to discriminate the ‘adhering type’ and ‘poor imagination type’.

Confirmation of thinking types by preparatory drawings
As mentioned in precedent section, we assigned two preparatory tasks to the subjects before main experiment was held, those were to draw most favorite plant and then to imagine and draw an unknown plant. We examined and classified the way of the preparatory drawings of each thinking type. The classification viewpoints were as follows.

(1) Elaborative drawing
(2) Cartoon like drawing
(3) Intermediate (Could not categorized into (1) or (2))

As the results, we found that:
The averaged number of sketches in evolving type and diverging type were apparently larger than the other types.

The proportion of elaborated drawings was large in evolving type and adhering type, but was extremely small in poor imagination type, and was intermediate in divergent type.
The proportion of cartoon-like line drawing was large in divergent type and poor imagination type, but was small in evolving type and adhering type.

Those results seemed to support our classification of the thinking types.
Experiment 2

Purpose of experiment 2
The purpose of the experiment 2 was to know how the differences of the words that were hard to associate to form, and the word that was easy to associate to form, appear as the difference of drawings.

Procedure of experiment 2
This experiment was done as a part of a usual practice in first year class students of Chiba University in Oct. 2000. About 80 subjects were assigned a task to design two kinds of flower vase with two different keywords, one of which was ‘give soft image’ and the other was ‘humorous’. 20 minutes was given for each drawing task with a ballpoint pen on a B5 paper, and finally, 74 subjects presented in both tasks.

Method of evaluation
Two expert design educators evaluated each 74 sketches with following evaluation items by 3 steps grading.

(1) Whether the keyword was visualized by using metaphor or not?
(2) Whether the keyword visualized by using form itself or not?
(3) Whether the keyword was successfully expressed in drawing or not?

Analysis on the results of experiment 2
On the basis of those evaluations, the value of rate of success was calculated in each keyword. We found two typical thinking modes from the results, one was that tried to express a keyword by form itself (we named it ‘Thinking mode F’) and the other was that tried to express by using metaphor of the image from the keyword (we named it ‘Thinking mode M’). Then, we examined the results focusing on the thinking modes.

(1) The number of success in expression of form of soft image was 22, and the number of success in expression of form of humorous was 5 (Table 2).
(2) In the group of success in expression form of soft image, the number of the thinking mode M was 1, and the number of the thinking mode F was 14.
(3) In the group of success in expression form of humorous, the number of the thinking mode M was 3, and the number of the thinking mode F was 1.
(4) In the sketches by keyword ‘soft image’, thinking mode F was 20 and thinking mode M was 3 in number.
(5) In the sketches by keyword ‘humorous’, thinking mode M was 36 and thinking mode F was 28 in number.
(6) Most of metaphors related to keyword soft were imaginations from plants, water and so on; those were related with the functions of a vase. However, metaphors related to keyword humorous were based on humorous things or humorous gestures and facial expressions.
Table 2: The rate of success in two keywords

<table>
<thead>
<tr>
<th></th>
<th>Evaluation items in (Thinking types)</th>
<th>Numbers of subjects</th>
<th>The keyword was successfully expressed in drawing</th>
<th>Rate of success</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>soft</strong></td>
<td>The keyword was visualized by mainly metaphor (M)</td>
<td>3</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>The keyword was visualized by using form itself (F)</td>
<td>20</td>
<td>7</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>toss-up (evaluation value 2)</td>
<td>51</td>
<td>14</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>74</td>
<td>22</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>humorous</strong></td>
<td>The keyword was visualized by mainly metaphor (M)</td>
<td>36</td>
<td>3</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>The keyword was visualized by using form itself (F)</td>
<td>28</td>
<td>1</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>toss-up (evaluation value 2)</td>
<td>10</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>74</td>
<td>5</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Figure 3: (A pair of sketches of F mode and M mode)

From the results, we supposed that the most of subjects used F mode when they were given keyword ‘soft image’ and used M mode when they were given keyword ‘humorous’. However, in case of the success in expression of from with keyword ‘humorous’, most of the subjects seemed to use F mode, too.

**Experiment 3**

**Purpose of experiment 3**

This experiment was held in October 2000 at Chiba University to know how the subjects created different images of design objects from 5 different keywords.

**Procedure of experiment 3**

The subjects were about 80 students of first year class of Department of Design and Architecture in Chiba University. The class was divided into 5 groups (the number of members of each group was about 15 to 16), and each group was assigned a task to design of streetlight giving different keyword in each: ‘calm’, ‘vigorous’, ‘familiar’, ‘cool’ and ‘elegant’. These keywords were selected
in consideration that they have as different meanings as possible each other. At first, the subjects were given 60 minutes to make idea sketches, then after it, they were given 80 minutes to make a final drawing using color pencils. The mid term sketches were gathered for examining the subjects’ mid term thinking process.

**Method of evaluations**

Two expert design educators evaluated the drawings in each evaluation item (shown below) according to the 3-grade system.

1) Whether was the keyword successfully expressed in drawing or not?
2) Whether was the interpretation of keyword fresh and interesting or not?
3) Whether was the drawing related to other keywords or not?
4) Whether was the keyword visualized in the form by using some metaphors or not?
5) Whether was the keyword visualized in the form by using form itself or not?
6) Whether was it good design or not?

<table>
<thead>
<tr>
<th>Keyword</th>
<th>number of sketches</th>
<th>successfully expressed keyword in drawing</th>
<th>Interpretation of keyword was fresh and interesting</th>
<th>Drawing was not related to other keywords</th>
<th>Visualized by using associations or metaphors</th>
<th>Visualized by using form itself</th>
<th>Good design</th>
</tr>
</thead>
<tbody>
<tr>
<td>calm</td>
<td>16</td>
<td>3(0.15)</td>
<td>3(0.21)</td>
<td>9(0.19)</td>
<td>4(0.31)</td>
<td>7(0.20)</td>
<td>1(0.09)</td>
</tr>
<tr>
<td>vigorous</td>
<td>14</td>
<td>5(0.25)</td>
<td>5(0.36)</td>
<td>11(0.23)</td>
<td>4(0.31)</td>
<td>7(0.20)</td>
<td>1(0.09)</td>
</tr>
<tr>
<td>familiar</td>
<td>14</td>
<td>2(0.10)</td>
<td>2(0.14)</td>
<td>5(0.10)</td>
<td>1(0.08)</td>
<td>6(0.17)</td>
<td>1(0.09)</td>
</tr>
<tr>
<td>cool</td>
<td>15</td>
<td>6(0.30)</td>
<td>3(0.21)</td>
<td>15(0.31)</td>
<td>1(0.08)</td>
<td>10(0.29)</td>
<td>5(0.45)</td>
</tr>
<tr>
<td>elegant</td>
<td>12</td>
<td>4(0.20)</td>
<td>1(0.07)</td>
<td>8(0.17)</td>
<td>3(0.23)</td>
<td>5(0.14)</td>
<td>3(0.27)</td>
</tr>
</tbody>
</table>

Table 3: Results of evaluations of streetlight sketches

**Analysis of the results of the experiment 3**

Table 3 shows the values of rate of success in each evaluation item. The value of rate of success was calculated by ratio of numbers of high-ranked drawings to all numbers of drawings in each keyword.

(1) In the evaluation item ‘successfully expressed keyword in drawing’, the group of keyword ‘cool’ and the group of keyword ‘vigorous’ were successful.

(2) In the evaluation item ‘the interpretation of keyword was fresh and interesting’, the group of keyword ‘vigorous’ was successful.

(3) In the evaluation item ‘the drawing was not related to other keywords’, the group of keyword ‘familiar’ seemed to be most related to other keywords. In contrary, the group of keyword ‘cool’ was seemed to have no relation to other keywords.

(4) In the evaluation item ‘the keyword was visualized in the form by using some associations or metaphors’, the group of keyword ‘vigorous’ was in high rank order but the evaluation value was not so high.

(5) In the evaluation item ‘it was good design’, the group of keyword ‘cool’ and the group of keyword ‘elegant’ were successful.
Figure 4: (A pair of sketches of ‘vigorous’ and ‘cool’)

From these results and examined result of mid term sketches, we supposed that the subjects took complicated thinking processes when they were given difficult keywords like ‘vigorous’ or ‘familiar’. There were some precedent researches on the thinking modes. Woo pointed out that L mode and R mode were switched in the thinking process of design (Woo 2001). The L mode and R mode were depended on the categories of physiological function of human brain. However, we thought that there were more complicated relations between the physiological functions and thinking modes. Then we needed to focus on the thinking path in relation with thinking mode when the subject was given ‘difficult’ keyword.

**Experiment 4**

The purpose of experiment 4

The purpose of experiment 4 was to know how create visual image from goal description that was difficult to relate to form directly.

**Procedure of experiment 4**

For getting clue of thinking process, we gathered words written in sketches and drawings during the time subjects were thinking under the task. About 80 subjects of first year class students in Chiba University were assigned a task to design ‘a chair that made sad image’. All the subjects developed their ideas on B4 paper with drawings and words appeared during they thought.

**Method of evaluation of experiment 4**

76 sets of idea sketches and final presentation with comments were collected and evaluated by two expert design educators based on evaluation items shown below.

1. Whether final form was realized keywords or not?
2. Whether basic function and structure of chair were realized or not?
3. Whether the design was fresh or not?
4. Whether the form was developed in the process or not?
5. Whether it was divergent thinking or not?
6. Whether the words were structured or not?
Analysis of the results of the experiment 4

We totalized the results of this experiment as follows.

(1) The largest number of subjects (46) was seen in the item ‘basic function and structure of chair were realized’ and the smallest number was seen in the item ‘it was divergent thinking’.

(2) In correlation values between each item, it was seen correlation between ‘the form realized keyword’ and ‘the design was fresh’ (0.49).

(3) Weak negative correlation was seen between the items ‘basic function and structure of chair were realized’ and the item ‘the design was fresh’ (-0.27).

We picked up all the words written in sketches as clues of understanding the thinking process of subjects. Then we structured the words into hierarchy of concepts (Table 4). From this table, we can guess how the subject draw sketches by using keywords in the hierarchy of concepts: for example, keywords ‘back to back’ ‘stiff’ ‘hang over’ ‘swing’ ‘lacked’ ‘bow’ were made easy to think out the forms. However, if the keyword was in high level of hierarchy and not directly related to form, the subject had to break down the keyword into other keywords in low-level concepts.

In addition, we considered that there was a parting point on the ways of thinking a form of chair in the mid hierarchy in meaning of sadness. For example, ‘back to back’ and ‘face to wall’ were in the under hierarchy of ‘alone’. It could be said that ‘solitude’ was one of general concept to construct the basic meanings of ‘making feel sad’ with ‘anxiety’ and ‘disappointment’. A framework of expression of the form was changed by difference of the keywords in the first class hierarchy. We found through the observations on the sketches that the drawings by keyword ‘pose of sadness’ was clearly different from others those used keywords in third class hierarchy. In case of using metaphor of ‘pose of sadness’, subjects seemed to think the form of chair in imaginations of when they were sad. In contrast, with the keywords ‘instability’ and ‘restricted’ they seemed to think the form of chair based on the rearrangement of their concept on physical situation in meaning of the keywords (Fig5). Therefore the form was tended to be symbolic.

Figure 5: (A pair of sketches of sad chair)
Table 4: (The hierarchy of meaning of word sadness written in drawings)

**Totalized analysis and discussions for all the experiments**

From the results of the experiment 1 on the design of paperweight, we came to believe as mentioned below.

In the beginning of design process, designer gets goal description of design object. The goal description can be divided into two parts: one is subjective part and the other is predicative part. We call the predicative part as ‘keyword’ because the predicative part indicates the state of the subjective part that is to be obtained after design thinking. As we saw in the experiment, even if in the simple design process, the keyword was not directly represented its visual image at first. Then, the subjects had to search as possible as many associations and/or metaphors of well-known objects. This stage of thinking process was typically seen in the drawings of the ‘diverging type’. After doing it, they might have to look into common factors in them at high abstracted level of the
imaginations or metaphors. This stage of thinking process was seen in drawings of the ‘evolving type’. It was supposed that most of evolving type could include diverging thinking process in them but not explicitly.

If the keywords of goal description were not directly related to the function (in this case “give a sense of relaxation”) of utility at first, many well-known things associated from the keywords had to be imagined in no consideration of its function of utility. This meant that the predicative part of goal description was thought separately from the subjective part. Then, many associated things and/or events were drawn in this stage of thinking process. The divergent thinking type was supposed to stay in this stage and did not go forth.

However, this process was not creative yet. To make it creative, the well-known images of associated things should be once raised to high-level abstracted thinking for form generation. This process needed trial and error in evolving forms. Only when the abstracted form could be connected to the function of utility, good solution will be carried out. This would be the reason why the evolving type could generate many creative drawings.

Some part of the adhering type could be included in the evolving type, but another part of them supposed to be included in the poor imagination type. We supposed that if most of this type could make explicit their divergent thinking stage, they would make more good results. The poor imagination type was supposed to be in low activated level of thinking.

From the results of the experiment 2 on the design of flower vase, we considered that as follows. Even if it was in the same subject, different thinking modes were found in condition of giving different goal descriptions of design of flower vase. When one gave a keyword as clue of thinking form, if it were easy to relate to form of it, he/she would express it by drawing forms directly. For example, the keyword ‘soft’ was easy to understand to express as a form because we had many imaginations of ‘soft’ things as in a quality of themselves. However, the easy keyword had tendency to become stereotyped in expressing a form associated with it. On the other hand, there was another mode in the creative thinking. In case of giving a keyword of difficult to relate to form, metaphors were used as a clue of expressing form of it. For example, it was difficult to relate the keyword ‘humorous’ to form directly. Therefore most of expressions in form by keyword ‘humorous’ were using metaphors related to states or atmospheres of humorous.

After all, we assert that, in creative thinking, the subject changed thinking mode and took the adequate one in condition of difference of a keyword as a clue of thinking form.

We supposed that the thinking types seen in the former experiment seemed not so depended on subject’s personality but rather depended on the meaning of keyword in the goal description. Then, we call them thinking ‘modes’ that anyone can take them.

From the results of experiment 3 on the design of streetlight, we presented discussions as follows. It seemed that as the keywords ‘cool’ and ‘vigorous’ were not so easy to express as the forms of streetlight, they brought unique forms in terms of being not bound by existing styles. However, only ‘cool’ can reached to good design. The judgment whether good design or not was largely depending on the possibilities of manufacturing and affections to circumstances. From these viewpoints, even if the keyword were successfully expressed in the form, it would not always mean good design and/or fresh design.
As the keyword ‘elegant’ and ‘calm’ were supposed to be easily related to metaphors and/or associations, M mode thinking might be dominated in them. However, some acceptable designs were seen in the group of ‘elegant’.

As the keyword ‘familiar’ was supposed to be not easily related to metaphors and/or associations, moreover it was difficult to image forms directly, both M mode and F mode were not efficient to make images. The ‘familiar’ was supposed to be most difficult keyword in this case. Consequently, we recognized that there were different levels of difficulty in translating keywords to forms of design objects and the subjects changed their thinking modes depended on the difficulties of keywords.

From the results of experiment 4 on the design of sad imaged chair, we presented discussions as follows.

We considered that it was not difficult to realize forms of a chair as an object that has, at least, function as a chair (subjective part of goal description). Also, it was easy to remind some metaphors associated to sad image (predicative part of goal description). However, it was quite difficult to connect ‘form of a chair’ and ‘sad image’. We confirmed it based on the result of the evaluation in which ‘divergent thinking’ was low percentage of success. In spite of the difficulties, if it could successfully connect to the form of chair, it would be a fresh design. On the correlations between final form was realized keywords’ and ‘the words were structured’, we inferred that the subjects would try repeatedly to associate the word ‘sad’ with the form of chair and searched word down hierarchy of meanings to reach a suitable one.

We examined the thinking process of drawing by the concept hierarchy, and found that there were two different thinking paths in this case. Based on the analysis, we presented a model of thinking process in creative design as a translating process from keywords to suitable visual forms of it. One of them was thinking forms by using metaphors of one’s pose in sad feeling. This needed to sink into one’s mind and had to take complicated path to make form of chair. The other was thinking forms by using conceptual metaphors and did not need complicated path. As the result, the former case had more possibilities of success in creating new form of a chair. We discussed the reason of it that the former case needed longer thinking path in searching suitable forms, and had to make repeated drawings under considering good forms.
Conclusion
We concluded those results of the experiments and analyses as follows. There were several types of the thinking process in design, and they could be recognized from differences of the drawings. The thinking types could be classified into two major thinking modes (we call them ‘M-mode’ and ‘F-mode’). The subjects seemed to change his/her thinking mode depending on the difficulties of translating goal descriptions to the forms fitted to it. If it was difficult (like as ‘humorous flower vase’ and/or ‘vigorous streetlight’), he/she used metaphors to get a clue of thinking form (M-mode). If it was not so difficult (like as ‘soft imaged’ flower vase and/or ‘elegant’ streetlight), he/she directly searched forms (F-mode). However, good metaphors did not always result in good design and also sketches from easy keyword did not always result in fresh design. The sketches directly brought from metaphors were characterized as cartoon like and outlined drawing. Most designers who drew this type of sketches did not make effort to generate new forms. On the other hand, most designers who drew elaborated drawings from easy keyword did not make effort of searching metaphors.

From the experiments, we also confirmed that the subjects took separate path of thinking in predicative part and subjective part of goal description until he/she reached to be able to make effort of integration with the form and basic function of the design object.

The most creative form could be generated when the designer found good metaphors associated from the given goal description and kept effort of elaborations to make nicely fitting form to the predicative part of the goal description. Then, we asserted that, to get creative design, designer need to make effort of thinking in long path from goal description to the final form, and he/she needed to change thinking modes several times during the thinking process.
References


Designing information appliances: the evaluation of a design process framework based on a designer-friendly prototyping environment

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Abstract

This paper presents a new design process framework for interaction design of computer-embedded products (information appliances) and examines the feasibility of the framework in the design education and practice through case studies. The main feature is the application of a new prototyping environment that employs a widely available presentation tool, MS PowerPoint, for building fully functional engineering quality prototypes of computer embedded digital products without assistance from electronic engineers. The proposed interaction design process framework involves four phases. i) to analyze the user context, ii) to create conceptual models using State Transition Charts, iii) to develop hardware-software hybrid prototypes using the designer-friendly prototyping environment, vi) to conduct usability studies using the prototype. Scenarios, storyboards, concept generation tools, State Transition Charts, a hardware-software hybrid prototyping method, and an automatic usability data collection method are introduced as key practical techniques to be employed in each phase of the process framework. Case studies undertaken in the UK and Korean universities show that the framework was feasible for the design education and acceptable for the design students in both countries. The paper also presents how the framework and the prototyping environment can be extended for developing interaction design of multi-user products through the case study project of designing a set of portable information guides for group visitors of the natural history museum.
Designing information appliances: the evaluation of a design process framework based on a designer-friendly prototyping environment

Introduction
Digital technology has changed the way we live and the artifacts surrounding us. Ubiquitous computing (Ark and Selker, 1999) and information appliances (Norman, 1999) are becoming prevalent as the computing technologies are widely and cheaply available. The characteristics of the everyday artifacts have changed from static and hardware orientated to dynamic, interactive, intelligent and complex. This implies significant transition of the objects that designers are dealing with.

Meanwhile, the design profession has also evolved. The role of industrial designers in the early periods of the profession was to articulate and resolve aesthetic problems of mass produced products. In order to be effective, designers needed to have deeper understanding of production techniques, engineering, marketing and ergonomics. Designers have found themselves responsible to both client and consumer, sorting out ergonomic, safety and performance factors to satisfy both parties. The dynamic and interactive aspects of the emerging digital artifacts these days demand that designers become problem solvers not only for visual, physical and functional attributes, but also for emotional and contextual attributes. There is therefore growing concern on how this change should be reflected in design education and professional design practices. If these concerns are appropriately addressed, design professionals can play an important role as coordinators in the multidisciplinary product development team involving social scientists, psychologists, computer scientists, electronic engineers, production engineers and other business professionals for designing the new digital artifacts.

This paper presents a new design process framework for designing the new breed of digital products. The framework focuses on the interaction design aspects of these products and has been evolved both from traditional design process models and user interface design models. The techniques to be used in each phase of the design process framework are reviewed and the feasibility and effectiveness are examined. In particular, the paper introduces the application of a new prototyping environment that employs a widely available presentation tool, Microsoft PowerPoint, for building fully functional engineering quality prototypes of digital products without assistances from electronic engineers. It also presents how the framework and the prototyping environment can be extended for developing interaction design of multi-user products such as mobile phones, communication devices and multi-user PDAs.

The objectives of this study can be summarized as follows.

- To investigate an effective design process framework to reflect the changed design paradigm.
- To review and examine designer orientated tools and techniques to be employed in each phase of the design process.
- To develop an effective and interactive prototyping method for designers.
- To examine the feasibility of the framework and the prototyping method by applying them to design education and professional design practice.
Interaction design process framework
There have been many design process models suggested from the design research and the user interface design fields. Among the user interface design process frameworks, Lewis and Reiman (1993) suggested eleven phases for the user interface design: figure out who’s going to use the system to do what, choose representative tasks for task-centered design, plagiarize, rough out a design, think about it, create a mock-up or prototype, test it with users, iterate, build it, track it, and change it. Spreenbergen et al. (1995) suggests five stages of interaction design process; understand, observe, visualize and predict, evaluate and refine; implement. These design process models highlight two common issues: the user and task centered approach, the iterative development and evaluation of design concepts. One of the ways to achieve the user and task centered approach is to draw participations of actual users from early phases of the design process. Efficient methods of user participation have to be investigated. The user involvement is also to be continuous throughout the design process. For the interactive development and evaluation of the design concepts, collaboration between designers and other experts is essential. The more efficient and faster the iterative design cycle is, the better is the quality of the design solution. For digital products, hardware-software integrated development is also important as the two aspects are closely related. It is also necessary to employ appropriate quantitative and qualitative evaluation methods for reflection.

Prototyping in interaction design
When designing digital products, effective hardware-software hybrid prototypes are fundamental to the rapid iterative design development and evaluation. The importance of effective prototyping is recognized from the interview with designers at Samsung Electronics and its’ Software Design Center. The Samsung designers expressed that, in designing digital products, such as mobile phones and digital televisions, they have difficulties in producing good quality design solutions due to the lack of tools to combine the software and hardware features. The development and the usability tests of the hardware and the software are carried out separately, so designers often miss the opportunities to improve the integrated quality as they have to wait until the final engineering prototype is to be produced just prior to production.

The prototyping of multi-user devices, such as mobile phones and multi-user game machines and communication devices, is even more difficult for designers to develop a concrete design ideas. The ways these devices are used and operated are closely connected to the service and the dynamic multi-user communication behaviors of the users. The effective prototyping allows designers to produce more concrete design concepts with respect to the user interface and the relationship between the software and the hardware attributes.

The proposed process framework
The proposed process framework in this study consists of four phases; context analysis, conceptual modeling, prototyping, usability study. The framework simplifies the existing process models and highlights key techniques that are directly applied to the practical development of design concepts. Figure 1 shows the overview of the process framework.
Phase 1

In the first context analysis phase, the design team needs to investigate usage context of the product, create insights and specify functionality. There have been many practical techniques used in this phase. They include focus group interview, user observation, user diary, role playing to name a few. While these techniques provide useful insights on the context, it is often difficult to associate the results to the concept generation of the new product. In this paper co-designing techniques with generative tools, scenarios and storyboards are suggested as useful practical techniques in this phase. Co-designing is based on the user centered design philosophy and stresses active user involvement in the design process. Sanders (2000) suggests that by using generative tools that can drive dreams and imagination of everyday people the co-designing technique provide a way to connect the social science investigations and the practical design development. For co-designing, designers need to consider new roles in their profession. First, they need to develop various tools that can draw dreams and creativity of everyday people. These generative tools could be a drawing board, Velcro covered blocks, Lego characters, board games, and a movie making process (Pedersen and Buur, 2000). The second role of designers for co-designing is to analyze, translate and develop the results expressed by the users using these generative tools into valid and viable design solutions.

Other practical techniques in the context analysis phase are scenarios and storyboards. Scenarios are reality stories in prose form and can be classified into two types: current context scenarios and future context scenarios (Kolli et al., 2000). Current context scenarios are the description of users’ activities and tasks at present situations. It allows designers and users to have a clear picture of the present usage context. Future context scenarios are the description of the refined situations by introducing the new artifacts or processes. It is a very early abstract model that initiates a number of design concepts of new products in the context. Storyboards are pictures illustrating various
functions of the future product, along with explanatory text about what’s happening in the picture. Readers of the storyboard can get a general idea of the size and form of the new product in a very general way and its context of use. Scenarios allow designers and users to make the concepts more visual and concrete.

**Phase 2**
The second phase is to develop basic concept models. Users and domain experts are to be encouraged for the early concept generation. The methods and tools need to be provided for their active participation. Practical techniques in this phase include idea sketches, making and evaluating concept mockups and hand-on tangibility tests. In addition to these techniques focused on physical attribute of the products, contextual, organizational and interaction quality of the product, such as participatory diagramming, screen slide show, are also to be used. State Transition Charts (STC) is one of these techniques proposed to explore the organizational and interaction quality of the concepts. STC is based on the assumption that a product interaction can be modeled by considering states and events from the outside world. The events cause the product to transition from one state to another. For example, a digital watch has a number of states (time displaying state, changing time state etc.) and an event of pressing a button by a user causes the transition between the time display state and the changing time state. STC provides a way of exploring and defining what states should exist, what events should occur and what effect they can have on the product.

STC is similar to State Transition Diagram (Booch, 1993) that is commonly used in software engineering. The STD is one of the software engineering models to construct a software application. STC is however more graphical and realistic in terms of the visual components and associated events of the product. It is also focused on the interaction between the product and users. Creative concept modeling may be achieved through collaborative construction of STCs in a group session. One of the methods that allow more dynamic and collaborative creation of STCs is Post-it and Whiteboard method shown in Figure 2.

![Figure 2: Post-it and Whiteboard method of the STC construction in a group session](image)

Designers investigate essential states to provide for product functions and the user interface. Then by placing and connecting the states on the whiteboard, a new STC can be rapidly constructed while all members in a group session can participate in the construction. When states and events
connections are made, a digital image can be taken using a digital camera for the record and to compare it with alternative STCs. This method can be extended into a new concept generation tool for co-designing by employing a digital media, such as electronic whiteboard and input devices (James et al. 2001).

**Phase 3**

The third phase of the framework is to refine the basic concept models through efficient prototyping. In the design of computer embedded digital products, prototyping is essential to examine the integrated quality that involves both software and hardware attributes. The prototyping can be classified into three types in terms of the techniques used; i) using Virtual Reality(VR) or Mixed Reality(MR), ii) touch screen based prototyping, iii) virtual simulation driven by physical prototypes. VR and MR (Ohta and Tamura, 1999) provides new dimensions in prototyping as the computer hardware and software technologies are rapidly developing. In particular, MR shows a potential in interior and architectural design fields (Anabuki et al., 2000). The bulky equipment and the lack of reality feelings, however, hinder the technologies to be effectively used for iterative and rapid prototyping of interaction design concepts. Touch screen has become a useful technique for the simulation of the products such as a microwave oven (Sharp, 1988) and VCRs. Due to the restriction on two dimensional control panels, the product controls and displays in different panels cannot be implemented through the touch screen based prototyping technique. The best prototyping is a hardware-software hybrid prototype that allows the controls and software attributes to be fully illustrated within an integrated unit. Typically these prototypes are connected to a portable computer via special interface units for input and output. The problems with this kind of prototyping is the time and cost involved in building the prototypes. Design teams need to have sufficient support from engineers for the construction of these prototypes. Although there is full support from engineering teams, it is time consuming and expensive to build a series of prototypes.

For the investigation of a designer-friendly prototyping method, the following requirements are to be considered. First of all, the prototyping method should allow designers to effectively employ the metaphor used in the concept modeling phase. The core components of STC, states and events, are to be smoothly integrated in the method. In fact, one of the most popular tools for prototyping interactive systems in industry is Micromedia Director, which is originally used for the production of interactive movies and CD-ROM titles. It employs the time line as the fundamental metaphor that is not always consistent with the concept modeling of interactive features. The new method should support the STCs in the framework described above. Secondly, it also needs to allow efficient construction and incorporation of highly visual elements. Thirdly, interactive features are commonly implemented by programming support within the tool. The programming environment needs to be intuitive and have minimum complexity as it may be used by designers who may not have the training in computer programming. Fourthly, the method should benefit other stakeholders in the product development by providing evolutionary features. For example, smooth transition from the designers’ prototype to the engineering prototypes increases the productivity at the later phase of product development. Finally, software tools are to be based on the widely available software application and not to require advanced hardware and software equipment. In order to address these requirements, we proposed a new prototyping method based on the popular Microsoft Office application, Microsoft PowerPoint (Nam and Gill, 2000). The method allows designers to construct an engineering quality hardware-software hybrid prototype without the support from engineering disciplines. The prototyping is accomplished in five steps. First, the concept models developed using STC are transformed into a primitive software simulation (Figure 3a) that only supports slide links between states. It illustrates the basic state transitions but cannot show any interactive features of the prototype. The next step is to construct an interactive simulation by adding ‘Controls’ and ‘Visual Basic for Application’ scripts associated with each control (Figure 3b). All the events are then translated from mouse based to keyboard based. The hardware model
including switch components are constructed (Figure 3c). Finally the hardware model is connected to the software simulation via keyboard encoder unit developed for this study (Figure 3d). More detailed description of the ways of incorporating Visual Basic for Application in the PowerPoint simulation and connecting the hardware via the encoder is presented in Nam and Gill (2000, 2001).

Figure 3: a) Primitive PowerPoint Simulation of a digital watch only supporting slide links, b) Interactive PowerPoint simulation of a digital watch with Controls and Visual Basic for Application scripts, c) Hardware model with basic input components, d) Hardware-software hybrid prototype of a simple media player connected via key encoder

Phase 4
The final phase is to evaluate the prototype through usability study. The usability study is accomplished through both quantitative and qualitative methods. Quantitative analysis is carried out as an experimental study, where a number of measures, such as time to complete a task, count of button press and the number of breakdown, are automatically collected using the prototype and the usability data collection mechanism within the software simulation. Qualitative analysis methods include exploring navigation map, advanced protocol analysis by rerunning the user trial along with video recordings. For example the raw usability data is collected in the form of [state id, event detail, event time] in our example prototypes. These data can subsequently be restructured for the advanced quantitative and qualitative analysis. Due to the simplicity and effectiveness of the data collection, it is possible to conduct a usability study with large samples.

Case study
The framework and the prototyping method have been applied to a series of undergraduate design projects in the ‘Information ergonomics’ module at the school of product and engineering design, University of Wales Institute of Cardiff (UWIC), UK and the ‘Interaction Design’ module at the department of Industrial Design, Korea Advanced Institute of Science and Technology (KAIST). At
UWIC, the framework was introduced to the second level students at the BA product design course. The students had no prior knowledge about programming languages and electronics. An exercise project was carried out before the introduction to the major design assignments, to design a portable visitor guide for the Museum of Welsh Life. The project was chosen because the site provided sufficient context for the new digital product. The module was run for 14 weeks but the actual time dedicated to the project was about 6 weeks, for which four weeks were spent for the concept development and software implementation and another two weeks for the construction of the hardware model. Due to the time constraint, the evaluation was not accomplished in the module. Figure 4 shows the hardware results of the projects. These models can drive associated software simulations.

Figure 4: Samples results of the portable information guide project at UWIC

The interaction design module at KAIST was for the third year students in Industrial Design BSc course. The Korean students had a basic training on computer programming and science subjects such as Math and Physics. The module ran for 16 weeks but first 10 weeks were spent on the introduction of interaction design issues and the exercise of the prototyping implementation. The major design project was carried out for six weeks. The design assignment for the major design project was to design a portable assistance device that has similar characteristics with the portable museum guide. The Korean students had more flexibility than the UK students as they could decide the design context and the functionality details. The example projects were ‘a visitor guide for an amusement park’, ‘Kyungbok Palace guide’, ‘shopping guide’, ‘concert guide’, ‘gallery guide’, and ‘city tour guide’. The framework was successfully employed in the all these projects.

**Designing mobile multi-user devices**

The framework and the prototyping method were also applied to the design of a mobile multi-user device. One of the interaction design projects at KAIST was to design a set of portable assistance devices for group visitors of the Natural History Museum in Daejon, Korea. A user scenario of the guide was for teachers and elementary school students who need educational aids when they visit the Museum as a group. It is necessary to support communication and other multi-user features such as collaborative learning and a question and answer sequence. In order to address the mobility issue,
A wireless key encoder using infrared technology was developed. By placing two states in one screen, it was possible to illustrate the interactions and state transitions of multiple devices (Figure 5a). The wireless connection enabled acceptance of two different sets of key events to control different software simulations without conflicting the input and output mechanisms. By using this method the multi-user interactivity could be examined at a similar level of effort and skills for the implementation of a single-user device. The screen shot of Figure 5b shows how the teachers and students communicate with each other for a question and answer session through the device while they are in the Museum.

Figure 5: a) A set of portable museum guides for group visitors. Software simulation (top), Hardware prototypes (middle), the wireless key encoder (bottom). b) Example screen shot showing the communication between the teacher and the students for a question and answer session.

The usability data are automatically collected as a single user device situation. Table 1 shows a sample of the collected data from one of the user trials. The state, events and time of the events are recorded automatically for multiple users. These data can be used for the further analysis of the usability study.
Device for Teachers | Device for Students
---|---
Time: sec | State ID | Button ID | Time Difference | State ID | Button ID | Time Difference
0 | 0 | 0 | 0 | 0 | 0 |
0.031 | 1 | 1 | 0.03 | 1 | 1 |
1.195 | 2 | 1 | 1.16 | 2 | 1 |
1.773 | 3 | 2 | 0.57 | 3 | 2 |
2.382 | 3 | 2 | 1.17 | 4 | 2 |
2.953 | 3 | 2 | 1.17 | 5 | 2 |
4.179 | 3 | 2 | 1.17 | 6 | 2 |
4.742 | 3 | 2 | 1.17 | 7 | 2 |

Table 1: Sample of usability data collected from a user trial. The table shows all the records of when both users pressed the buttons in the devices and how the states changed according to the button-press events.

**Discussion**

This case study provided some lessons and future directions for improving the framework and the prototyping method. The concept models were evolved smoothly through the prototyping method. There was however a gap between the context analysis and concept modeling. The student designers expressed concerns that the findings and investigations in the context analysis phase were sometimes not directly applied to the concept modeling phase. Ways of linking the techniques between the context analysis and concept modeling phase need to be further investigated. The framework and the prototyping method were feasible for student designers from both countries to undertake the interaction design project. They were able to implement the hardware-software hybrid prototypes without assistance from engineers during the progress of design concepts. It means the reduction in time and cost in the design development and a fast iterative cycle of the design process. It is possible for designers to use the prototyping method for the presentation and to visualize interaction design ideas, in particular for developing concepts of the organizational and interaction quality of the product. More concrete and advanced design development may be possible due to more realistic prototypes. The prototyping method also shows a potential being a participatory design tool where the users can actively participate in the development of interaction design ideas. To achieve this, the method needs to be further simplified in terms of the concept modelling and the software interface.

The framework could be applied to design projects of various digital products. This includes existing consumer electronics products to the new information appliances and digital media products. The usability data collection was automatically executed and it was straightforward to translate the data into a format for further analysis.

The framework suggests new areas of design education: basic computer programming and electronics. These skills allow designers to understand the overall product attributes. It helps for designers to become coordinators or integrators in the product development of digital products. A number of limitations in the prototyping tools were also found. The input method was limited to the button types while new digital products, such as PDA and information stands, often have a touch screen based input system. The output devices, such as display and audio, were not incorporated in
the hardware prototype so the question remains whether the separated display makes any impact on
the iterative development and the user study. Ways of developing wireless and multi-user
prototypes also need further investigation for more reliable and efficient implementation. Current
infrared based system is restricted in terms of the direction and the range of the receiving unit.
Different buttons, sensors, display devices are to be used for more realistic prototype construction.
Software features such as database connection also needs further investigation.

Conclusions and future work
This paper presented a design process framework for interaction design of digital products. The
practical techniques were suggested and illustrated in each phase of the framework for the purpose
of supporting design professionals. The techniques suggested include Scenarios and Storyboards,
Generative tools for co-designing in the context analysis phase, State Transition Chart in the
concept modeling phase, a new prototyping method using MS PowerPoint and embedded Visual
Basic for Applications in the prototyping phase and the automatic collection method of the usability
data in the usability study phase. The case studies employing the framework were introduced to
examine the feasibility of the framework. Our experience of designing a set of museum guides for
group visitors illustrates that the framework is applicable for the implementation of mobile multi-
user devices.

The study presents a systematic approach in the interaction design of digital products. The practical
techniques presented could be useful contents in design education and practical design practice. The
effective original prototyping method that employs a cheap and widely available software
application which is suggested as a new means of visualization and concept development for
interaction ideas of multi-user devices.

The study suggests several future directions. Further investigation is to be carried out to examine
the feasibility of the process framework and impact of the new techniques in professional design
practice. In the case study, further investigation can be made regarding the comparison between the
student projects of Korea and the UK. The prototyping technique is also to be improved by
addressing the existing limitations. Ways of combining other control components and output
devices needs to be explored. Ways of incorporating the framework in the entire product
development cycle can be investigated, seeking collaboration with other disciplines such as social
sciences, computer science, electronics and manufacturing.
References


Design judgment: decision making in the ‘real’ world

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Abstract

Design is about creating the ‘real’ world around us. Real life is complex, dynamic and uncertain. Truth is difficult enough to know, even with the best science, but ‘reality’, the domain of human experience, can be overwhelmingly paralyzing and beyond comprehension or understanding. Careful, accurate description, concomitant with clear explanation, is necessary but not sufficient in the quest for enough understanding to allow wise decisions to be made. The value of judgment is that it allows individuals to overcome their paralysis and engage with the messy complexity of life in a way that, when done well, can bring function, beauty, and meaning to human existence. In this paper we will examine judgment, particularly design judgment. We argue that a better understanding of judgment is needed if we want to improve our design ability in an intentional manner. Judgment is a key dimension in the process of design. The ability to make design judgments is what distinguishes a designer as a designer. The ability to make good design judgments distinguishes good design.
Design judgment: decision making in the ‘real’ world

Introduction

Design judgment holds many things in common with the other categories of judgment, but the outcome or end is distinct because design judgment facilitates the ability to create that-which-is-not-yet. It is the type of judgment related to creativity and innovation. It is concerned with judiciously crafting the compositional whole of an imagined design. When well executed it can create beauty and evoke the sublime. Design judgment is the ability to gain or project insight, through experience and reflection, into situations which are complex, indeterminate, indefinable and paradoxical. This results in the formation of meaning and value by engendering relationships of unity, form, pattern and composition. Judgment is a process of taking in the whole in order to formulate a whole. The outcome of judgment is the expected unexpected outcome that yet fits congruently, with integrity, the driving intention behind the design process in the first place. In other words, the operational outcome of any judgment is dependent on the nature of the intention.

In the examination of design judgment we have found it productive to distinguish between several types of judgment (these are developed in greater detail in Nelson & Stolterman, 2002). The reason for this is that the complexity of design is such that a too simple definition of design judgment will be both insufficiently rich and impossible to relate to the different kinds of experiences met in design practice.

This paper is based on the idea that design judgment must be made a full and equal partner with rational decision making in any design process. To facilitate this, judgment must be made more intellectually accessible and pragmatically effective. The effectiveness of design judgment is not jeopardized by an improved understanding of its ‘nature’ as intuition can be threatened by too much self-consciousness. The designerly approach, or perspective, taken in this paper, is based on the conviction that it is possible, through intentional (intellectual) effort, to understand and improve our capacity and skill in making judgments, particularly design judgments.

The ideas presented in this paper are not about making ‘true’ judgments – but are about treating design as an aesthetic and purposive form of making the imagined real by utilizing our ability to make ‘adequate’ judgments. To be more reflective in order to understand more about the activity of judgment will not interfere with the ability to make good or better design judgments. It will only help. Learning to treat design as an informed process of intention and not one of chance or necessity can improve the possibility of achieving good design outcomes.

What is judgment

Judgment is a key dimension in the process of design. The ability to make solid design judgments is often what distinguishes a stellar designer from a mediocre one. By judgment, we mean that which is at the heart of wisdom, in all of its manifestations. For us, judgment is the means, and wisdom is the outcome. In fact, wisdom can be defined as good judgment, which enables right action, and appropriate change.

Judgment is a form of decision making that is not dependent on rules of logic found within rational systems of inquiry. Judgment, however, is not irrational because it follows its own form of dialectic. In lieu of judgment being founded on strict rules of reasoning, it is more likely to be dependent on the accumulation of experienced consequences of choices made in complex situations. Learning to make good judgments is therefore not a matter of learning to follow the steps of a technique, or to follow directions dictated by a method or algorithm, or to impose the a priori constraints of a theory.
What one acquires here is not a technique; one learns correct judgments. There are also rules, but they do not form a system, and only experienced people can apply them right. Unlike calculating-rules. (Wittgenstein, 1968)

Judgment is, by nature, an elusive animal. It is as distinct from rational decision-making, as it is from intuition. Judgment has practical, pragmatic value, and academic rigor, without it being codified and generalized, as reason demands of its offspring, science. We believe the capacity to judge can be designerly learned, practiced and applied in design circumstances, without destroying its essence and value. This is unlike the case of intuition, where too much intellectual attention is often feared by artists who feel that reason, at its best, is the opposite of intuition and, at its worst, a mortal enemy. The ability to make good judgments is equally as essential in design as it is in business, law, medicine, politics, art, or any other profession. For a skill that is necessary to so many human endeavors, it is surprising that judgment making is so little understood, and so seldom part of one’s formal education. Even so, there have been some significant exceptions to the overall lack of attention paid to the formal development of the concept of judgment.

Immanuel Kant, for example, a German philosopher in the eighteenth century, placed judgment as one of three cognitive faculties of human beings. For Kant, meaningful propositions were not just the consequence of empirical fact or analytic logic. They were also the consequence of normative judgment. In addition to his categories of judgments-of-fact, he developed philosophic concepts of judgments-of-ethics and judgments-of-aesthetics as well. His concept of aesthetic judgments (Kant, 1790) is not focused on the same outcomes as the concept of design judgments developed here but there is some influence never the less.

John Dewey (Dewey, 1910) stated that there is an intimate connection between judgment and inference. The intention of inference is to terminate in an adequate judgment that is equally a good judgment, through the interpretation of facts. According to Joseph Dunne (1993), John Henry Newman, a nineteenth century Christian apologist, proposed that judgment was made possible by the intervention of the Illative Sense, which informed reasoning leading to correct judgment. In Dunne’s book he develops his own, well-grounded, argumentation for judgment by elucidating the distinction between the two Aristotelian forms of knowledge; techne (Gr. productive, technical knowledge) and phronesis (Gr. practical, personal knowledge). Dunne argues for an understanding of “practical wisdom” that makes it possible to take the complexity of reality into account.

More contemporary examples of judgment focused scholarship, with close relationships to the present work on design judgments, includes the seminal contributions of C. West Churchman (1968). Churchman defines judgment as a “well substantiated” belief, a belief held collectively by a group, in contrast to a belief held by an individual. Sir Geoffery Vickers (1995) is known, as mentioned earlier, for his development of the concept of appreciative judgment in public policy design. Appreciative judgment is the capacity to understand, or appreciate, a situation through the discernment of, what is to be considered as background and what is to be considered as foreground, in the formulation of a project context. Horst Rittle, another example of someone who has formally developed the concept of judgment making, focused his attention on the fields of design and planning (Rittel, 1972). Rittel went so far as to state that every logical chain of thought is ended only by an off hand judgment, one of several types of judgment he considered, and not by reasoned decision making.

A lack of appreciation for judgment as a legitimate means of decision making is not only revealed by its absence in curriculums, and professional discourse, but by the negative connotations one hears, regarding judgment, in everyday conversations. These conversations are full of comments that are indicative of the distrust of judgment: “Don’t judge me.” “Don’t be judgmental.” “That’s only your judgment.”
Judgment can best be understood when it’s considered within the context of knowledge, knowing, and the knower. To put it simply, judgment is knowing, based on knowledge that is inseparable from the knower. By this, we mean that judgment is based on accessing knowledge generated in the particularity or uniqueness of a situation; knowledge that is inseparable from the knower and is only revealed through the actions of the knower. This is in contrast to decisions that are made, based on knowledge that can be - and is of value primarily because it is - separable from the knower.

Judgment knowledge cannot be stored in libraries or on databases. Colleagues in controlled experiments can’t replicate it. Neither can it be memorized, or accumulated in any quantity so as to build a field of expertise. Judgment knowledge has instrumental value only for a particular situation, and loses its direct and immediate relevance in the next setting. Therefore, it becomes clear that while separable knowledge deals in that which is universal, or generalizable, the inseparable knowing of judgment deals with particulars and ultimate particulars. This implies that designers can learn to make better judgments, but cannot learn - a priori - the kind of knowledge necessary for particular judgments at the moment they occur. Skills and competencies can be practiced and mastered, in support of future actions, but should not be confused as knowledge from judgment itself. Scientific knowledge, the ultimate separable knowledge, plays a necessary supporting role in good judgment making, but is very different in character from the knowing that’s embedded in judgment.

Knowledge that is separable is part of a continuum of knowing that moves from data, to information, to knowledge. There is no similar continuum in judgment knowledge. However, there is a connection to what has traditionally been considered wisdom. The outcome of good judgment - wise action - has been considered, directly or indirectly, as evidence of wisdom.

Given these general definitions, we will examine judgment, and especially design judgment. We argue that a better conceptual understanding of design judgment, in its different specific manifestations, is needed if we want to intentionally improve our design ability. Although design judgment cannot be separated from the designer, the designer can reflect upon the nature of judgment making, and begin to approach the ability to make good judgments as an essential key to accessing design wisdom.

Unfortunately judgment is often dismissed as an inappropriate means of decision making. It is also deemed to be an unsuitable foundation for action or belief. Judgment is put into the same category as mere opinion or conviction, which, since the time of Socrates, has not been considered a legitimate form of knowledge in the Western tradition. Thus, it has not been considered to be a fit candidate for accessing design wisdom, the necessary condition for right action (It is paradoxical that we often receive the advice to “Trust your own judgment,” when others want some demonstration of our personal accountability).

Judgment is also touted as the enemy of creativity. Students of creativity are constantly admonished to suppress their judgment, to hold it in abeyance, and allow the free flow of their ideas to emerge. Creativity and innovation are often proffered as the polar opposites of judgment. In reality, though, well-managed judgment is a necessary component in the synthesis activity of creativity and innovation. Without exercising judgment, creativity is diffuse, and innovation rootless. Judgment is acceptable in day-to-day settings in the arenas of life that traditionally require judgment calls to be made. Judges are required for beauty contests, in order to decide who is the most “talented”, and in sports competitions to make decisions on whether a specific behavior is good sportsmanship or not. Judgment takes on its most serious role in the realm of law. Judges, in
this case, are expected to make considered judgments, based on their own experience, as well as their understanding of the qualitative and quantitative truth of a particular situation, as compared to an idealized code of law.

And not to be forgotten is another form of judgment that has concerned humanity for millennia, often called “the final judgment”. In this situation, a supreme deity sits in judgment of an individual’s life, in anticipation of the inevitable end of worldly existence, and the beginning of eternity. The anxiety and fear of this form of final judgment filters into attitudes towards more corporeal forms of judgment that carry the threat of punishment from some authority figure. Police, judges, bosses, parents, teachers and others with positional authority are confronted with negative reaction against their actual or potential for authoritative judgments. The antagonistic reaction to this kind of ultimate authority and power over the measure of an individual’s worth, often results in the rejection of the idea of judgment all together.

Our distrustful attitude toward judgment is quite fascinating when you stop to consider that people are engaging in judgment all the time. It is as common as breathing. In fact, nothing would ever get done, without small or immense judgments being made by people all the time.

This is because real life is complex, dynamic, and uncertain. Fact is difficult enough to know even with access to the best science, but reality, the domain of human experience, can be overwhelming, and beyond comprehension. Careful, accurate description, concomitant with clear explanation, is necessary but not sufficient in the quest for enough of the right kind of knowledge to allow wise decisions to be made.

Therefore, without the capacity to authentically use judgment, there often emerges a situation, commonly referred to as the ‘paralysis of analysis’, and its frequent companion, ‘value paralysis’. These two types of paralysis result from the popular assumption that decisions need to be based on a comprehensive, factual understanding of a specific situation. Further, this comprehensive, accurate understanding, imbued with rational logic, will eventually lead to the ‘correct’ solution. It is also assumed that this approach renders results not swayed by any personal preferences. In other words, that it is an objective and unbiased process. Due to their aspiration to be comprehensive, approaches like this often lead to oversimplifications at the same time as they lead to endless efforts in finding and analyzing all the ‘necessary’ facts and information.

This is because to be comprehensive means to deal successfully with an unimaginable amount of data and information. In order to deal realistically with the complexity and complication of large amounts of information, within a reasonable amount of time, it is necessary to find ways to simplify. This means ignoring or leaving things out that cannot easily be characterized. It also means using generalized abstractions to stand in for the multiplicity of particular constellations of sense data. In the process of simplification and generalization, nuances and subtleties are lost. Even things that are obviously apparent are lost because they are not easily understood and conveniently accessible through descriptive or explanatory frames of reference. There is, obviously, a danger in not dealing with the full richness and complexity of reality.

The value of judgment is that it allows individuals to overcome these forms of paralysis, and engage in the messy complexities of life in a way that, when done well, can bring function, beauty, and meaning to human existence. Formal, rational decision-making processes are often held up as the standards to be used by businesses, governments, institutions and foundations, and even by individuals, when one must engage in complex, dynamic issues. The irony in this, is that decision-making, based on rational analysis alone, actually creates more options and divergence, than it does convergence (in the form
of focused outcomes). This is true, even when there are resources and time enough to allow a comprehensive process to unfold. Judgment, on the other hand, is a convergent process. It brings diversity and divergence into focus; that is, it brings form and meaning to messy real-world situations. Best of all, it is ‘on time’ or ‘in time’ which means that it takes place within the constraints of a reasonable time frame based on a time line of realistic expectations and limitations. This is the ‘discipline’ of judgment. It is making good choices in a timely way without the delays associated with never-ending studies.

We believe that judgment is a basic human activity. But, what exactly is this phenomenon? There is not just one kind of judgment because reality presents itself to us with such a full richness and complexity that it compels us to develop different configurations of judgment. In any complex situation—where there is a particular purpose and need to make decisions and take actions—we rely on a number of different types of judgments. These include: intellectual judgment, practical judgment, ethical judgment, esthetic judgment, professional judgment, and design judgment.

These various kinds of judgment relate to specific aspects of our experience of reality. People use these judgments to deal with the opportunities, problems, questions, and uncertainty they face. Keep in mind that we never find any of these judgment types in their pure form, there is always overlap between them. Because we are interested in how judgment affects us as designers, we will focus more intently on the phenomenon of design judgment.

**Design judgment**

In our examination of design judgment, we have found that it actually encompasses several different types of judgment. For instance, as designers, we face situations where we may have to make an overall judgment on the quality of a specific material or personnel used in a design. At other moments, we may have to judge how the chosen parts of a design fit together as a whole—as a composition. These two situations are not only different in their focus, they also reveal how different the act of making a judgment can be, and how our skills and knowledge underlying a judgment may differ.

We do not claim that the types of judgment presented below are the only possible ones, and we want to be careful to recognize that we are only talking about design judgments—this is not a discursive, generalized theory of judgment. Also, this not an attempt to define design judgment as residing in the realm of the true, instead this is a concept that resides in the domain of the real. It is an attempt to create an image of design judgment that is practical enough to help designers, and non-designers, better understand how designing works, and improve their competence as designers.

Reflecting on design judgment, we can initially distinguish between client judgments, and designer judgments. We can also divide design judgments into conscious or subconscious acts.

Before we explore designer judgments, let us briefly discuss client judgments. A client or someone acting on their behalf, first of all, has to make the judgment of intention. For a client, it is always possible to choose - or not to choose - design as a way to approach a situation. The client can make the judgment that design is not the appropriate approach, and may instead choose a problem-solving approach, a political approach, or even a management or spiritual approach. Design is, in every situation, only one of many options. And sometimes design is not necessarily the right option. If a client needs an approach that will lead to a guaranteed, and predictable, result, design is not appropriate, since it is about creating the not-yet-existing, which, by definition, is always a risky business. This judgment of approach, if made in favor of design, marks the entry into a design project and is always made by the client or surrogate client.
Once within the design process, the client or client’s agent must make a judgment of purpose. It is the client who has to make the overall judgment about the purpose of engaging in a design process. This does not mean that the client necessarily will decide what has to be the outcome of the design. By this judgment, the client will set the stage for the design process, and also provide the designer, or design team, with a first approximate direction for all energy, thoughts, and actions.

In the design process, the client is also responsible for making judgments of worth or value. A designer can never make that judgment on behalf of a client. He or she might be able to suggest, or try to influence, or educate a client to appreciate certain qualities and certain design consequences, but the final judgment of the worth and value of a design is in the hands of the client.

These client judgments ought to affect the designers’ judgment on whether or not to serve the client in the first place. The making of these seminal judgments by the client not only creates restrictions on possible actions by the designer, but also instills accountability and responsibility by the designer, concerning the systemic effects of the judgments. There is rarely a clear demarcation, however, between these client and designer judgments, because of the mutual influence clients and designers have on one another. This means that the judgments made by the designer have an impact on the clients’ realm of judgment. These initial judgments are also modified and refined throughout the design process by the cross-catalytic effect of judgments being made in the different domains of responsibility.

It should be obvious, at this juncture, that the client does not merely provide an entry point into the design process. The client plays an ongoing role throughout the design process, by having the responsibility for the judgments described above. Design judgments are never made once and for all. New ideas, creative changes, changed preconditions, and increased understanding and knowledge, all change the context for the judgments made. Judgment making in design is fully dynamic, and dialectic, between conscious and subconscious judgments, and between client and designer judgments.

Designers are expected to make a lot of judgments and are held accountable for their consequences. But since these judgments are not all of the same type and, depending on which category of judgment the designer is engaged in, different strategies and tactics are demanded, which require different commitments of time and energy.

The entry point - or gateway - for a designer into a design process is marked by an altruistic judgment of whom to serve — the judgment of service. Once this judgment is in place, with all its concomitant relationship-building, contracting, and related activities, a design project can be initiated.

Within a design project, we divide designer judgments into ten different types. These judgment types are described in greater detail elsewhere (see Nelson & Stolterman, 2002), here we will only briefly introduce them. Our only purpose here is to make the case that a better understanding of design judgments is fundamental to the further development of a designer’s competence. Just as the client is responsible, and accountable, for client judgments—approach, purpose, and worth—the designer is fully responsible, and accountable, for the ten presented below.

Default judgment—internalized judgments of skill
Deliberated off-hand judgment—experiential learning judgments
Appreciative judgment—discernment of foreground from background
Appearance judgment—judgments of style, nature, character, and soul
Quality judgment—judgments of excellence and worth
Instrumental judgment—judgments of craft
Navigational judgment—judgments in the moment in a dynamic environment
Framing judgment—determination of boundaries and limits
Compositional judgment—causing distinction and diversity to stand in unity
Core judgment—subconscious limits of value and meaning

A designer will in any design process face situations where all or some of these types of judgments are needed. In summary, both clients and designers are elements in a compound relationship, which is animated by the interaction of many different types of judgment. Judgments are continually being made, and then refined, throughout any particular design process. Each set of judgments, whether designer or client related, must be made by the accountable individual(s). If, for instance, clients allow the designers to make judgments of purpose and/or worth, then the process becomes one of art, rather than design. If, on the other hand, the clients are encouraged to make judgments regarding composition, or framing and containing, then it becomes a process of facilitation, rather than design.

The key idea is that design is a system of relationships, which include a variety of roles and responsibilities (such as designers and clients), from which design activity, and outcomes, emerge. It is a composition that depends on the interaction of different design roles for the emergent quality to be produced, in the same way that oxygen and hydrogen combine to form water. Wetness is an emergent quality, not present in either type of gas, when observed in isolation. Similarly, the role of designer cannot exist out of relationship with a client, because design action is an emergent quality.

This plethora of judgment types creates a rich ‘map’ of complex relationships. In a design situation, neither the client nor the designer can use this map as a guideline, not even when the meaning of the different judgment types is more developed. Its purpose is instead to make us realize that design is a process, fully guided by design judgments of astounding variety and type. There is no temporal aspect in the map, and there is no priority to the type of judgments necessary. In real situations, these judgments are made all the time, in a complete dialectical relationship. Of course, certain design processes do demand more of specific kinds of judgment, while others demand less. Yet, the map is still valuable as a tool for reflection, and as an intentional aid for improving one’s design ability. The map can even be used as an analytical tool. Such an analysis might be helpful, to explore one’s own way of approaching a design task.

We must address at least one more type of judgment, and that is mediative judgment. All the previously discussed types of design judgments will, in one way or another, contribute to the final design. A designer therefore needs to make a judgment on how this whole should be orchestrated. Thus, he or she must balance and proportion the different types of designerly judgments using mediative judgment.

A designed whole is the emergent consequence of all the judgments made in a design process. It is a synthesis of three wholistic domains: the adequate whole, the essential whole, and the significant whole.

The meaning of the concept of ‘whole’, in relation to judgment in design, is one of the most crucial things to understand about design; in effect distinguishing it from other intellectual traditions. Design judgment has a special character, since the resulting design is something produced from imagination, something not-yet-existing. In its various forms, design judgment relies on all our capabilities as humans. It is based on intellectual and conceptual thinking, as well as aesthetic and ethical considerations, and its fundamental starting block is the character of the designer.
Conclusion

As stated at the beginning of this paper, we believe that design judgment is a full and equal partner in any form of design inquiry, on a par with rational decision-making. Design judgments are not weakened by an improved understanding of their nature, as opposed to the mystery of intuition, which can be threatened by too much self-consciousness. The judgments that constitute design, as illustrated in this paper, are based on the conviction that it is possible, through intentional intellectual effort, to understand and improve our capacity, and skill, in making any judgments, especially design judgments.

Again, we should emphasize that we are not talking about making true judgments. Rather, we are talking about treating design as an aesthetic and purposive approach, whereby we make the imagined real, using our ability to make good adequate judgments. Design is about making crucial judgments, ranging from reflexive off-hand judgments, to judgments emerging from our core being. It is about an appreciation for the whole, and all its systemic relationships. Therefore, being more apperceptive, in order to understand more about the self-conscious activity of judgment, will not interfere with a designer’s ability to make good design judgments. It will only help to improve those judgments.

This leaves us, as designers, fully responsible for our judgments and our actions. There is no way of escaping this responsibility. Designers, in relationship with clients, have complete responsibility and accountability, for their designs. This is because they have chosen, based on their design judgments, to make a particular conceptual design into a concrete reality, without the protective cover of ‘true’ design. This leads us to believe that good design is possible to achieve through good judgment, as an informed process of intention, and not something gained simply by chance or necessity.
References


Designing conceptual mapping in cyberspace

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Abstract

The design of virtual place constitutes a special and new class of design. Virtual places are both forms of information as well as information of form. Though we already have actual experience with virtual functions in the form of virtual museums, virtual shops, virtual schools etc., there, as yet, exists no theoretical basis informing the design of virtual place. New experience is beginning to emerge that deals with key issues in the use of, and interaction in, virtual places. Among these issues is designing the sense of presence in what is a virtual world. This new knowledge and understanding is beginning to help to define this new field of design. The objective of the research has been to determine and define the generic requirements of a virtual place from a design point of view. The paper describes an experimental program whose objective was to identify generic design concepts of “virtual place”. A goal of this work has been to make a conceptual mapping of Cyberspace. We present the basis for the conceptual mapping employing the ICF formalism in making the survey, analysis and the categorization of relevant sites.
Designing conceptual mapping in cyberspace

Introduction
Online activities of diverse functions such as shopping, banking, and travel planning are occurring more and more often in virtual environments. Currently, these are commonly “information environments” rather than spatial experiences. However, as beside the physical environment, networked environments become an important part of our actual daily experience, the design of virtual space may enhance our presence and functionality in the new world of information.

The design of virtual space constitutes a special and new class of design in which the verisimilitude of the constituents of place is becoming a central issue. However, there is a more fundamental problem beneath the obvious requirement of “reality”. The design of E-place has dual importance. It is the design of both the sense of place in terms of the “information of form”, as well as the unique experience of the virtual in terms of ability to simultaneously experience the “forms of information”. It is the reconciliation between making the virtual appear real and preserving the uniqueness of the medium as “conceptual space” that is the essence of the design problem.

Though we already have considerable working experience with the design of virtual space in the form of recent virtual museums, shops, schools etc., we lack a theoretical basis for design. Furthermore, we still lack a coherent statement of the design problem. Without any doubt, among the challenging problems is the achievement of a sense of place in this medium which might duplicate, replace, or improve the traditional human perception of place. However, whether such an effort should be based upon the effort to achieve an analogy with physical space is as yet unclear. Should the virtual be like the real?

Early attempts to deal with the design of virtual space by providing a sense of place and physical presence are beginning to emerge. Our knowledge is becoming formulated around the concept of “typological verisimilitude”. That is, for each type of distinctive experience of a human function, e.g. a bank, there is a particular form of spatial presence that is required. The place, bank, is a distinctive spatial experience as it is a distinctive conceptual environment.

We are attempting to address the complexity of this interpretation of “presence in place” as it relates to the performance requirements of virtual functions. Rather than treating the problem as the visual duplication of actual physical environments we are attempting to conceptualize the new design problem of place and presence in information space.

In our on-going research we are particularly interested in capturing generic knowledge related to the following issues:

a. How is the relationship between people and place transformed in electronic environments;
b. How should place be conceptualized in order to accommodate these transformations;
c. How can the conceptualization of place-based experience be achieved;
d. How can spatial metaphors and spatial interactions be achieved;
e. What experience beyond perceptual space-based experience should be accommodated?

The initial stage of the research was based upon the collection of theoretical materials as well as a systematic survey of web-sites offering a range of interpretations of place. Following these early stages, we have undertaken an experimental program whose objective was to identify and define generic design concepts of virtual place. The experiment was carried on in an educational situation in which a team of student-researchers collaboratively constructed a generic knowledge base for the
programmatic and performance requirements of the design problem. We report below on the results of this experimental research. The experiment is a unique form of social interaction made possible by the communication and collaboration potential of Cyberspace.

In the following sections we first briefly introduce a theoretical basis for the definition of cyberspace and of its impact on space-time relations in virtual spaces. In the next section we present approaches related to the spatiality of cyberspace and how we conceptualize space and place. Following this we describe the experimental program, its theoretical assumptions, the provisions for the collaborative construction of the knowledge base, and the methods of knowledge collection. In the last section we present our findings.

**What is Cyberspace?**
The meaning of the term “Cyberspace” is derived from the Greek word *Kyber* – “to navigate”. There are two basic interpretations to this term. The first refers to Cyberspace as a navigable digital space of information created by networked computers and known today as the Internet. The second interpretation is taken from the writings of William Gibson who is commonly credited with inventing the term. This first appeared in his novel, *Neuromancer*, (Gibson, 1984) in which he refers to Cyberspace as a *conceptual space* within the technology rather than the technology itself. The distinction is non-trivial, since for Gibson Cyberspace is a particular form of mental space within the technology itself.

**Place in Cyberspace**
In his novel Gibson presents Cyberspace as placeless and spaceless. Spaceless in his view is described as a visual metaphor that provides an abstracted view of the real world, but is lacking tangible substance. In a later work (Gibson, 1986) Gibson describes that in Cyberspace there exists neither space nor place and therefore, there is no spatiality. In fact, he proposes Cyberspace as a linked digital information system that employs spatial metaphors in order to assist in the navigation and interaction with data constructs. According to Dodge and Kitchin, (Dodge and Kitchin, 2001) Cyberspace is actually transforming real world spatiality into a “placelessess” world. As such it is changing the conventional relationship between people and places.

The provision of a sense of place in the virtual world requires the following components: physical settings, a functional context, and a social setting. We consider these components in the following sections.

**The physical setting in virtual worlds**
According to Benedikt (1991) Cyberspace contributes to the blurring of reality and virtually. Similar to other media such as television and film, the sense of a place may be possible with the representation of an analogy of the real. In the field of Virtual Reality immersion techniques have been developed to allow us to experience the virtual as real place in “mimetic spaces”. According to Benedikt, Cyberspace is an indefinite artificial world where humans navigate in information space (Benedikt, 1991). First examples of virtual architecture in Cyberspace fall into this category. Most of these examples of virtual architecture are mainly digital simulations of physical architecture. They illustrate the visualization of physical architecture and focus more on visual effect and digital navigation. Many are still lacking real interactive potential.

**Architecture and interaction in Cyberspace**
However, virtual architecture is more than an information-based view of architectural typologies or navigation in the empty virtual space of inanimate architectural images, or a web address to function, communicate and exchange information. Virtual architecture should provide consistent
cognition for the organization and navigating in Cyberspace by providing a sense of place, a sense of function, as well as a sense of awareness of others in the same place (Gu and Maher, 2002; Kalay and Marx, 2001).

Today, interaction with architectural metaphors allows users to be involved and experience the environment and the sense of place in an online fashion. User interaction becomes a significant attribute, which contributes to the experience of interaction with a virtual space in the architectural sense.

**Spatial form and virtual space in Cyberspace**

Cyberspace does not have an explicit spatial form. It is accepted that Cyberspace has a spatial and architectural form that is dynamic, dematerialized and devoid of the laws of physics. It is “space in which the mind can explore spaces that are in every way socially constructed, produced and abstract” (Benedikt, 1991).

Holtzman (Holtzman, 1994) explains that “there is no there there”. It is a space without space, “a nonplace” (Gibson, 1987) and yet it possesses a potential for spatiality which can contribute to the possibility of virtual places. A virtual place need not and will not be subject to the principles of ordinary space and time. According to Benedickt, Cyberspace is a “common mental geography” in which mystical or imaginable spaces become visible. Abstract spaces of the imagination are free from geometry and conventional typology. They can be re-invented; the formal qualities of time and space are different. “Temporality is erased and transcended within Cyberspace”.

In Cyberspace there are no physical constraints that dictate the dynamics or the spatio-temporal qualities of portrayed virtual space. In general, all principles of real space may be violated in Cyberspace and the characteristics and constraints are only determined by the specification that defines the particular digital space (Memarzia, 1997). Novak addresses the transient, ephemeral, dynamic and changing qualities of mediated spatial experience when he refers to “liquid architecture”. “Liquid architecture is an architecture that breathes, pulses, leaps as one form and lands as another. Liquid architecture is an architecture whose form is contingent on the interest of the beholder” (Novak, 1991).

**The social setting in Cyberspace**

Researchers who have explored the relationship between people and places have indicated that it is the relationship of the two that creates the sense of a place. “People are their places and place is its people” (Relph, 1976). In this view, Cyberspace, rather than as a physical location, can be considered a place based on interest and involvement. Such places can be accessed from anywhere. They can be defined according to modes of interaction and thus they potentially enable new forms of social relationships based on shared interests.

This social view of Cyberspace refers to it as a place where rules of interaction are created (Dodge and Kitchin, 2001). According to this definition, as soon as people interact in Cyberspace it gains spatiality. A recognized virtual place such as the Lambda Mall (Williams, 1996) gains the recognition of acting as place where people can interact by using a spatial metaphor of a mall in order to structure an online activity. Thus the interactivity setting appears to be more, or at least as, important as visual analogy in creating the sense of a place in an electronic environment.

**The functional context in Cyberspace**

In Cyberspace we can perform many functions that were once assigned to specific architectural typologies. We can learn, read, communicate, exchange documents, make bank transactions, or buy clothes or furniture. Virtual places in Cyberspace are actually in the historical process of replacing
traditional building types: libraries, museums, bookstores, shopping malls, schools, etc. (Mitchell, 2000). Physical spaces in virtual architectural typologies are, in fact, analogues of physical elements. As a functional place, virtual architecture is understood as a networked place supporting an extended range of online interactions. Without the use of the architectural metaphor, virtual typologies remain a set of linked web pages. Architectural metaphors provide a potential basis for linking and interacting with other virtual environments, users and online activities. Today there are many metaphors of place that are used for information-based activities in Cyberspace: Chat Room, Meeting Place, Conference Room, Cyber-Cafe, Shopping Mall, Virtual Bank etc. However most of them are still lacking a perceptual sense of place, the sense of physical presence, and the kind of interactivity that traditionally constructs our sense of place.

Towards a sense of place in Cyberspace

Cyberspace and the Internet have changed and restructured relations between people and place. New media and spatial metaphors are being employed in changing our conceptual understanding of what Cyberspace actually is and may become. The conceptual space that is Cyberspace is extending both our functional and social life through interaction and communication. Currently there are two basic metaphors for place:

1. “The “document” metaphor, or information-based models of place – this model is analogous to Web Pages and navigation and interaction are supporting documents;
2. The “physical place” where metaphors analogous to our real experience with the world are employed.

As was said above, in order to go beyond these two dominant models and provide a sense of place in the virtual world, it requires physical setting, a functional context, a social setting, and interactivity. With these general requirements in mind, the objective of our research has been to determine and define the generic requirements of place from a design point of view.

The experimental work also includes the attempt to create a new dimension of place that we believe is characteristic of an environment of information. This new concept of place seeks to combines aspects of various models. It includes navigation and browsing concepts from information-based models, social interactions from the social model, and orientation and belonging from the physical model. In combining the physical presence attributes with the conceptual and informational attributes it is truly unique.

Our main research objective has been to determine how interaction with virtual architecture contributes to experiences of place in Cyberspace. This has been undertaken through a survey of, and experimentation with, existing sites that exploit a virtual architecture metaphor. In order to enrich this experimental work we have also attempted to map the relevant activities that are dealing with the conceptualization of Cyberspace as well as to learn from existing precedents in the media. The theoretical aspect of the survey has provided the definition of a range of significant issues to be solved in this emerging field. The survey and experimentation with precedents has provided a specific set of concepts and solutions to these issues which are characteristic of the current state of the art. Given the relative newness of this as a field of design, and given the dramatic uniqueness of the design field, both of these methods, the theoretical as well as the experimental, have proved to supplement one another.

Mapping Cyberspace is, in itself, an extremely complex task. If the goal of this work is to explore the conceptual impact of Cyberspace on the architectural design of virtual places then, somehow, we require a medium for the conceptual mapping of Cyberspace itself. We present the basis for conceptual mapping that was commonly employed by the student-researchers to execute the survey,
analysis and categorization of relevant sites. It is the structure of the conceptual method that provided a common basis for the analysis, evaluation, and documentation of the relevant material gathered on the sites. The common method also provided a “social framework” for collaboration on group integration of the separate modules of knowledge that were collected by the individual researchers.

A structure for conceptual mapping in Cyberspace
Examples of the designs that were considered of significance as exemplifying the generic characteristics of virtual place were assembled to form a conceptual structure. This method includes the construction of a semantic net of design concepts as a basis for selecting, storing and retrieving precedent knowledge. It is based upon our prior work in which it has been exploited as a basis for knowledge formalization of design precedents. The method is relevant to the study of design precedents, in this case, of designs for web sites. In addition, the method has provided a framework in the form of a basis of convention for the social construction of knowledge in a collaborative process.

Employing a common method, and a formalism for the documentation of knowledge derived from case studies of web sites, the group of researchers developed a semantic net of concepts related to the constituents of place in virtual architecture. The method employs Case-based Reasoning as a model for capturing and formalizing knowledge of the design problem. Case-based design is a relevant method which has frequently been employed in capturing design knowledge. Recent works in case-based design have also demonstrated how case libraries of collected and analyzed precedents of prior designs can be employed as a resource for learning and study of design knowledge which can be useful and applicable in current design. (Oxman, 1994; Akin et al., 1997; Oxman and Heilighen, 2001)

One of the distinctive problems in representing designs, including web site designs, is the richness and complexity of their descriptive content. Each design contains many related chunks of information that are difficult to decompose. A theoretical model for the representation of design cases is the Issue-Concept-Form (ICF) formalism (Oxman, 1996). This representation refers to three coordinated abstracted levels of design knowledge which have been defined as the ICF model. The design issue is domain-specific semantic information related to goals and issues of the problem class. Issues may be formulated by the programmatic statement, intrinsic problems of the domain, or by the designer himself. The design concept is a domain-specific formulation of a solution principle, rather than the explicit physical description. The design form is the specific design artifact that materializes the solution principle.

This tri-partite schema has implications for memory organization, indexing, and search in the knowledge base collecting the examples from the sites. It provides a method for documenting and storing the knowledge derived from the analysis of precedent sites, and of structuring that knowledge into a semantic net. In distinction to current navigational systems, memory is organized by the knowledge chunks, rather than by holistic cases. Conceptual links in the semantic network can connect different precedents. From any node, related ICF links can be retrieved which in turn, call up their precedents. So each site can be characterized by various concepts, or characteristics, of place. Figure 1 illustrates a conceptual mapping of virtual place precedents employing the ICF structure.

WebPAD is a tool which will be employed in our research (Oxman and Shabo, 1999). It exploits the ICF formalism for extracting and representing knowledge from design precedents. It provides an environment in which new knowledge can be in-put by independent agents using the system. It
provides certain utilities that support the *independent and collective construction and modification of the case-base*. To our knowledge this is a unique property of the WebPAD system. This property addresses one of the inherent possibilities of knowledge construction in cyberspace. Figure 2 presents a screen illustration of the Web-Pad system.

Figure 1: A conceptual mapping for virtual place precedents employing the ICF structure

Figure 2: Analyzed virtual precedent in the Web-Pad system
Conceptual mapping of places in Cyberspace

In the following section we present the method and findings which are the result of working with the ICF formalism on selected site precedents which were found interesting and meaningful on the web today.

The selection of precedents was based on site types that have a natural reference to architectural place-based models rather than to document-based models. Those selected for study were further processed to emphasize sites with maximal emphasis upon applications of spatial representation and the presence of the constituents of place. The initial selection determined the following types to be most promising for additional detailed analysis: virtual museums and exhibitions, virtual learning environments, virtual shopping centers, virtual meeting-rooms, etc.

The following precedents are representative of the material studied in the survey and analysis:

Virtual Museums:

- Virtual Museum of Arts El Pais
  http://www3.diarioelpais.com/muva2/#

- Art Museum.net - Van Gogh’s Van Gogh
  www.artmuseum.net/vangogh/gateway.asp

- Math Museum – interacting with objects by video clips
  www.math.brown.edu

Virtual Learning Environments

- Alfy
  www.alfy.com

The ICF in mapping Cyberspace

In encoding design knowledge, selected web-sites provided a basis for the acquisition of conceptual knowledge. This was accomplished through content analysis of design issues, concepts, forms in each of the sites. The virtual design domain has raised several generic issues. Among them are the following: how the collapse of temporal boundaries can be experienced in a new way in virtual space, how the collapse of spatial boundaries makes physical boundaries more interesting, and how the collapse of social boundaries can contribute to new experiences in virtual places?

Design concepts are solutions that are employed as generic strategies to solve issues. In the example illustrated in figure 1, selected concepts are extracted from the sites in order to describe the unique virtual experiences in Cyberspace.

Metaphors function as a “form solution” in many of the virtual places. By using a conceptual metaphor a new meaning is perceived which changes the root concepts. For example a spatial metaphor can introduce visualizations, pictures and images of the real world to the user in order to create a sense of place. However, by interacting with these metaphors a new experience can be achieved. For example, in the museum of Van Gogh we are introduced to an exhibition hall and pictures on the walls. However, while we navigate we experience new kinds of relations between time and space. First, we navigate through a domestic space of the exhibition hall directly into a mental space of a picture that was painted by Van Gogh. Secondly, we visit both in the same time –
the space today and the space in the past. (See figure 3). A conceptual mapping of places on cyberspace was mapped employing the ICF structure. This is illustrated in Figure 3.

Figure 3: A conceptual mapping of places in Cyberspace
Conclusions
As Cyberspace becomes a new frontier for design, we are entering a new design discipline. In this paper we have introduced some of the complexity of this new field, and presented the need to understand and redefine its theoretical basis. In order to map the complexity and the role of place making in this new electronic dimension we have undertaken research to identify issues and concepts. In addition we have begun to map the relevant existing design precedents and their potential contribution to emerging identification of the objectives and possibilities of place making.

Beyond the conventional monotonic definition of visual verisimilitude as a design objective for simulating the visual content of place, we have begun to suggest a new range of performance requirements for place in Cyberspace. Furthermore, place in electronic environments must have attributes that are different to those of physical place. The clue appears to us to be in integration of modes of space time and information. This, rather than focusing on the visual recreation of spatial environments, can enable the existences of places that provide data access and knowledge within the visual scene. We have seen just this in the Van Gogh museum.

We can conclude that such multi-modal environments are the real design future of place in Cyberspace. Interactivity and social presence are significant performance requirements which must be realized. The future of place in Cyberspace is a new reality rather than a recreated reality. As such it is truly a new design frontier.
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A geometric aid during the first stages of product collaborative design

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Abstract

The technological advances carried out these last years in the field of products development led the researchers to elaborate the approaches that reduce the cost and time of product development, enhance the quality of product and help the designers to be more creative. These objectives are difficult to obtain due to a large number of phases, which should be carried out during the product development and the large number of experts of different disciplines that are involved. Currently, computer aided systems and software have concentrated on the capture and representation of geometrical shape and technical information as opposed to providing supports for product design in the earlier stages of design process. In a non–routine design, it is delicate and extremely complex to obtain the best products answering customer’s specifications. The aim of this paper is to present a methodology to assist designers during the first stages of design. The objective is not to construct automatically the shape but both to automate a certain number of heavy and tiresome tasks, and assist designers during collaborative design. In the best case, this assistance makes the designers’ stimulation possible by presenting them the solutions that they had not thought of before.
A geometric aid during the first stages of product collaborative design

The will to capitalize upon the know-how of firms, and to reduce production times, mean that we now approach CAD/CAM systems through the view of functional/conceptual modelling (Minich and Pallez 1999). The development of CAD/CAM systems knew several phases; restricted themselves to geometry first, they were little by little enriched with information of higher semantic level; this information could be dedicated to specific trades that took part in the product design. By this way, features and product modeling represent an improvement of design models by adding to the geometry necessary information to the manufacture, for example.

The goal is to assist a CAD software user during the earlier stages of the product design. However the current systems are still based on geometry and in order to achieve the desired goal, it is necessary to delay computations and to introduce higher semantic level concepts (Minich and Pallez 1999). Introducing form features carried out a first effort (Salomons 1994). They assemble elements of geometry of very low level (as faces or edges) to form generic entities easily handled by the engineer because they could be directly associated with functionality (Feng, Huang, et al. 1996) like sliding motion for a groove or buttress for a shouldering wall. Even if the engineer is brought to manipulate entities he apprehends, he is still obliged to think and to generate the product’s shape to be designed. Moreover form features are essentially based on geometry as it is made by current software systems. But these ones give a too significant part to the geometrical models by encapsulating them with specific information of various activities. And it is to go against a current tendency of the research that tightens to oust geometry of its central position (Brun 1997). Research tends to reverse this inclination: it makes possible the representation of the product from a more conceptual point of view in introducing functions. The latter represents the translation of the product’s specifications from the first stages of the design (that are the most determining). To design a product that satisfies all its functions makes it possible to obtain a product of quality, taking into account the cost, the longevity and the adaptation (Ullman 1997). Currently, only manual or assistance techniques of functions of product development exist (value analysis, Qualitative Function Deployment (Ullman 1997). Handled information is mainly expressed in natural language (Figure 1a), which makes it not easily automatisable even if there exists models making it possible to build a functional decomposition facilitating the product’s simulation. FBS (Function Behaviour Structure) (Tomiyama, Umeda, et al. 1993) (Umeda, Ishii, et al. 1996) (Ranta, Mäntylä, et al. 1996) describes the product according to three levels: the first draws up functions (Figure 1b); the second specifies how to fulfill these functions by behaviors (Figure 1c); the last level describes behaviors like a sequence of states of the product’s components (Figure 1d). Consequently, the capacity to treat functions by computer opens the way with an automation of the earlier stages of design.
However, in a more general way, one notes that methods of assistance in manufacturers’ product design are manual during the first phases of design because manipulated information is mainly written in natural language. As a consequence, any automation attempt will be difficult because, at this time, one knows that it is hard, computationally and automatically, to interpret the significance of a text. Therefore, it limits the aid proposed by the different software tools; they are more used in a verification level, as simulators for instance. So, we assume that this information can be manually translated into more easily interpretable information by a software system: the translated information is mathematical constraints on parameters of a relatively elevated semantic level (the volume of the design object, the coefficient of penetration in air and so on… Figure 1e). Those parameters are called intermediate parameters and are defined as quantifiable and measurable entities referring to the physical world and are not necessarily related to geometry. The set of constraints using intermediate parameters defines what we call the intermediate specifications (Gardan, Minich, et al. 1999a, 1999b). It could appear abusive to suppose that the initial specifications (Figure 1a), expressed in natural language, can be translated into intermediate specifications (Figure 1e). However, in a number of cases, the thing is really possible and by this way, a starting point is obtained for the almost automatic shape synthesis. For example, in the case of a box design, aesthetics functions may be converted as the following: the ratio of length to height of the box approaches the gold number \((\frac{1}{\sqrt{5}} + 1)/2\). The corresponding constraints would be: length = \((\frac{1}{\sqrt{5}} + 1)/2\) /height. In a larger extent, the handling of a water bottle by a human being, which is a function, may be converted into constraints on the weight, the compactness and so on, which are parameters. In (Gardan, Minich, et al. 1999b), we have defined an intermediate constraint by a quadruple \(<IP, R, Exp, W>\) where \(IP\) is an intermediate parameter, \(R\) is a relation among \(\{<, >, =, \neq\}\) that must be considered as fuzzy relation, \(Exp\) is an arithmetic expression and \(W\) is the relative weight of the intermediate constraint in comparison with the other constraints of the intermediate specifications. For the moment, only one designer gives the weight for all the intermediate constraints.

From intermediate constraints and a library of primitive shapes (Figure 1e), we propose to size every shape of the library so that they verify the intermediate constraints (Gardan, Minich, et al. 1999a). We obtain what we called the solutions space, which contains all solutions (Figure 1f). We agree that a shape is defined by what we call terminal parameters (mainly geometric and of weak semantic level: radius, length, width…). We suppose, in addition, that an expert of the design
domain has provided the software system with sufficient knowledge so as to know how to translate intermediate constraints into terminal constraints. The latter apply to terminal parameters of a parameterized shape of the library. For example, a weak penetration coefficient can result in a weak radius for the circle or a weak width and an elevated length for the rectangle whether the circle and the rectangle are parameterized shapes of the library… As the shape synthesis of primitive shapes is not very interesting from an industrial viewpoint, we have studied different methods that permit synthesizing more complex shapes (Gardan, Minich, et al. 2000).

As we assume that terminal parameters vary in real intervals, there is a great number of shape solutions that satisfied the intermediate constraints, or even an infinite number. However, the conviviality of a shape synthesis software tool implies the presentation of a restricted number of solutions to designers. It means that it is necessary to define a method of searching for the best solutions among the synthesized shape solutions; it raises two problems: to browse the set of shape solutions in an intelligent manner and to compare solutions between them.

The second problem consists in defining a degree with which a solution satisfies the intermediate specifications. This degree is called Satisfaction Degree and is obtained by computing a weighted average on satisfaction degrees of intermediate constraints affected by their weighting. The computation of the satisfaction degree of an intermediate constraint (cf. Figure 2) is computed from the three following points (Gardan, Minich, et al. 1999a):

- the value of the intermediate parameter for the considered solution, so-called real value;
- the wanted value, that corresponds to the value of the mathematical expression contained in the intermediate constraint;
- a curve depending on the mathematical relation used in the intermediate constraint.

![Figure 2: Satisfaction curve associated with the ‘=’ relation for the following intermediate constraint: < IP, =, 5>](image)

In fact, the satisfaction degree of an intermediate constraint is obtained by computing the existing gap between the real value and the wanted value on the considered curve. The computation of the intermediate specifications’ satisfaction degree for a given solution is an operation called estimation.
We showed that the estimation of combined shapes (represented by a Boolean combination of primitive shapes contained in the library ≈ CSG tree) could not be deduced from the evaluation of the primitive shapes used to define combined shapes (Gardan, Minich, et al. 1999b).

Knowing how to estimate a shape solution, now we are able to browse a solutions space that is modeled by variation intervals of terminal parameters for every parameterized shape of the library. As we have noticed that it seems difficult to use exact optimization methods that are mainly expressed in a mathematical way (as the Simplex method for instance), we study the possibility to apply some stochastic methods such as simulated annealing method or genetic algorithms (Gardan, Minich, et al. 1999a). Then, we have proposed a method more adapted to our approach (Gardan, Minich, et al. 1999b). The latter consists first in sampling terminal parameter variation intervals. Secondly, each sample must be estimated in order to interpolate a curve in the case where the shape is defined by only one terminal parameter, a surface in the case where the shape is defined by two terminal parameters or a hypersurface in the case where the shape is defined by more than two terminal parameters. Afterwards, it is possible to determine with a mathematical method the maximum of the hypersurface. Moreover, the best solutions are obtained by sampling over again close to a certain number of maxima. Finally, shapes obtained by the application of the previous method can be presented to designers (Figure 1g). Once this step is finished, designers have to give their opinion on the selected solutions. In the case where they are not pleased with proposed shapes, and it will be often, designers have to modify intermediate specifications, modify the intermediate constraints weights, modify initial specifications of the product, add new intermediate constraints or new parameterized shape in the library, and so on…

In summary, the above methodology consists in translating manually functional information in constraints on physical entities of the product to design. From this information represented by the intermediate specifications, also from a library of parameterized shapes and expert knowledge, numerous shapes solutions are synthesized. To encourage the conviviality of the software system, the most promising solutions are searched and presented to designers so as to stimulate their creativeness.

We studied the validity of our methodology in the case of a very precise domain: foundry mould design (Gardan, Lanuel, et al. 2001). From an industrial viewpoint, the caster (foundry mould designer) cannot take the liberty to study and to estimate a big number of solutions in so far as the estimation of each solution is a long time consuming. Therefore, the caster uses trade rules to limit the solutions space. On the contrary, our methodology synthesizes too many solutions. So, in that study, we have modified our methodology by introducing some trade rules coming from an expert of the foundry domain. The aim of the modifications was to reasonably reduce the solutions space by determining a priori the most promising solutions families, but by preserving an area large enough in order to preserve the property of creativity. For instance, the placement of pieces to manufacture makes the solutions space browsing difficult. So, by automatically computing the different possible arrangements of pieces in the mould in use including shapes for pieces, it is possible to automatically define classes of solutions. This computation is less time consuming than testing and estimating each placement of pieces in the mould. Finally, the application of this method leads to a mould where the weight ratio is better of 40% than the one designed by the caster.
Recently, we worked on the way to facilitate a collaborative function-to-form mapping. Firstly, we have studied the problem of representation of experts’ multiple-view in a collaborative conceptual design environment (Pallez, Dartigues, et al. 2001). In that study, we have defined some coherence rules between different models. Each expert at any time can define his model and may collaborate with the other models using a STEP standard language named EXPRESS–G (cf. Figure 3). As a consequence, when one model is manipulated, corresponding effects should be made automatically in the others. Finally, in (Pallez, Dartigues, et al. 2002), we have improved the methodology by studying the case of a water bottle design with three different design domains: experts on materials, experts on geometry and manufacturers. The resulting methodology is a function-to-form mapping in a collaborative context and is the following:

**First step:** Each design domain has to define its own intermediate specifications for only one component of the product to design. The intermediate constraints are deduced from the functional decomposition of the design product regardless of the other design domains participating in the design process. As a consequence, in this step, intermediate specifications of a domain will use only physical parameters of the domain. By this way, a designer of a domain can be considered as an expert of this domain in contrary of the methodology presented previously.

**Second step:** Next, as we are convinced that there exist relationships between constraints from one design domain to another, this step consists in establishing those constraint’s relations. There are several ways to achieve this: either manually or semi–automatically by considering the rule “if two constraints from two different domains are deduced from the same function, then they are related each other”.

**Third step:** This step corresponds to the solutions space generation and it is almost the same as our previous method. For the moment, we assume that only experts of design domains who have a shapes library are in charge of proposing solutions by applying the methodology presented previously.

**Fourth step:** Once shapes solutions are generated, experts of the design domain who do not have a library must react to the proposed solutions by participating in the selection of the most promising solutions. So, in this part, experts from all design domains participate in selecting solutions.

**Fifth step:** As it is inconceivable that a promising solution could be found after the first try of shapes solution generation and selection, designers will be obliged to collaborate in order to modify

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**Figure 3: Intermediate specifications model expressed in an EXPRESS–G format**
the weights of constraints and/or add other intermediate constraints and/or add other parameterized shapes in their library so as to increase the satisfaction degree of promising solutions. The function-to-form mapping process starts again from the second step until a promising solution satisfies all the designers involved in the product design.

Our experience shows us that an automatic and direct mapping of the functional information to geometric information represents a very difficult problem for the moment. Moreover, numerous authors are working on this computer-aided-design problem (Gorti and Sriram 1996; Ranta, Mäntylä, et al. 1996; Rosenman and Gero 1996a; Tomiyama, Umeda, et al. 1993; Umeda and Tomiyama 1997; Zhihui and Johnson 1997). To synthesize our methodology, we have previously proposed establishing a median difficulty level that is represented by the intermediate specifications. We assume that the latter is obtained manually from initial specifications mainly expressed in natural language. We concentrate on the almost automatic mapping of the previous model into one of several shapes. The intermediate specifications model is made up of a set of constraints named intermediate; each constraint is made up of physical parameter also named intermediate. These parameters are quantifiable quantities that remain to a high semantic level. Our approach is independent of design domains even though experts of design domains must define some information, necessary to a good working of the function to form mapping. However, the notion of “perimeter”, for instance, remains the same whatever the design domain considered. By this way, there is knowledge capitalization and as and when designs are done, one becomes less and less necessary to consult an expert of the considered domain. Information provided by designers permits, among others, the mapping of intermediate constraints into variation intervals of terminal (geometric) parameters. A Cartesian product of intervals defines the solutions space. On the one hand, we have assumed that the shapes contained in the library were primitive shapes. We can show that the addition of more elaborate shapes, or combinations of primitive’s shapes, don’t modify the proposed approach. However, the number of terminal parameters for those shapes increases considerably.

Our future works are numerous. First of all, in the short-term, it is necessary to identify all the possible relations between constraints from different design domains in order to allow more precise communication between experts of these different domains. Then, it is important to study how to maintain the consistency of models. In that case, future works will focus on the definition and formalization of coherence rules between different models so as to improve the proposed multiple-view model. Secondly, the application of our methodology in the very precise framework of foundry mould design permitted us to consider the automatic creation of shapes that would enrich the library. An evolution of our methodology would consist of not preserving shapes in a library but to construct these shapes automatically according to concerned design domains. The idea would be to elaborate a second intermediate model, between the intermediate specifications and the solutions space, that would permit a less abrupt passage again between functions and shapes. Moreover, according to our methodology, the estimation operation requires instantiation of a solution that is the assignment of a real value to every terminal parameter of the solution. Another improvement would consist of estimating a set of solutions rather than a unique solution: for instance, estimate the shape “circle” without knowing precisely the value of the radius. The shape “circle” is called a class of solution. The possibility to estimate a class rather than a shape would permit, for example, the construction of the first satisfactory classes, of which the best would be examined. Then, in the most promising classes, one would choose the most promising solutions.

In the long term, future works should be related to geometric reasoning: it could be interesting for the experts to define intermediate constraints using other kind of relation. For instance, instead of using well-known mathematical relations (≤, ≥, =, ≠), experts on geometry would like to use a “look like” relation (≡) in order to introduce new experiences on shapes. Once it will be done, it will be
very interesting for designers, and especially for experts who have a shape library (expert on
gometry), to combine shapes contained in the library so as to be more creative. For instance,
evolutionary algorithms could be used (Taura, Nagasaka, et al. 1998; Rosenman and Gero 1996b;

Perspectives in a more general context are also numerous and often make call to other domains of
research. In particular, works done in artificial intelligence could serve as a basis for a better
semantic understanding of functional information. It would allow software systems to provide a
more precocious aid for the function-to-form mapping. In addition, the quality of the man-machine
interface is an essential notion for software appreciated by its users. Even if improvements are
brought to software which implements the function-to-form mapping, the place of designers is still
very important in this mapping. So, a scrolling of the most promising solutions should be done so as
to give designers the possibility to intervene when an aspect of the shape solutions suits them or
displeases them. It raises important difficulties of zones designation by designers, of their
interpretation from a functional point of view and how they will speak in the next step of function-
to-form mapping.

If solutions follow each other in any order, the operation will be especially long and laborious for
designers. To make it convivial, we foresee presenting solutions so that they present a geometric
continuity; by this way, their scrolling will appear like an animation. It presents the advantage
evolving solutions in a progressive manner. To provide this geometric continuity, it is necessary to
realize an algorithm that browses the solutions space and finds a solution that looks like another.
Another possibility is to realize a geometric morphing algorithm that converts progressively a
solution into the following solution. The drawback is to generate shapes that are not solutions.
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Verbal language and sketching

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Abstract

This paper attempts to identify designers’ sketches in different forms for a classification system by use of verbal language. Designers have a creative vocabulary, which has rich meanings in design communication. This study was carried out with the cooperation of 11 academic staff in the domain of industrial design. It was concluded that none of verbal language was found descriptive enough for the purpose of separating sketches into different forms to support a classification system. While this study has not produced a possible means for classification of sketches using verbal language, the methodology employed has proved interesting for future investigative styles of sketching and communication between designers.
Verbal language and sketching

Introduction
Sketching is an old form of communication, which has been used to visualise, record, and exchange information for thousands of years. People communicate knowledge and emotional feelings to others in many ways such as verbal language, body language, words, illustrations, symbols etc. (Horn, 1998). Artists and designers use a vocabulary, which has particular meanings in the form of information to communicate with others.

Birtley (1990) described the way that words such as ‘slippery’, ‘fluid’, ‘taut’ etc., formed a language of car studio, which described particular forms or implied ‘feelings’. This might be useful for classifying designers’ sketches into different forms. Tovey (1997, 2000) also stated that the use of such a vocabulary could be interpreted within a small group, where designers worked together for a quite long period of time. It would be worthwhile to study this sort of language, and to see if it could form a basis of classifying designers’ sketches.

Studies concerning the identification of concept sketches have recently occupied many researchers and several methods have been introduced (Mcgown, 1998; Purcell 1998). They have discussed different classification systems for concept sketches in different domains such as architecture, engineering, sculpture, etc.

The primary motivation for this study is to understand more about the verbal language of design in designers’ sketches and to explore the feasibility of classifying sketches using this sort of verbal language, and to find out whether such words have a common meaning.

Aims
The aims of the study are:

- To understand and explore the meanings and the use of verbal language by designers
- To investigate whether there is a common verbal language amongst designers
- To investigate whether a useful classification scheme can be based on verbal language

Methods
The data collection was carried out with the cooperation of 11 academic staff in the domain of industrial design at Coventry School of Art and Design. The workshop based session was carried out in the following stages:

The 11 designers were asked to bring sketches with them. The collection reached a total of 19 sketches which were from a wide range of design areas. There were nine from transport design, seven were general product design, one GA (General Arrangement) drawing, one illustration and one practising sketch. The sketches included the range from early concept sketches to detailed finished drawings.
Figure 1: Sketches were collected from academic staff in the domain of industrial design.

The designers were asked to contribute adjectives that they used to describe and discuss the style of sketches. The list of adjectives reached 58 words, and included such words as “Loose”, “Animated” etc. These were compiled into a data sheet that could be used to assign scores to the collection of 19 sketches.
The sketches were displayed one by one to all designers, and they were asked to score the applicability of every adjective to each sketch using the following scoring system:

<table>
<thead>
<tr>
<th>Scoring Figure</th>
<th>Meanings of the figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Keyword does not apply to this sketch</td>
</tr>
<tr>
<td>1</td>
<td>Keyword has slight application</td>
</tr>
<tr>
<td>2</td>
<td>Keyword has medium application</td>
</tr>
<tr>
<td>3</td>
<td>Keyword has strong application</td>
</tr>
<tr>
<td>4</td>
<td>Sketch is exemplar of this keyword</td>
</tr>
<tr>
<td>Blank</td>
<td>No opinion</td>
</tr>
</tbody>
</table>

Table 1: Designers used the key to fill data record sheets.

**Analysis of adjectives**

The aim of the analysis was to reduce a small list of the number of keywords, in order to obtain words suitable as a starting point for a classification scheme by following the three steps:

1. Elimination of the adjectives which were inconsistently used by designers
2. Identification of antonyms and synonyms. In the case of adjectives, which have similar or opposite meanings, one of these can be selected to represent all of the forms.
3. Selection of those words which provide clear differentiation between different groups of sketches

**Elimination of inconsistent use of objectives**

Inconsistency of use was gauged by the standard deviation of the score given by the 11 assessors, a high standard deviation indicating that the word was not being used consistently.

The standard deviation of the scores given by the designers for each adjective for each sketch was calculated. The mean standard deviation was then calculated for each adjective. One examination of the results, a natural break was found around 0.9, and sketches with a standard deviation higher than 0.9 were eliminated as being inconsistently used.

Thirty-four adjectives were thus rejected due to the inconsistency of interpretation. These words were:

Energetic, Dynamic, Laboured, Atmospheric, Silhouette, Insensitive, Flat, Shaded, Bold, Overstated, Clean, Defined, Evocative, Realistic, 3-Dimensional, Cartoony, Impressionistic, Analytical, Powerful, Bright, Dull, Unresolved, Distorted, Sensitive, Crude, Graphic, Flashy, Informative, Smooth, Precise, Descriptive, Soft, Hard, Imaginative

**Identification of synonyms and antonyms**

Twenty-four adjectives remained, a Pearson Rank correlation was carried out to examine the relationship between these (See Table 3). A correlation of greater than 0.6 was used as an indication of common or similar meaning. Likewise, a correlation lower than –0.6 was used to indicate opposite meaning, as is common practice in statistics (Jain 1988; Sigel 1956). The results of the definition were shown the antonyms and synonyms as follows:

**Synonyms (Correlation > 0.6)**

- Loose, Free-spirited, Spontaneous, Vague, Grubby, Ambiguous, Fuzzy, Sketchy
• **Animated.** Free-spirited, Amorphous

Antonyms (Correlation <- 0.6)

• **Loose, Tight**
• **Free-spirited, Controlled**
• **Grubby, Crisp**
• **Fuzzy, Slick**

After eliminating synonyms and antonyms 12 keywords were left which might be used as ‘axes’ of a classification scheme, these words were:

- Animated, Blobby, Blunt, Chunky, Exaggerated, Loose, Meaningless, Moody, Repetitive, Resonant, Subtle, Understated

The words above can be used as the basis for a classification scheme. This would yield 4096 different classes of sketches, which is too large a number to be useful.

**Visual clustering analysis**

To reduce these number, words which provided the clearest classification were selected, using a visual clustering analysis.

Two main properties in Cluster Analysis are compactness and isolation (Jain and Dubes 1988). Compactness measures the internal cohesion among the objects in the cluster whereas isolation measures separation between the cluster and other pattern. A Visual Cluster Analysis (VCA) in this experiment is to use the mean of each single keyword against others, to show the clusters via the pair of keywords in a two dimensional chart. If a pair of keywords is not useful at differentiating it can be abandoned. The clusters appeared to show keywords that do differentiate the characteristics between sketches.

If VCA gives a well separated cluster, the sketches in the group of that cluster can be picked out. The similar features among these sketches can be extracted forming the basis for classification of sketches in different groups. The classification could eventually be used to help software designers to specify appropriate means of handling different kinds of sketch.

**Selection of Visual Clusters**

Sixty-six VCA charts were produced using every combination of pairs of keywords, as pointed out earlier, every combination gives 4096, 40 pairs of keywords were rejected because there were no clearly differentiated clusters such as Subtle/Chunky, Understated/Animated Loose/Animated, Resonant/Chunky, Loose/Blunt, Understated/Repetitive, etc.

A further 23 combinations were rejected because there was only a single cluster such as Animated/Repetitive, Animated/Blobby, Subtle/Blobby, Meaningless/Repetitive, etc.

This left three pairs of keywords with visually separated clusters. The most valuable clusters are with obvious gaps arising between groups (See Figure 2). These pairs of keywords were:

- Loose and Blobby
- Understated and Chunky
- Subtle and Moody
Figure 2: the three pairs of keywords were valuable clustered

Four groups emerged via the Visual Clustering Analysis in keywords “Loose” and “Blobby”.

Group A: Not loose and not blobby
Group B: Slightly loose and not blobby
Group C: Medially loose and not blobby
Group D: Strongly loose and not blobby

Four groups emerged via the Visual Clustering Analysis in keywords “Understated” and “Chunky”.

Group A: Medially chunky and not understated
Group B: Slightly chunky and not understated
Group C: Not chunky and not understated
Group D: Not chunky and slightly understated

Three groups emerged via the Visual Clustering Analysis in keywords “Subtle” and “Moody”

Group A: Medially moody and slightly subtle
Group B: Slightly moody and slightly subtle
Group C: Not moody and not subtle

**Extraction of common features**
The aim of this study was to pick out if there were common visual features, which would be associated with the groups identified above. The study focused on the following aspects:

1. The drawing techniques:

This concerns the basic visual graphic techniques used in the sketches and the fundamental drawing elements used to describe an object. They can be divided into two aspects:

- Expression of sketching forms, e.g. the use of form line, shading, composition, colour, template etc. to describe the shapes physically

- Applied artistic techniques, e.g. abstractionism, impressionism, realism, and the use of ‘artistic license’ such as exaggeration, stretching, rotation.
2. Level of finish of the sketches

This is concerned with the sketch in different design stages, which have obvious different features. At the very early concept stage, designers may only use line to capture the ideas as quickly as possible, but in the design development stage, they are involved with detailed descriptions by using a variety of media.

3. The communication of intentions

This relates to the intention of the designer when sketching. The techniques that the designer uses in sketching to describe the form of design objects must have some meaning for conveying information to others. For example, the concept sketch mostly uses brief form lines without much shading which does not convey the surface details an observer, but a finished sketch usually will have detailed shading and tidy clean lines, which communicates to an observer a lot of information about the shape, surfaces and even the suggested materials. This part of the study aimed to discover whether the different groups would be related to different intentions on the part of the designer.

**Results**

We summarise the three sets of keywords in the following tables:

<table>
<thead>
<tr>
<th>Loose / Blobby</th>
<th>Used keywords</th>
<th>Separated groups</th>
<th>Drawing techniques</th>
<th>Expressive level</th>
<th>Communication of intention</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Group A</td>
<td>1 illustration, 1 GA, 2 rendering</td>
<td>Detailed stage</td>
<td>By using form line and form shading</td>
<td>Sketches were used in obvious different drawing techniques, and in different finished levels in both groups B and C, which were difficult to categorise into the four groups,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group B</td>
<td>Many different techniques were used</td>
<td>Sketches went to different stages</td>
<td>Different levels of information to observer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group C</td>
<td>From brief line to detailed shading</td>
<td>Sketches went to different stages</td>
<td>Different levels of information to observer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group D</td>
<td>Using form line and little shading</td>
<td>Beginning stage</td>
<td>Giving suggested shape without details</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: The summary of set one
### Table 3: The summary of set two.

<table>
<thead>
<tr>
<th>Used keywords</th>
<th>Separated groups</th>
<th>Drawing techniques</th>
<th>Expressive level</th>
<th>Communication of intention</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>Tidy form lines and simple shading</td>
<td>At the middle of design stage</td>
<td>Well conveyed the shape and depth</td>
<td>Set two has very close drawing techniques and similar finished levels between groups B and C which was difficult to distinguish sketches from the two groups.</td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>Detailed shading and form lines</td>
<td>Detailed stage</td>
<td>Well conveyed the shape and detailed surface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>1 GA, 1 Illustration, the rest are same as Group B</td>
<td>Detailed stage</td>
<td>Well conveyed the shape and detailed surface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group D</td>
<td>Using form line and little shading</td>
<td>Beginning stage</td>
<td>Rough shape without detailed infor.</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4: The summary of set three.

<table>
<thead>
<tr>
<th>Used keywords</th>
<th>Separated groups</th>
<th>Drawing techniques</th>
<th>Expressive level</th>
<th>Communication of intention</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>Detailed shading and form lines</td>
<td>Detailed stage</td>
<td>Well conveyed the shape and depth</td>
<td>The use of drawing techniques, finished and communication levels were quite consistent in same group with an exception of group C.</td>
</tr>
<tr>
<td></td>
<td>Group B</td>
<td>Shading and form lines</td>
<td>At the middle of design stage</td>
<td>Conveyed the general shape and depth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group C</td>
<td>Form lines and little shading</td>
<td>At the beginning stage</td>
<td>Giving rough concept without details</td>
<td></td>
</tr>
</tbody>
</table>

By comparing the groupings, which were obtained via three pairs of keywords, we found that sketches classified using “Loose” and “Blobby” were difficult to identify using similar sketching features within the groups, because there was too wide a range of characteristics within both groups B and C. They used quite different drawing techniques and were finished to different design levels.

Sketches classified using “Understated” and “Chunky” used similar drawing techniques within groups B and C, and were finished to the same levels in all of the different groups.

The sketches classified using “Subtle” and “Moody” were clustered into three groups, and most sketches in each group had a similar use of techniques, finish levels, and communication levels. These classification axes are interesting for further research, but the visual classification was not clear enough to support a classification system, which can be used to identify sketches into different groups for the purposes of software design. Eventually none of the sets of keywords was found that would be useful for classification of sketches into different groups for this purpose.

Although this study has not produced a useful classification system for the classification of sketches by using verbal language of design, there have been some significant findings:
First, designers use verbal language to describe the form of design in a quite individual way, which may not be commonly understood by others, and thus cannot be used to classify sketches.

Second, one interesting finding occurred in set three. Sketches in this set formed three groups and sketches in each group have similar drawing techniques and the same level of finish, except for two sketches, which visually appeared to be “out of place” in the group assigned by the analysis. Farther research based on this classification may reduce this anomaly and produce a more useful result.

**Discussion**

This experiment was carried out with 11 academic staff, but not with current real industrial designers. It was not clear whether the results would be the same if conducted using industrial designers, and whether the sketches would be representative of their work. On the other hand, academics are the ones who talk about sketching (have the vocabulary), designers do rather than talk, so perhaps academic staff are appropriate. Also, the reason for not doing it with designers was that the experiment didn’t seem to be sufficiently productive to justify the effort.

The other issue concerns the collection of sketches from a wide range of design drawings such as GA drawing and illustration, while this may be a valuable experiment in categorising design drawings in general. It distracted attention away from the concept sketches, which were the intended focus of the investigation.

Only 19 sketches were examined, which is a small sample size. It is not clear whether this sample of sketches covered the whole range of design sketches or whether it lacks some types of sketch. However, despite the small sample size, an increased understanding of sketching vocabulary and its relationship to the classification of sketches was gained.

Following this experiment, there are two aspects of design verbal language, which warrant farther discussion. One is the discussion about the language of designed objects, that is the language that makes it possible to communicate information from designers to users, and even from users to other users. The other is the language used by designers to understand each other. This sort of verbal language needs to be specialised (as is the language of medical doctors, and other professions) because it has to address specific problems, techniques and characteristics in the design process.

In both cases we need a language of design and they are both problematic. In the first case, the language is generated by the interaction between designers and users. In the second case, which this experiment focused on, the specialistic language is already in place, but it has proved to be very difficult to recognise.

**Conclusions**

It was concluded that none of these sets of keywords was found strong enough for the purpose of separating sketches into different groups to support a classification system.

While this study has not produced a possible means for classification of sketches using verbal language, the methodology employed has proved interesting for future investigation of styles of sketching, and communication between designers.

Maybe more important than design language is the idea of verbal communication of the visible characteristics in products and sketches. The outcome appears to indicate the verbal communication is not clear or consistent. This leads to a conclusion that the visual communication is more likely to be successful, leading to the future experiment, which concerns the visual analysis of sketches and the extraction of common visual features.
Acknowledgement
This research has been supported in part by Ford and the first author would like to thank Dr A. Woodcock and all participants in Coventry School of Art and Design.
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Developing design research: the study of research as a tool for research

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Abstract

This paper will propose that learning - as occurring in all those circumstances whereby agents have an uncompleted understanding of the context in which they operate - has been an effective driving force that has characterised the reflection on design research itself. Some “forms of research” as “forms of learning” acquire even greater importance in those evolutionary environments - intended in the most generic terms - where heterogeneous agents display different forms of rationality, where there is a persistent appearance of novelties deriving from technological, behavioural and organisational innovations driven by the agents themselves, where out-of-equilibrium interactions may frequently occur among the agents. The general key to approach the theme shall be that “learning as a form of research” entails cognitive activities of construction and modification of mental models and behavioural patterns. But as learning may happen in different cognitive and behavioural domains as well as occurring through different processes, a significant emphasis shall be put on those strategic sites for design research that best perform this “learning as research” function in terms of:

- potential skills to capture key aspects of design research development,
- potential skills to manage the complexity of design issues deriving from the technology-society interaction.

The purpose of this work is intended as an informal reflection on the learning processes in design research. While trying an ideal framework for this reflection, an attempt will be made to stress the relevance of the Ph.D. programmes as research strategic sites, where crucial efforts are concentrated to produce collective learning. Observations derived from empirical experience stem from the research context of the Ph.D. programme in Industrial design of Politecnico di Milano. The parts of the paper focusing on this programme experience have limited generalisability.
Developing design research: the study of research as a tool for research

The knowledge gap and the problem-solving gap

In its wider sense learning may occur in all those circumstances whereby agents have an uncompleted understanding of the context in which they operate. Such an imperfect understanding may be “due to lack of information about it, or more fundamentally, to an imprecise knowledge about its structure: or, when they master only a limited repertoire of actions in order to cope with whatever problem they face - as compared to the set of actions that an omniscient observer would be able to conceive: or, finally, when they have only a blurred and changing understanding of what their goals and preferences are” (Dosi, Marengo and Fagiolo 1996: 2). Learning, so defined, can be thus recognised as one of the ubiquitous characteristics of most economic and social environments.

A fundamental aspect of learning regards most often cognition (Dosi et al. 1996: 10), that is to say the process by which decision makers form and modify representations in order to recognise some sense of a reality which is generally too complex to be fully understood. As a consequence a systematic gap is usually identified between the agent cognitive abilities and reality itself, the gap taking at least two forms: a knowledge gap (involving incomplete or wrong representations of the environment) and a problem-solving gap (between the complexity of the tasks to be faced and the agents’ ability to cope with them). A similar concept is introduced as “C-D (competence-difficulty) gap” (Heiner 1983).

Here, it is assumed that design research - as developed within academic contexts - experienced a knowledge gap in the last decade, a decade when the pace of contemporary industrial production dramatically accelerated, and a progressive, impressive shift in the nature and structure of industrial and social organisations took place. Turbulent, uncertain and evolutionary environments have driven industrial systems to quickly adapt to changes while ensuring in any case effective organisation; markets have evolved in unforeseeable and unstable ways, and most organisations have started learning to evolve in uncertain environments.

It is also assumed that - somehow adapting to turbulent environments - the domains of design research are now slowly progressing from a knowledge gap to a problem-solving gap. The expected sense and nature of design research will be consistent with its capability to face both a knowledge gap (improving the cognition of a complex reality) and a problem-solving gap (improving the competence and skill of agents having to face that complexity). In other words, it is proposed that the part of design research developed within our academic contexts is now slowly shifting from a condition of “substantive uncertainty” - a lack of isomorphism between the complexity to be faced and the agent’s model of that reality, as in Dosi and Egidi (1991) - to a “procedural uncertainty”, with or without substantive uncertainty.

As a premise for this reflection we will concentrate on the question: how cognition about design research may be formalised within academic contexts?

To approach some temptative answers we shall move within limited borders:

(i) we shall consider the past and present experience of the doctoral research in the domains of design at Politecnico di Milano as the empirical horizon for this reflection;
(ii) we shall assume as appreciable theories of reference the fields of technological and organisational learning;
(iii) referring to extra-disciplinary fields will imply a level of generality.
An empirical background: from “searching” to “learning how to make research”

A Ph.D. programme in industrial design in Italy was first opened by Politecnico di Milano in 1990. At that time the domains of research were mainly centred on large scale innovation-related phenomena, usually developed from a theoretical angle. Furthermore, proposed areas of research and training programmes overlapped. Similarly, no clear separation could be identified between subjective reflection and objective search.

If it is true that, “in the shortest form, research is a way of asking questions” (Friedman 2000: 18) we dare say that paradoxically a form of search was experimented in absence of a clear set of questions.

As Friedman (2000:19) further observed: “What distinguishes research from reflection? Both involve thinking. Both seek to render the unknown explicit. Reflection, however, develops engaged knowledge from individual and group experience. It is a personal act or a community act, and it is an existential act. Research, in contrast, addresses the question itself, as distinct from the personal or communal. The issues and articulations of reflective practice may become the subject of research, for example. This includes forms of participant research or action research by the same people who engaged in the reflection that became the data. Research may also address questions beyond or outside the researcher”. The approach to design research opened by our very first Ph.D. programme seldom exceeded the reflection borders.

This approach was motivated by various factors, partly internal to the dynamics of the discipline of industrial design as articulated by the programme itself, partly deriving from the historical approach to design studies that had been developed within the school, and again partly depending on the perception of the growing complexity of the innovative process in the nineties - a systematic gap in the definition we used above.

A relevant number of investigations carried out within the doctorate emphasised the importance of technological change, orienting the direction of conceptual analysis towards systemic, evolutionary, complex approaches. Whatever the motivations for the analysis of technological change and innovation, this field of enquiry highlighted the factors and fundamental ingredients of the process of development and transformation of industrial products, services and systems, around which the doctoral programme was activated as a pole of concentrated theoretical reflection. Moreover, as a starting point, a broad view of innovation was assumed, considered as a dynamic process related to achieving competitive advantages involving the development or improving of new products, services, technology, processes, institutions, systems, solutions. This view of innovation encompassed not only science and technology, but the range of economic and social activities competing in the marketplace and relevant to design in areas such as communications, corporate organisations, education, institutions.

Research addressing research

In 2000 the Ph.D. programme was radically revised from the former intention and training articulation, adopting the overall idea of the Ph.D. programme as a highly advanced, partly taught programme in design research. The present doctorate programme task was elaborated as the training of a high profile researcher, whose aim is to develop design research either in academic or industrial contexts. Relevant steps connected with such a training are the refinement of analysis techniques, the development of critical abilities, the organisation of an original contribution to the knowledge in technological and industrial culture, the proposal of innovative approaches and visions of the theory and practice of industrial design and multimedia communication and the
building of increasing skills in research planning, research strategy building and research management.

In the continuity with the activity carried out in the previous decade, the complex of issues investing the theme of innovation still represented the conceptual trajectory of the whole programme. As before, an extensive approach allowed to be open to that horizon of activities and entities (communication, firm strategies, dynamics of the market, education and public institutions) that are part of the area of action of industrial design as physical or immaterial artefacts themselves.

In doing that, attempts were made to foster interpretations of innovation and its relationships to social, technical, organisational factors on one hand, and market processes on the other, arguing that such interpretations are essential for the understanding of differences in the mode and degree of innovativeness and, specifically, for the understanding of the role of design as a discipline and design research as a coherent component of that discipline.

Although a strong element of continuity with the past still marked the nature of this Ph.D. programme, the transition was obvious when the training programme moved from the overall intention of “searching in design” to that of “learning how to make research in design”. Moreover, this research activity is expected to go “beyond or outside the researcher” (Friedman 2000: 19). Such a transition is now generating a form of knowledge - addressing the core questions of the nature of design research itself - that the training programme had never known or experienced before.

**Learning from experience, anticipating experience**

The process of learning and the nature of knowledge may not be necessarily completely understood: nevertheless, there is wide agreement that knowledge creation requires experience. Kolb's (1984: 38) definition of learning as "the process whereby knowledge is created through the transformation of experience" offers a perspective in this direction, while emphasising the relationship between experience and knowledge as a dynamic process of continuous reproduction and regeneration.

Friedman (2000: 13) recalled that, as Bunge suggests (1996:104-107), knowledge arises through the interaction of many forms of learning. Thinking, experience and action all are part of a process. Moreover, a fundamental distinction between information and knowledge (reported by Dosi et al. 1996: 23) states that while information entails codified propositions about states-of the world (know-what), properties of nature (know-why), identities (know who), explicit algorithms on how to do things (know-how) (Lundvall 1995), knowledge includes cognitive categories, codes of interpretation of the information, tacit skills, search and problem solving heuristics (Dosi et al. 1996: 24).

That is the definition of knowledge that more broadly includes visions and rules of search common to most activities of scientific discovery or technological and organisational innovation. Furthermore, Dosi et al. (1996: 24) state that “In this definition, knowledge is to varying degrees tacit, at the very least in the sense that the agent itself, and even a very sophisticated observer, would find it very hard to explicitly state the sequence of procedures by which information is coded, behavioural patterns are formed, problems are solved”.

The static model of learning as acquiring knowledge external to and independent of the learner is contradicted: human knowledge is not only the product of past experience, but also the product of anticipating the future. Knowing things involves feedforward as well as feedback, anticipating how things may be conceived and used in the future.
We believe that the process of learning in design research may positively be coherent with these observations and such an approach might significantly benefit from that branch of cognitive studies focusing on the nature and changes of categories and mental models (Johnson-Laird 1983, Lakoff 1987, Margolis 1987, Holland 1986, Bateson 1972).

To paraphrase some of the above statements, an elementary level of cognition of the sense of design research may thus take place at least:

(i) when an imperfect understanding of the (relative) world is recognized;
(ii) when actors involved are aware they can master a limited repertoire of research actions;
(iii) when actors are aware that design research goals may change in progress;
(iv) when thinking, experience and actions interact;
(v) when experience is both transformed and anticipated.

**Visions of learning dynamics**

It is also proposed that a number of basic regularities on cognition, decision-making and learning - stemming from contributions outside design disciplines (for example Bateson 1972, March 1994, Nelson 1993 and 1994, Kauffman 1993, Freeman 1982, David 1975, Thomson 1993, Winter 1987, Simon 1988, Nelson and Winter 1982) - could be among the building blocks of emerging theories of design research, so to open the horizon of its learning dynamics.

Moreover, in our opinion, a further general hypothesis may take shape: the one stating that learning through design research entails cognitive acts of construction and modification of conceptual and behavioural patterns hardly reducible to well defined problems.

The above hypothesis reminds similar observations developed around the experience of management facing product development in changing environments, where two sharply contrasting approaches - analytical and interpretive - can be detected (Lester, Piore and Malek 1998: 88-89). Although both approaches are valid, each serves different purposes and asks for different skills. Under the analytical approach the design of a new product is essentially seen as a problem that has to be solved. A clear objective, identifiable resources, constraints are the factors that need to be integrated in some optimal combination presumably leading to an ultimate solution.

But not all product development can be accommodated within a structured analytical framework: cases are given in which non-preexisting needs are detectable, while product features emerge from back-and-forth interactions, on going give-and-take between companies and customers: to say it differently, nothing is fixed at the outset. When such a degree of uncertainty is assumed, product development is an open-ended process rather than a problem-solving project, whose aim is to interpret a situation while discerning possibilities instead at aiming at a definite solution. We leave as an open question the hypothesis of a similar “interpretive” approach suitable for design research.

**Sites for research accumulation**

Dosi et al. recognized (1996: 27) that a relevant achievement in understanding the functioning of contemporary systems of production and knowledge accumulation has involved taxonomic exercises (Pavitt 1984), trying to map families of technologies according to their sources of innovative knowledge, while implicitly recognising firms as major, albeit not unique, repositories of knowledge.

It has been observed (Manzini and Pizzocaro 1999; 231-232) that Ph.D. programmes could serve as “strategic sites” and parallel repositories for design knowledge production and accumulation. Our
meaning of research strategic sites somehow paraphrases that of Bijker, Hughes and Pinch (1999: 191) when stating that there exist “research sites at which the complexity of the seamless web is manageable but which at the same time serve to capture key aspects of technological development”. Furthermore, the sense of strategic site is proposed for those doctoral programmes in design where the web of research and society is rewoven by breaking down the frequently encountered too rigid divisions among different domains (science and technology, technology and social impacts, invention, marketing and consumption). Our meaning of design research accumulation still implies obtaining something similar to shelf innovation as formulated within the dynamics and approaches of concurrent engineering. Shelf innovation consists of the anticipated development of technological solutions and components so that a heritage of innovation can be created, available at any time for possible use in new products, being the shelf concept that of storing solutions ready for future applications (Wheelwright and Clark 1992 and 1993). Following this model, the activities of component invention and testing are separated from product development: in this way advanced technologies can be incorporated in new products avoiding the risks associated with innovation.

A possible hypothesis still remains that it may be possible to conceive design research accumulation as similar to shelf innovation, accepting that it can generate "research components or portions" that can be shelved for future utilisation.

Here we will simply suppose that the nature of these research components might be generalised, assuming that they can be considered as “objects of learning”.

It is proposed that at least four broad classes of “objects of learning” can be stored or accumulated within Ph.D. programmes as research strategic sites:

(i) the states-of-the world (related to design domains),
(ii) other agents’ behaviour (in the domain of design),
(iii) how to solve selected design problems,
(iv) one’s own characteristics (preferences in research paths).

It might well be that these classes of learning objects map into different representations of the dimensions where learning connected to design research itself may act:

(i) the space of representations of the world,
(ii) the space of agents’ behaviour in a given system,
(iii) the space of actions and realised (or expected) outcomes,

where each level generates the following one: learning in the space of world representations implies learning other agents’ behaviour, implying selecting design actions and preferences among a number of possibilities, resulting in design outcomes.

Still lacking a robust background to sustain this vision, here we will not emphasise this point. We are simply working at the hypothesis that learning through design research may be reasonably founded on the idea of learning as a co-evolutionary process.

It is straightforward from our earlier discussion of the general view of learning that here where it is approached for design research it rests on the co-development of cognitive representations, behavioural repertoires and preferences in actions.
References


General strategic knowledge models and their interaction with domain-specific knowledge in design

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Abstract

This research concentrates on the modelling of general process knowledge that is understood to be represented as a common strategic knowledge relevant to the various design domains, such as product and information design. Its objective is to illustrate the connections between general knowledge and strategies and how they interact with the domain–specific design knowledge.

The knowledge identification in this research is based on the study of designers' sketches generated during the early stage (conceptual stage) of the design process. The applications of general and goal–limited strategies are analysed and compared within the domain of product design and information design. The findings are used as the basis to infer the models of general design strategic knowledge and its interaction with relevant domain–specific knowledge.
General strategic knowledge models and their interaction with domain-specific knowledge in design

Introduction
This research is based on the premise that studies of human expertise show that detailed specific knowledge is necessary to solve problems successfully. To relate this to any area of design one has to understand the design activity itself and what constitutes its general strategic knowledge and its domain-specific knowledge. Design can be categorised mainly as an adaptive expertise (Popovic 2000) as designers adjust to the design tasks by utilising their knowledge which they adapt to the current tasks and apply during the design process (Suwa, Gero and Purcell 1999).

In his research on creativity in design, Christiaans (1992) identified that for a designer to derive any solution, knowledge of strategies, domain–specific knowledge, and general process knowledge are required (Christiaans 1992). The process of designing asks for generating ideas which lead to new understanding (Greeno 1978). This encompasses: (a) knowledge of implementation methods for generating possible solutions; (b) control knowledge for guiding the search for satisfactory design. It involves knowledge of monitoring and evaluation of one’s own design process (Michell 1985). Simon (1984) identified that ill-structured tasks utilise domain–specific knowledge and knowledge for organising the overall solution process. This supports the claim that designers possess knowledge and strategies to execute the tasks and monitor the design process. Love (2002) defines designing as a "non–routine" human activity which he sees as being an essential aspect of processes that lead to a design of an artefact. This supports the notion of design being an "adaptive expertise" within the framework of the "non–routine activity" of designing. It might also help to explain the utilisation and interaction of knowledge between the domains, and within the domain, in order to look for communality between them.

Experience plays an important role in design and problem solving (Visser 1996; Kolodner and Simpson 1986); their research illustrates that experience contributes to problem solving activity and brings modifications to its associated reasoning processes. In cases of successful experience, already-known principles are reinforced and improper ones modified. In some cases "individual experience acts as exemplars upon which to base later decision" (Kolodner and Simpson 1986). Visser (1996) studied the use of “episodic” knowledge, which is "particular experience-linked sources" in design-related problem solving. It was found that a designer used personal and other people's experience during the problem solving activity and that previous experience could help in procedures to be followed or avoided. It could help to predict task outcomes and the steps to be taken in situations where immediate action is required, such as in an emergency. It may help in selecting and applying situational knowledge chunks to a particular task domain. In cases of error, it could suggest an explanation of failures (adapted from Kolodner and Simpson 1986).

Therefore, this research focus is on the strategic knowledge which refers to knowledge or processes and strategies that are utilised during the acquisition or utilisation of knowledge. This knowledge exists in varying degrees of generality or separation from specific domains. These are the procedures that are planned or intentionally included prior to, or during, or after the design task. Strategies can be associated within the domain or across domains.
Strategic and domain–specific knowledge

Knowledge is of major importance for understanding problem solving (Kotovsky and Simon 1990). This is identified by the assumption that human problem solving, in general terms, is described as an "interaction between the problem representation and cognitive action" (Reimann and Chi 1989). That is, problem representation is a mental representation that people have (Kieras and Polson 1985; Young 1981; Hammond at al. 1982; Rouse and Morris 1986).

Domain-specific knowledge is understood to be knowledge in the particular area of expertise. There are many studies done referring to domain-specific knowledge. They occur in well-structured or ill-structured problem domains such as physics and mathematics (Larkin, McDermont, Simon and Simon 1980; Chi, Feltovich and Glaser 1981), design (Akin 1979), and novice and expert user models (Popovic 1998). All these studies show that detailed, specific knowledge is necessary to solve problems successfully. However, a certain amount of domain knowledge is necessary to be able to use strategic knowledge on a domain task.

This research intends to identify general strategic knowledge and how this interacts with the domain–specific knowledge in design. To understand both knowledge categories that are utilised during the design process, relevant knowledge descriptions are presented. The knowledge associated with the design field (product or information design) is called "domain knowledge". It is the knowledge designers have within their particular area of expertise. It is a "segment of an individual's existing conceptual knowledge that is related to a 'specific' area" (Alexander 1992).

Domains of expertise differ. Some are in the area of academic research or design while others are driven by principles or by task performance. Tasks can be well-defined or ill-defined. Alexander (1992) argued that this distinction between tasks and "dissimilarity among domain" plays an important part in the interaction of domain knowledge and strategic knowledge. For the purpose of this work, the definition of domain knowledge proposed by Alexander and Judy (1988) is used. The generally accepted classification of domain-specific knowledge consists of four main categories.

These categories are:

- **Declarative knowledge** refers to factual information — knowing what.

- **Procedural knowledge** refers to the compilation of declarative knowledge into functional units — chunks that incorporate domain-specific strategies; knowing how.

- **Conditional (situational) knowledge** refers to understanding where and when to access particular facts or employ particular procedures.

- **Strategic knowledge** refers to knowledge or processes and strategies that are used during acquisition or utilisation of knowledge

The knowledge structure is manifested through the output of the procedure that will generate the appropriate response. Benefits of procedural representation relevant to design are " the ability to encode heuristics and to readily incorporate both knowledge processing considerations within the same structure" (Rumelhart and Norman 1985).

Domain-specific strategies are assumed to be generated from the proceduralisation of declarative knowledge (Chi 1981). Without a body of content knowledge, the existence of domain-specific knowledge is unlikely. Smith and Good (1984) argued that a certain body of relevant knowledge is a prerequisite to completing a task. Effective problem solving depends very much on the content...
and structure of knowledge about the particular domain (Greeno 1978; Bhaskar and Simon 1977; Chi, Feltovich and Glaser 1981). Strategies can be associated within the domain or across domains. There are "goal-limited" and "general" strategies. This classification was developed by Pressley et al. and reviewed by Alexander and Judy (1988). Goal-limited strategies include processes that are relevant for task accomplishment. General strategies are applied more on a broader level and they may interact with goal–limited strategies. Alexander and Judy (1988) overviewed some characteristics of the interaction of domain-specific and strategic knowledge from relevant literature. The following three hypotheses of their interaction are found relevant to this research:

1. A foundation of domain-specific knowledge seems requisite to the efficient and effective utilisation of strategic knowledge.
2. Strategic knowledge contributes to the utilisation and acquisition of domain-specific knowledge.
3. Perceiving the relatedness in domain and strategic knowledge across tasks and across domains seems to characterise competent performance.

Alexander and Judy (1988) also revealed differences between the knowledge structures and problem solving procedures of novices and experts. This is supported by the idea that a suitable, organised cognitive structure plays a significant role in retrieving and encoding knowledge relevant to problem solving. Chase and Simon (1973) argued that the main differences among novices, experts, and masters in different domains were related to their immediate access to relevant knowledge.

Problem solving theory and knowledge representation
Reimann and Chi (1989) pointed out that mental representations can be identified on the assumption that human problem solving in general terms can be described as an “interaction between the problem representation and cognitive action” (Reimann and Chi 1989). In other words, the problem representation is a mental representation that designers have of the artifacts they design.

The theory of problem solving has been developed in the context of information processing and cognition (Anderson 1983, 1993; Newell and Simon 1972). This framework gives opportunities to explore hypotheses of cognitive actions and their forms of representation (Greeno and Simon 1988) as they were manifested in the conceptual design stage.

Problem solving theory is based on problem space as a main organisational unit (Newell and Simon, 1972), around which different models and knowledge representational systems have been developed (Card, Moran and Newell 1983; Kieras and Polson 1985; Akin 1979, 1986). These are based on well-defined problem solving tasks where the whole problem space is simple when compared with interactive artifacts (Payne 1987; Carroll 1991).

Any human's task occurs in its context in which people construct its internal representation. Hypotheses about cognitive representations of problems are developed around the idea of problem space (Newell and Simon 1972; Greeno and Simon 1988; Maher at al. 1996; Dorst and Cross 2001).

There are two other characteristics present in problem solving which are semantically rich (Greeno and Simon 1988). These are (a) complexity of problem representation, characterised by complex domain-specific knowledge and (b) domain-specific procedural knowledge that allows designers to accomplish the task. Bhavnani and John (1997) reported Siegler and Jenkins definition of problem solving as any procedure that is “nonobligatory and goal directed”. Specific procedures relate to
know-how and when to apply domain-specific knowledge during the problem solving activity such as a specific design task.

Various types of strategies are associated with problem solving. Strategies may be divided into those that apply weak methods and those that use strong methods (Anzai 1991). Weak methods include general methods independent of domain-specific knowledge such as trial-and-error processes and means-end analysis. A person evaluates and compares the current state of information with a goal of the problem (task) to be achieved. This is understood to be general problem solving heuristics used to explore ill-structured domains (Newell and Simon 1972) and they are utilised in many different domains. Successful use of means-ends analysis requires the designers to have some domain-specific knowledge (Alexander and Judy 1988) in order to be able to associate them with the design task procedures.

The key to any problem solving activity is building the representation (Larkin 1985; McDermont and Larkin 1978; Simon and Simon 1978). These authors found that experts spent more time on "qualitative analysis" before they started to solve a problem. Reimann and Chi (1989) summarised the research on the representation of ill-defined problems (social sciences). Experts with the expertise domain (and also non-domain experts) worked on qualitative analysis and formed representations before attempting a solution. They often had better problem representation and therefore better solution outcomes.

Strategic knowledge and design: exploratory study
Two design domains were selected for this exploratory study. They were product design and information design. In both fields, designers were to do the following: (a) produce novel solutions, (b) work with information that is not complete, (c) use drawings and other media as part of problem solving and (d) apply imagination to problem solving (Cross 1995). However, the concentration of this study is on the analysis of visuals that designers use, as a part of problem solving, during the early stage of the design process. Its aim is to identify how strategic knowledge is represented across the domains and within the domain. It is understood that the utilisation of visuals is a very powerful strategy that designers use. This analysis is based on six selected projects (information design and product design) from practice and education. The educational projects were done in a postgraduate program and the students whose work was analysed had three to ten years of practical experience. Overall, the designers' experience was between three to more than twenty years. The early stage of the design process was analysed only. The designers had already dated all visuals during the design process and archived them as project documentation. Each project was analysed from its beginning.

The studies of design emergence (Oxman 2002) demonstrated that a high level domain knowledge of visual form can be seen as cognitive content. In design, word, images and shapes in combination or independently are used to communicate the concepts and represent the understanding of the physical world of artifacts. They are the most common media that designers use to interpret and reformulate the design concepts. The visual language (Horn 1998; Bucciarelli 2002) might be the media "to represent classes and structure of domain knowledge" (Oxman 2002) shown in them. This supports the hypothesis that the images and other visuals used by the designers might convey the strategies and knowledge representation within and across design domains. Therefore the main objective was to identify the following for both domains:

- general strategies (GS)
- goal–limited strategies (GLS)
- domain–specific knowledge (DSK)
- knowledge interaction
The visuals were divided into segments. Each segment was numbered and associated by the date of its occurrence. The coding process of knowledge was repeated three times by the same person with one week’s break between codings. The characteristic segments are used as representative examples (Figures 1 to 7).

**Information design**

Information design was analysed using the early stage of idea generation related to web and publication designs. Each project started with a brief or initiative from the client. However, the designer worked together with the client in order to develop the brief further. The general strategies that applied throughout the projects were strategic identifications of where and how to approach, and work with, a client in order to establish design constraints. The designer applied goal-directed procedures that were planned, intentional, or situational. Figure 1 illustrates her strategic identification of the design direction. The segment selected from the money action planner design (Figure 1) illustrates designer's initial strategy (GS) to understand the clients and their customers' needs utilising general strategy (GS) and goal–limited strategies (GLS) in order to acquire and interpret what they said.

![Diagram of Goal Limited Strategies](image)

Figure 1: Designer's identification strategies and knowledge representation

Figure 1 shows that goal-limited strategies (GLS) and experiential knowledge are utilised to interpret the needs. For example: in the first column, GLS was to look at what the "first user of a planner" might like to expect as (a) "basic/beginning"; the second column refers to a possible "linear approach" and the third column exhibits "references". Knowledge representations observed in this example are (a) general strategic knowledge (GSK) that interacts with (b) situational strategic knowledge (SSK) and (c) experiential knowledge (EK). General strategic knowledge controls the search for the satisfactory outcome of this segment.
The illustration in Figure 2 represents the designer's strategy of how to acquire domain-specific knowledge about the client and the users in order to apply these attributes to the design. Further within the project, the designer was searching for domain-specific knowledge of the attributes that might identify human experiences related to particular services and tasks. General strategic knowledge is represented through the process of guiding a search to generate domain-specific knowledge relevant to the task. This supports the view of design as adaptive expertise (Popovic 2000) as the designer generated the knowledge as she responded to the situation within a non-routine activity (Love 2002). Interpretation occurred at the end of the early stage of the design process where all attributes were incorporated into the search for the "best fit". This is demonstrated in the sketches presented in figure 3 where the designer used drawing to generate a solution. Here she interpreted the attributes of the product and services by applying the semantics of - "a helpful hand", "a guiding hand" or "building blocks". The knowledge is represented as general strategic knowledge, situational knowledge, and domain-specific knowledge. The designer's manipulation of images and their transformation (Figure 3) might be controlled by general strategic knowledge that
guides the search for satisfactory design that is supported by domain–specific knowledge (Alexander and Judy 1988; Oxman 2002).

Figure 3: Manipulation of images and their transformation

Segment in figure 4 illustrates sketches for the web pages for a petrol company. Each web page design is driven by the goal-limited strategies (GLS) in reference to the information they have to display, for example: "welcome" or "set up your order". Lines (textual information) or shapes (web "window") and the division of the web page into activity/interact zone and execution area illustrate evidence of domain-specific knowledge (DSK). The left side of each page has the company name and relevant information. Strategic knowledge representation was evident from the consistency in design of each individual web page.
In summary, all projects from information design had very strong strategic goals that were evident at the beginning of each project. The overall design strategy affected the choice for more specific strategies (Brazier, van Langen and Treur, 2002). General strategic knowledge (GSK) was represented through each segment and it was guiding the goal-limited strategies and utilisation or acquisition of knowledge. Interaction with domain knowledge and strategic knowledge is within the Goal-limited Strategies (GLS).

**Product design**
Product design visual information was analysed at the idea generation stage (beginning of the project) and related to a hand tool, a workstation, and medical device designs. Each project started with a client brief or written proposal that directed the designs. They had design constraints specified that directed the designers where to search for domain specific knowledge and what strategies to apply.
Figure 5 illustrates two segments from the hand tool design (fastening of concrete reinforcement). The first segment shows that the designer was looking for different possibilities of fastening techniques and that domain-specific knowledge was utilised to accomplish the task. For example: continuous or tight twist. This segment is coded as a goal-limited strategy (GLS) as it is related to the task accomplishment. The second segment illustrates visual thinking regarding the various kinds of handle design. The constraints were annotated and are interpreted as domain–specific knowledge utilised to accomplish the relevant task. For example: left and right handed, comfortable, good transition of forces. This is coded as a goal-limited strategy. Characteristics for this project’s conceptual stage was that it incorporated 93 segments of goal–limited strategies (GLS). The integration of different design tasks occurred at the end of the conceptual phase when general strategies were applied as goal directed procedures and represented as general strategic knowledge.
The decision steps were not ordered. They occurred on the basis of information available – information about fastening techniques.

The conceptual stage of the disabled children’s workstation had 232 segments coded as goal–limited strategies. Each GLS is associated with the utilisation of relevant domain–specific knowledge. From the documentation available it was evident that the designer at the beginning of the design process was searching for domain-specific knowledge about the station users and their needs. Figure 6 illustrates this search which was guided by strategic knowledge relevant for task accomplishment. For example: accommodation for children of different sizes or seat movement expressed by annotated sketches.

![Figure 6: Workstation design - goal-limited strategies and domain-specific knowledge](image)

Figure 6 illustrates an integration of processes that were relevant for different task accomplishments. The designer made the decision for the "table shape" that includes some goal-limited strategies and domain knowledge illustrated in Figure 6 eg. table shape.
In summary, all product design projects were guided by the constraints. Goal-limited strategies were a significant part of each project. The designers responded to the constraints that at the same time formed goal-limited strategies for domain knowledge acquisition or utilisation. Their goal directed procedures were evident at the end of the process. The goal-limited strategies and decision steps were not ordered. They were based on the problem structure and what information happened to be available.

Knowledge connections models
The design activity provides rich material to study design formulation and related activities. This work is based on process formulation that is part of the design activity and makes an attempt to model general strategic knowledge and its interaction with the relevant domain–specific knowledge within the design expertise. Models are used here to gain an insight into the design process. The models developed are centered on two paradigms – design and planning (decisions making) (Vinze et al. 1993). The model construction is seen as design activity based on the study of the process of designing in two different domains – product design and information design. The repetition of knowledge representation and strategies was evident in both domains.

These models are based on the comparison of two design domains. The models are constructed using the comparison of differences and similarities (Figures 8 and 9). There are structural variations within the models but the distinction of domain-specific knowledge was evident. The analysis demonstrated that design is a procedurally rich domain. Within the acceptance that domains differ, then the difference exists in the interaction of domain and strategy knowledge. It is
understood that with well-defined tasks domain-specific strategies play a more important role than general strategies (Alexander 1992).

Figure 8: Information design knowledge connection model

Figure 8 illustrates the information design knowledge connection model that is guided by goal directed procedures. The knowledge connections occurred between goal-limited strategies (GLS) and domain-specific knowledge (DSK). General strategic knowledge was monitoring the designers’ search for domain-specific knowledge (DSK) and its utilisation in design tasks.
Product design knowledge connections are illustrated in Figure 9. The strategies were determined by project constraints. They are expanding as more constraints are taken into consideration. Goal-limited strategies were determined by the project constraints. When all project constraints were explored they were integrated by utilising relevant strategies to control the integration of the accomplished tasks. Domain-specific knowledge interacts with both goal-limited strategies and general strategies.

Within this framework, it is expected to have both goal-limited strategies and general strategy knowledge (Goodchild et al as reported in Alexander and Judy 1988) that play an important part during the early stage of the design process. Goal–limited strategies include processes relevant for the task that are accomplished in different domains. General strategies can be applied more broadly and include the ability to relate to the current situation. The designer might be engaged here in strategic processing of a more general nature - general problem solving procedures. When working on a specific problem and details, the designer is utilising domain-specific knowledge that might interact with strategic knowledge.

The models are centred on the paradigm of design and decision making based on the analysis of the visual information. The decision steps were analysed and they are explained. It was found that the decision steps were not ordered. They were based on the problem structure and what information happened to be available. This is supported by the findings of Suva, Gero and Purcell (1999) who report that designers adjust to the design task by utilising their knowledge that they adapt to the current tasks and apply it to the design process.
Figure 10: Integrated knowledge connection model

Figure 10 illustrates the integrated knowledge connection model in which general strategies (GS) are expanding to guide the search for satisfactory design. They are goal directed procedures that guide the design projects. Their expansion depends on the accomplishments of goal-limited strategies and their interaction with domain-specific knowledge and experiential knowledge that are dependent on the domain (product or information design). The model is adaptable and dependent on the complexity of design project.

Conclusion

Within the framework of expertise, developed knowledge becomes more structured and better integrated with the past experience. It is noted that the level of expertise plays an important role in problem representation. However, the study of representation of knowledge from visual data is very rarely studied, with some exceptions (Goel 1995; Casakin and Goldschmith1999; Oxman, 2002). The visual language designers use can be seen as elements that contribute to distinguish their expertise, knowledge and skills. It is the language of design (Bucciarelli 2002) that illustrates the thoughts and knowledge or new thought generation and stimulates creative and analytical thinking. The integrated knowledge connection model (Figure 10) presented here is adaptable and supports the notion of design being an "adaptive expertise" by attempting to find answers to cross-disciplinary utilisation of strategic knowledge and clarification of the utilisation of domain–specific knowledge within the early stage of the design process. It might also support the hypothesis done by Alexander and Judy (1988) about the interaction of general strategies, goal-limited strategies and domain-specific knowledge. It is hoped that these models would contribute to the better
understanding of design as an adaptive expertise whose characteristics are cross-disciplinary
general strategies and goal-limited strategies that interact with domain-specific knowledge and
experiential knowledge.
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Acknowledgment
The author would like to acknowledge support from Montague Leong Pty Ltd, Sydney, commercial organisations and anonymous designers whose work was used for this research analysis.
SIRN (Synergetic Inter-Representation Networks): an approach to design

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Abstract

Our aim in this paper is to examine the relation between design and cognition in light of two aspects related to these disciplines: (a) Cognitive science’s negative attitude toward artifacts. (b) The fact that artifacts are the subject matter and end product of design. In our paper we firstly discuss cognitive science’s attitude toward artifacts and show that it contradicts the reflective-interaction approach that currently dominates the discipline of design. We then introduce SIRN (Synergetic inter-Representation Networks) as an approach that resolves this contradiction by treating artifacts and their design as innately related to cognition. We close the paper by discussing further research directions.
SIRN (Synergetic Inter-Representation Networks): an approach to design

The status of design in the cognitive science

The status of design in the cognitive science is somewhat ambivalent. To a large extent this is due to cognitive science’s attitude toward artifacts, which are the subject matter of the design process. Artifacts, as noted by Simon (1979), have a negative air around them – one doesn’t want artifacts in one’s data or empirical results. This is so in science in general and this is so in cognitive science. Its emergence was associated with an attempt to transform the “soft” study of mind, thought, imagination and language into a “hard” empirical and analytical cognitive science – *The Mind’s New Science* (Gardner, 1987). The negative attitude toward artifacts was (and still is) typical mainly of classical cognitivism according to which artifacts are simply ‘not cognitive’. They are the product of human actions, which are the outcome of cognition, and as such bodily artifacts, but not cognition itself. The following section by Chomsky on external and internal languages (E- vs. I-languages respectively) is indicative:

“E-languages are mere artifacts. . . the concept appears to play no role in the theory of language. . . The technical concept of E-language is a dubious one in at least two respects. In the first place, . . languages in this sense are not real-world objects but are artificial, somewhat arbitrary, and perhaps not very interesting constructs. In contrast . . statements about I-language . . are true or false statements about something real and definite, about actual states of the mind/brain and their components . . “(Chomsky 1986, 26-7, italics added).

From this view on cognition and artifacts follows two possible positions of design in relation to cognition. First, design, like thinking, is part of cognition while bodily action and artifacts are not. Here the process of design is essentially distinct and separated from its product – the artifact. Second, design is part of the production of artifacts and therefore it is not cognitive.

Cognitive science’s negative attitude toward artifacts is currently changing. A growing number of studies depart from this sort of hard cognitivism. Rumelhart et al (1986) and Cole (1996) neo-Vygotskian approaches, Edelman’s (1992) TNGS (Theory of Neural Group Selection), Johnson’s (1987) and Lakoff’s (1987) approach of experiential realism, Donald’s (1991) notion of the externalization of memory, and the recent pragmatist views of embodied cognition (Varela et al 1994) as well as the action-perception approaches (Thelen 1995, Thelen and Smith 1994, Kelso 1995, Freeman 1999) among others, all tend to see the cognitive system as including the body and its interaction with the environment and/or elements in it. These approaches suggest that in certain tasks and contexts cognition is confined to the brain; in others to the whole body and in some tasks and contexts the cognitive system includes the brain, the body and even stand-alone artifacts in the environment. The latter possibility refers to cases where artifacts function as an extension of the body – a view suggested by Gibson (1979) and reproduced here in Fig. 1.

From the above perspectives it follows that bodily artifacts are part of cognition while stand-alone artifacts are only in cases where they function as an extension to the body. In themselves, however, stand-alone artifacts and the process of their production are not cognitive. This view does not change the status of design in the cognitive science, at least not the design of stand-alone artifacts.
A concise history of design methods: the two major approaches

Over the last forty years, developments in cognitive science have been significant to different human related fields including design and urban design. Influenced by the classical cognitive sciences of the 1960s, the so-called ‘design methods’ approach proposed analytical/rational problem solving techniques. The main concept was that designers should be capable of predicting the effects and consequences of their designs, and describe the actions and steps that are necessary to achieve them. The design methodology movement paid little attention to the design solutions per se, and became much more concerned with the large network of predictions and specifications through the different phases of the design process (Jones, 1980; Lawson, 1980). With the aim of formalizing design processes, the design methods movement proposed prescriptive models of design, which were based on the idea that the different steps in the design process can be optimized and defined a priori. Thus, a strong emphasis was set on logical and objective analyses of the design process. A main example of this approach was the revolutionary paradigm presented by Simon in the early 1970s (Simon, 1973). In his view, design is seen as a rational search process, in which the design problem is defined by a problem space. This problem space is carefully explored while searching for a ‘satisfying’ design solution. However, Simon’s and other similar approaches did not take into account the individual properties and characteristics of the designer that they were supposed to support. According to Dorst and Dijkhuis (1995), the main emphasis of the ‘rational problem solving approach’ was set on the process components of the design activity, but the movement was unsuccessful to understand the knowledge structures of what designers perceive and think. As a consequence the design methods movement failed to support real design problems.

In recent years, the study of cognitive processes concerned with problem-solving activities began to capture the interest of design researchers. It was postulated that while solving problems under controlled conditions, individuals might be able to externalize representations of their internal mental processes. In contrast to the rational movement the major attempt of which was toward prescriptive design models, recent studies proposed descriptive design models that strongly emphasise the cognitive dimension of design (e.g., Cross, 2000). The main idea was to focus on the interplay between the designer’s internal and external representations in the early stages of the design process. An example is the pioneering work of Schon (1983) on design as reflection in action. Schon argued that the view of design as a rational problem solving process weakened the understanding of unique design problems. Basing his approach on a constructionist view of human
perception-and thought processes (Dorst, 1996) he perceived design as a reflective conversation between the designer and the external situation (named the environment). By identifying relevant aspects from the design problem, the designer chooses a problem situation, or frames the problem according to a particular situation, and develops a possible solution while evaluating and reflecting upon the design outcome (named the design artifact). These enable him/her to check his/her understanding of the problem situation, to create a new framing of the situation. And to verify his/her interpretation of it on the basis of prior experiences. Current cognitive research based on the analysis of design thinking and design behavior, saw in Schon’s approach a potential tool for enhancing our understanding on the design process.

Discussion

As noted above, from the point of view of cognitive science, stand-alone artifacts are essentially external to the cognitive system and process. In some circumstances they function as an extension of the body, but in themselves they are not cognitive. Such a view corresponds to Simon’s paradigm on design as a rational problem solving process, the end product of which is an artifact. Schon’s reflexive conversation view is somewhat different. The designer “talks” to the environment and the latter “talks back” to the designer. Here the designer (person) and the designed (artifact) form two parts of a single design system.

Schon’s main concern is the process of design and he therefore makes no claims about the cognitive process. Our concern is to look at the process of design from the point of view of cognitive mapping and the cognition of large-scale artifacts such as cities. From this perspective we suggest, first, that the ‘reflective conversation’ view on design contradicts cognitive science’s view on artifacts. Second that it indicates the possibility to understand the cognitive system as including in addition to perception and action also productions (Fig. 2). Third, that the action-perception-production view of cognition implies that design is an innate human capability active in the production of small as well as large artifacts such as cities. These three suggestions are derivations from the notion of SIRN that is introduced next.

![Figure 2: Action/Perception/Production view on cognition](image)

SIRN’s four propositions and design

SIRN is an approach to cognition suggesting that artifacts and the process of their design and production are part of cognition (Portugali, 1996; Haken and Portugali, 1996). In this section we introduce SIRN and show its implications to design. We do so by examining the SIRN’s four basic propositions.

1. **Humans have an innate capability for representation that comes in two forms: external and internal.** Internal representations are the outcome of brain processes the end product of which is various forms of information (visual, olfactory, haptic, lingual, etc.,) that are enfolded (i.e.}

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represented) in the matter of the brain. External representations refer to behavior or action that represent internal representations. External representations can be further divided into *bodily* and *stand-alone* representations. Bodily representations (mimetic, lexical, etc.) are made by the body and never extend beyond it. Stand-alone representations are made by the body, but extend beyond it to become stand-alone artifacts. Stand-alone artifacts are the products of design processes. From this follows three interrelated corollaries: (1) Design is an innate human capability. (2) Humans perceive, learn, think and execute many cognitive operations by designing and producing artifacts. (3) Humans design not only in order to achieve goals or intentions, but first and foremost because they are “born to design” – their innate capability to design and produce artifacts allows them to achieve many of their aims, intentions and goals by means of the design and production of artifacts.

2. Many cognitive processes, those associated with the production of artifacts included, evolve as an interaction between internal and external representations. This is typical of complex cognitive process that are subject to “The magic number seven plus or minus two” that according to Miller (1956) “… limits our capacity for processing information” in short term memory. In his paper Miller discusses several tactics by which the mind/brain may overcome this constraint. Haken and Portugali (forthcoming) suggest that another trick the mind/brain/body uses to overcome this constraint is by means of external representations and the production of stand-alone artifacts. The production of artifacts and by implication their design are thus integral parts of the cognitive process of humans. This is typical of sequential cognitive processes that evolve by means of an interaction between emergent internal and external representations. Thus, one starts to develop a thought, or an idea by first constructing it in mind in the form of an internal representation. Then one develops it a few steps further in short-term memory. When the threshold of Miller’s “magic number 7” is reached, one externalizes one’s internal representation in the form of a talk, a written sentence, or a sketch, observes how it looks, etc., then internalizes it again as a starting point for further development in mind and so on in an interplay between internal and external representations.

3. The boundaries of the cognitive system should be perceived as distinct from the boundaries of the brain (the skull) and the body (skin). This is the logical conclusion of propositions 1 –2. In design tasks, the boundaries of the cognitive system correspond to the boundaries of the design system. The latter includes the designer’s mind and body, the design action and the produced artifact. That is, the cognition-design system is composed of action-perception-production.

4. The cognitive system is a self-organizing system the dynamics of which is captured by the synergetic approach to self-organization. Self-organization is a fundamental property of open and complex systems that attain their order spontaneously and are typified by phenomena of non-causality, non-linearity, instability and chaos. Such systems are open, in the sense that they exchange matter, energy and information with their environment, and complex in the sense that their large number of parts are interconnected in a nonlinear fashion by a complex network of feedback loops (Portugali 1997, 1999).

*Synergetics* is Haken’s (1983, 1987) theory of self-organization. The theory focuses on processes by which the local interactions between the many parts of a system give rise to qualitative changes at the system’s macroscopic state. According to synergetics such a qualitative macroscopic change happens when a given internal or external control parameter acting on the system triggers a chaotic movement and interaction between its many parts. This chaotic movement enfolds several systemic order states that co-exist and in this respect “compete” among themselves. When the control parameter crosses a certain threshold, the hitherto chaotic form of movement and interaction suddenly and spontaneously give rise to a coherent movement and interaction where all the parts behave in concert. This coherent movement is termed order parameter, and the process by which
the many parts abruptly “obey” the order parameter and in this way support and reproduce it – the *slaving principle*.

Synergetics was applied to the domain of cognition and brain functioning (Haken 1979, 1990, 1991, 1996, Kelso 1995). The basic proposition here is that the brain and its various cognitive systems are self-organizing systems. The paradigmatic case-study here is pattern recognition by means of associative memory: the cognitive system is given a few features of a certain pattern (i.e. face) referring to one out of a repertoire of patterns stored in memory. This triggers a process of self-organization in which several order-states emerge and enter into a competition. This competition is resolved when a certain order parameter "wins", enslaving the various features by means of associative memory, and a recognition is established.

A similar process typifies the construction of cognitive maps (Portugali 1990; Portugali and Haken 1992; Portugali, 1996), behavior and action (Kelso 1995). With respect to the latter two, synergetics suggests seeing the brain, mind, bodily behavior and action as open, complex, task-specific and context-dependent systems that achieve their coherence spontaneously, by means of a complex co-operation and interaction between their many parts. The interacting elements of that system are, therefore, both internal and external.

The SIRN basic model and its three prototypes as models of design

Haken and Portugali (1996) have cast the notion of SIRN into the formalism of *synergetics*. They have done so by developing the SIRN basic model. The model was inspired by Bartlett’s (1932/1961) *scenarios of serial reproduction* devised by him in his book *Remembering*. A typical Bartlett scenario evolves like this (Fig. 3): a test person is given a text or shown a figure and is asked to memorize it. He or she is then asked to externally reproduce the text or figure out of memory, by rewriting the text or re-drawing the figure. This externally represented text or figure is given to another test person and so on. The usual result of such scenarios is that after several strong fluctuations in the reproduction, the text or the figure stabilize and do not change much from iteration to iteration. Bartlett reports that the same happens when the experiments are carried out with a single person. This experiment includes all the ingredients of synergetics and inter-representation and can thus be regarded as a paradigm case study for the operation of SIRN (Portugali, 1996; Haken and Portugali, 1996): A play between internal and external representations that emerge spontaneously out of the dynamics as ad-hoc entities, strong fluctuations at the start and an ordered state that eventually “enslaves” the interaction.
Figure 3: A typical Bartlett scenario

The basic SIRN model is described in Fig. 4. In the context of the present paper this model refers to a designer that is subject to two kinds of input information: internal information that is coming from the designer’s mind/brain, in the form of ideas, images, thoughts, and the like, and external
information that is coming from the environment via the senses, the designer’s body and/or the
information afforded from stand-alone artifacts. The interaction between these two flows gives rise
to an order parameter that governs both the designer’s action, and the information that feeds back
from the artifact produced to the designer’s mind. The order parameters are determined in line with
the theory of synergetics as described above.

Figure 4: Basic SIRN model

The basic SIRN model is applied to specific case studies by means of its three prototype sub-
models of design: (1) Intra-personal, that describes a solitary designer working by him/her self. (2)
Inter-personal that refers to a sequential process involving several solitary designers not necessarily
aware of each other. (3) Inter-personal with a common reservoir that describes a group dynamics
by which several designers are working simultaneously and publicly on a large-scale artifact.

The Intrapersonal submodel
The intrapersonal submodel is described in Figure 5. It refers to the Bartlett’s serial reproduction
experimented with a single person or to a solitary designer engaged in some creative work. A nice
illustration for this process is Brancusi’s Kiss that evolved as a typical process of interaction
between internal and external representations (Figure 6). As can be seen, similarly to the Bartlett
scenario, here too the figure is gradually transformed from a realistic to a highly schematized
geometrical shape. This by means of an interaction between internal representations in the form of
images, ideas, etc., that emerge at the artist’s mind, and external representations that represent the
artist’s ideas and images as they take a specific shape in the material with which the artist is
working. What is specifically interesting in Brancusi’s Kiss is that its final reproduction (The Gate
of Kiss) was imbedded in the cityscape of Bucharest, thus illustrating how a very personal SIRN
process ‘goes public’.
Figure 5: Intra-personal sub-model by means of SIRN

Figure 6: The evolution of Brancusi’s Kiss
This process is typical also of the role of sketches in design. Free-hand sketches are frequently produced by architects and designers at the early stages of the design process. A sketch is characterized by having an ambiguous and amorphous nature that serves the purposes of clarifying existing design ideas stored as internal representations in the mind, and generating new ones through external representations (e.g., Casakin, 1998; Do, et al, 1999; Evans, 1989; Fish and Scrivener, 1990; Goldschmidt, 1992). Researchers such as Suwa and Tversky (1997) explored the sketch as a means for gaining a better understanding of how subjects perceive and cognize content and process components while solving a design problem. Goldschmidt (1994) proposed that the design process often starts with vague ideas that are gradually elaborated and structured. In this process of elaboration sketches can aid in generating and strengthening them. Moreover, different features of a yet non-created artifact can be produced, transformed, and externalized through sketches for communication and evaluation. Thus, a critical aspect of sketching is the possibility of generating sequential and abstract design representations before they are clear in the mind. This enables the identification of relevant from irrelevant information, and on the other hand, the reinterpretation of previously unforeseen or unpredicted information. As the sketching activity evolves, an interactive dialogue or reflective conversation is established between the designer internal representations retrieved from memory, and his or her produced external representations that ‘talk back’ to him (Schon, 1983; Goel, 1995) until a suitable design solution is reached. Goldschmidt, (1999) referred to this phenomena as the backtalk of self-generated sketches, which points to the designer capability to read meaning, and discover new interpretations from his or her own external representations. Verstijnen (1997), and Verstijnen et al (1999) claimed that when designers have difficulties of interpretation in mind, the use of the sketch plays an important role as a tool for aiding idea reinterpretation and problem restructuring. An example of a practical use of the sketch is illustrated through the work of the architect Jorn Utzon (Figure 7). His sketches are not intended as the production of just beautiful drawings, but made with the aim of understanding a design problem, and proposing a design solution (Lawson, 1994). With the purpose of constructing the roof of the Opera House in Sydney, a rich sequence of sketches are developed to learn about engineering structural aspects. During this process, a sketch establishes a dialogue with another, as ideas develop and gradually evolve from evocative conceptual sketches related to rather organic forms, to more detailed and refined representations.
The difference between the examples of Brancusi and Utzon sketches is that in the case of sketches the play between internal and external representations continues until the end product – the artifact – is completed; after this stage the design process ends. In Brancusi’s case “the play never ends” – the artifact has a status of a sketch.
The Interpersonal process

This is the classical Bartlett scenario, as illustrated above in Figure 3. A typical experiment starts, as noted, with a given external input and proceeds with a sequence by which each person's externalized reproduction of the remembered input becomes an input to the next person to remember and externalize, and so on. As above, after several initial steps that exhibit major changes from one reproduction to the other, the story or the drawn figure stabilizes and does not change significantly from iteration to iteration. In terms of synergetics we assert that a certain order parameter has enslaved the system and brought it to a steady state. This interpersonal process implies that several persons, with their individual-subjective cognitive systems, participate in producing an externalized collective cognitive product, without being aware of their collective enterprise. As this sequential process evolves, and its collective product constructed, each individual's externally represented reproduction gradually becomes "more" collective and so does each individual's internally represented remembering. The individuals engaged in the process are thus being ‘enslaved’ by the collective order parameter that emerges in the process. Figure 8 graphically describes this interpersonal scenario by means of our SIRN model.

Figure 8: Interpersonal sub-model by means of SIRN

An example in the domain of architecture can be the design of complex artifacts such as public buildings by a design team composed of structural engineers; environmental engineers; interior designers; etc. As the design process develops, the problem is decomposed into sub-problems in order to answer initial programmatic requirements (Cross, 2000). In doing so, designers establish an interactive dialogue between their own internal and external representations related to their domain of expertise, and a sequential interplay between external representations of the other designers. A synergetic, self-organized system among the various designers thus emerges and develops until a design solution is found.

An additional example is Rossi’s (1986) concept of urban ‘typologies’ as ‘perpetuating permanencies’ capable of adaptation to modifications performed by different designers through history. According to Rossi, socially relevant buildings were able to last because they managed to keep their external formal attributes while adapting their internal functions to new programmatic requirements, new conditions, and uses. While the design of the building evolves or changes, a sequential–temporal inter-play of external and internal representations is established between different architects that are not necessarily aware of each other.
**Interpersonal with a common reservoir**

In the intra- and inter-personal sub-models the process depends fully on the biological memories of individuals. Here the process depends partly on biological memories, but partly also on externalized non-biological memory termed a *common reservoir*. This common reservoir of external, artificial and non-biological memory, might take the form of texts, Internet, buildings or whole cities. To illustrate and study such processes a set of experiments – *city games* – was devised (Portugali, 1996b). Their essence is a process of sequential reproduction that is interpersonal, collective, and *public* – the participants observe the game as it develops. Each player is given a 1:100 mockup of a building, and in his/her turn is asked to locate it in the virtual city on the floor. In a typical game (Figure 9), the players observe the city as it develops, and in the process also learn the spontaneously emerging order on the ground. After several initial iterations a certain urban order emerges. The participants internalize this emerging order and tend to locate their buildings in line with it. Such an experiment includes all the ingredients of the SIRN process: a sequential interplay between internal and external representations, the emergence of a collective complex city as an artifact, and a typical synergetic process of self-organization as demonstrated below. It is typical in such games that after a few initial iterations an observable urban order emerges, the participants internalize this emerging order and tend to locate their buildings in line with it.

![Figure 9: Four snapshots from a typical City Game](image)

Figure 10 illustrates graphically this public-collective SIRN sub-model. Each individual player/agent is subject to internal input constructed by the mind/brain, and external input which is
the legible information coming from the common reservoir. In the above city game it is the virtual city on the ground. The interaction between these two forms of input gives rise to a competition between alternative decision rules that ends up when one or a few decision rules “wins”. The winning rule(s) is/are the order parameter(s) that enslave(s) the system. The emerging order parameter governs an external output, which in the city game is the player’s location action in the city, and an internal output, which is an information feedback loop back to the mind/brain.
Figure 10: Interpersonal with a common reservoir sub-model by means of SIRN

**Design and self-organization**

From the above follows a view of design as essentially a self-organizing system. On the face of it the two notions ‘design’ and ‘self-organization’ contradict each other: Design is commonly regarded as an intentional, and as such externally organized process, in contrast with spontaneous self-organized process. But there is no contradiction here. To see why let us look once again at the various examples introduced above. Consider first the paradigmatic case study of Bartlett scenario of serial reproduction (Fig. 3). This scenario includes all the ingredient of a self-organizing, cognitive, SIRN system: emergent internal and external representations, strong fluctuations at the start of the process, an emerging order parameter in the form of a schemata of an abstract shape of a face that eventually enslaves the many parts of the system and brings it to a steady state. A similar process takes place in the cases of Brancusi’s Kiss (Fig. 6), and Utzon’s sketches (Fig. 7). The
latter two case studies should be taken in conjunction with Miller’s magic number 7 discussed in Proposition 3. As a consequence of the number 7 constraint on short-term memory, a design idea or intention are usually not yet the final product but its trigger. The end product, that is to say the artifact, emerges as noted above out of the SIRN play described above. Many design processes, in particular those associated with complex artifacts, thus involve a sequential, self-organizing processes.

The case study of the city game (Figs. 9, 10) refers to a much more complex process of self organization. As elaborated recently in *Self-Organization and the City* (Portugali, 1999) the city is a dual self-organizing system: On the one hand, the city as a whole is a self-organizing system whose elementary parts are the many agents operating in it. On the other, each of the agents operating in the city is itself an open, complex and as such self-organizing system. The agents act and interact, with and in the city, among other things according to their cognitive maps of it. This interaction give rise to the city dynamics and structure, that once emerges feeds back to the agents’ cognitive map and so on in a process of circular causality and reproduction. The city in this respect is similar to language. As in language each of the parts is a self-organizing system and the local interaction between the parts gives rise to a highly (self) organized global structure. Unlike language, however, the city is full of planning, design and attempts to control the city. In fact, each agent operating in the city is a planner/designer at a certain scale (Portugali, 1999, Chap. 11). And yet, due to the size and complexity of the city, none of the many planners/designers operating in it can fully control its final form, structure and evolution.

It should be emphasized that many of the planning and design actions taken in a city – the design and construction of buildings, bridges, roads and the like – require full control and external organization. But as just noted, in the last analysis none of these designs can fully determine the overall structure of the city – not even large-scale urban design projects. From this follows two forms of design: *engineerable design* that is necessary in the design of some of the urban artifacts, versus *self-organized design* that typifies the design of neighborhoods, whole cities and metropolitan areas.

**Concluding notes**

Our aims in this paper have been, first, to expose the ambivalent relations between design and cognition. Second, to introduce SIRN as an approach to cognition suggesting a perception-action-production view of cognition. Third, to make a start at introducing SIRN as an approach to design. The next step, with which we are currently engaged, is to put these ideas into empirical tests. So far we have done so by means of the *city games* discussed above and by means of computerized urban simulation models. Preliminary results indicate, first, that designers never come to the city tabula rasa. Rather, each comes to, and starts to design in, the city with a *conceptual cognitive map* (cCM) that refers to his/her previous experience in cities. The most prominent cCMs were found to be *mono-centric* and *multi-centric*. Second, the first interaction between the designers and the city gives rise to *specific cognitive maps* (sCM) that are dynamic and change as the structure of the city evolves. It is according to sCMs that the design process proceeds. We have also started to experiment with the two qualitatively distinct design processes noted above – *engineerable* versus *self-organizing design*. However, these and several other experiments and results will have to await further publication.
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Is there a specific type of knowledge associated with design?

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Abstract

This paper is concerned with the question of whether or not there are forms of knowledge that can be regarded as unique to design. On the basis of protocol studies of architects designing we identify three types of knowledge that may be considered as candidates for design knowledge. These we refer to as interpreted and embodied knowledge, compiled knowledge and strategic knowledge relating to the use of design representations. Each of the potential types of knowledge addresses a core problem in design how to move from knowledge that is abstract and conceptual to a representation of that knowledge in physical form.
Is there a specific type of knowledge associated with design?

Introduction

“There is no evidence that the results of such experiments are of interest to designers or educators and attempts at applying methodologies derived from such analysis have failed over three decades.”

This is taken from a referees report on a recent grant application concerned with innovation and high level expertise in design. Needless to say the grant application was not successful. However this comment presents a challenge to design researchers. Is design research simply concerned with understanding the design process? As a basic research area it has considerable legitimacy. Design is a paradigmatic example of ill-defined problem solving and ill-defined problem solving represents a central and under-researched aspect of human cognitive capacities. Design can also be associated with innovation and creativity, again fundamental human capacities. However we, along with many if not all design researchers, want our field to be both a strong area of basic research and to have it contribute to the education of designers and the practice of design. The challenge is – how can design research contribute in these areas? This paper is an attempt to begin to chart the relationship between design research and design education. In particular we want to address the question of the nature of design knowledge. This particular issue was brought into focus through our development of a new undergraduate program that was based on the results of design research and recent research in the area of teaching and learning.

Design and ill-defined problems

Before addressing this question directly we would like to focus initially on the general nature of ill-defined problems and on a specific facet of design as ill-defined problem solving. In our view it is the ill-defined nature of design problems which is at the core of both the importance of design research as basic research and equally is at the core of design education. The nature of ill-defined problems has been discussed extensively (Simon, 1973; Reitman, 1964; Goel, 1995), however the basic characteristics of such problems are that the statement of the problem is incomplete and there is no single correct or even optimal solution. These basic characteristics have a number of consequences, for example the problem solver must discover what is relevant to the problem before or while developing the solution. In the context of design these are important issues but another equally important characteristic is introduced. The statement of a design problem is both incomplete and its content is not directly related to the specific physical characteristics of the artefact (or the representation of the artefact) that must be the end result of the process. If the designer is asked to design a house for a specific family on a particular site, the statement of the problem has no direct relationship to nor does it directly constrain the physical attributes of the house that might be designed.

Not only does the statement of the problem not specify any physical attributes but the information related to the issues that might be identified as relevant is generally at a more abstract or conceptual level and it too does not directly relate to specific physical attributes of the design. For example such a problem would involve issues to do with materials, structural systems, construction methods, the experiential attributes to be associated with the home and many others. The knowledge that is available in each of these areas simply provides possibilities that would have to be made concrete or realised by the designer in the particular attributes of the building. Moving between the abstract and conceptual and the physical differentiates design of physical artefacts from other forms of ill-defined problem solving and, creates great difficulties for design students and it is the ways of dealing with this problem we will argue that generates the types of knowledge that are specific to design.
Design knowledge
Designed artefacts and the designers who produce them can be situated within a number of contexts. A designed artefact, because it exists in the world, has a set of relationships with various aspects of that world. For the purposes of this discussion we will refer to these aspects of the world as environments and these are illustrated on the right of the diagram below. Once it is manufactured or built, a designed artefact exists within a physical, biological, human and many other types of environment. These environments are typically associated with bodies of knowledge that are the result of research activities designed to understand what they are made up of, how they work and so on. A designed artefact can be examined from the point of view of how it fits into these various environments using this knowledge that is it can be evaluated. This is recognised within the diagram by the arrows in the diagram linking the object with the various environments. While this type of analysis and evaluation can be carried out independently of the designer (or a design student) the knowledge that is involved could be used by the designer.

This is also identified in the diagram by a link to the designer and student. This relationship could take a number of forms. For example the knowledge could inform the design process or the knowledge could be used to evaluate the design as it evolves. However the knowledge that exists in these areas is typically abstract and conceptual seeking to represent the underlying laws and principles in the area. Because the designer is concerned with a specific situation for which a physical object must be developed, there is a gap between the knowledge that is relevant to the design and how that knowledge can be introduced into physical form as discussed above. It is possible to reason from first principles as indicated in the diagram. However there will always come a point where the designer has to move to a specific physical form. Once this has been done it is then possible to assess and evaluate what is proposed but the question is do designers actually design in this way and is this an answer to the question what is design knowledge. If they do act in this way it would appear that there is not a specific knowledge that is associated with design. Rather the knowledge that informs design is the use of existing knowledge from other domains unless that is there is a form of knowledge associated with the step from the abstract to the physical and this is one issue we will pursue in the following discussion.

Figure 1: Contexts for designers and designed artefacts
However the diagram also identifies another context within which a designer / student and a designed artefact are situated. These are, in the case of architecture, architectural history and theory, precedents and design representations. A particular designed artefact is a part of and therefore related to all other designed (and possibly not designed) examples of the type and designed artefacts generally. Some existing designs can be considered to be exemplary or at least worthy of study that is they come to be considered as precedents. Often the content or knowledge associated with architectural history is concerned with such precedents, the designers who produced them and the cultural context they existed within. Designers are clearly concerned with precedents and design students are often told to look for precedents. The question is - what is the relevance of precedents and does this relevance constitute a type of design knowledge? This issue will be examined in the following discussion. Finally it is clear that designers use many different forms of representations - simple block diagrams, unstructured plans and sections, three dimensional representations, physical models, detailed and explicit plans and sections and so on. In one sense these are skills and can be taught as skills. While there is knowledge involved in these skills, it would not seem to be a knowledge particularly associated with design. However it is possible that the strategic deployment of these skills could involve a form of design knowledge and this issue will also be examined in the following discussion.

**Interpreted or embodied knowledge**

One of these types of design knowledge is what we refer to as interpreted or embodied knowledge. In order to illustrate what we mean we will use the contents of a protocol of a design session of an expert architect engaging in the design of a museum. This protocol has been used in an intensive examination of the cognitive processes involved in sketching during design (see, for example, Suwa, Gero and Purcell, 1998; 2000). The designer was video taped while designing but he was not asked to think aloud during the process. Because the focus was on sketching, it was considered that thinking aloud could interfere with the process. At the end of the design session, the designer was shown the video –tape and asked to say in as much detail as possible what he was thinking about while he was making each mark on the paper. From this material a detailed coding scheme was developed. Four broad categories of cognitive actions were identified: the physical, the perceptual, the functional and the conceptual. The following description of these categories is taken from Suwa, Gero and Purcell (1998).

The first category, **physical**, refers to actions that are directly relevant to physical depictions on paper. It consists of three actions. One is to make depictions on paper, such as diagrams, symbols, annotations, memos, and sentences. We call it 'D-action'. The second is the motion of a pencil or hands that do not end up with depictions. We call it 'M-action'. The third is to pay attention to the existence of previously-drawn depictions. We call it 'L-action'.

The second category, **perceptual**, refers to actions of perceiving visuo-spatial features of depictions, such as shapes or sizes of depicted elements and spatial relations among elements. We call it 'P-action'. For example, if a designer draws a new depiction near an existing one by attending to the spatial relation between both, the new depiction is coded as a D-action, his attention to the existing depiction as a L-action, and his attention to the spatial relation as a P-action. This P-action is viewed as having occurred dependent on the D-action and the L-action. This way, P-actions have inherent dependency on physical actions.

The third category, **functional**, refers to actions of thinking of non-visual functional issues or abstract concepts with which designers associate physical depictions or their perceptual features. We call it 'F-action'. For example, if a designer attends to a spatial relation between two regions and associates it with a view from and to both places, his thought on "view" is coded as a F-action. This...
way, functions or abstract concepts are not actually given in the appearance of elements and relations, but suggested by it. Therefore, F-actions have inherent dependency on physical actions and/or P-actions.

The fourth category, **conceptual**, refers to actions that deal with non-visual information which is not inherently suggested by the appearance of elements and relations. There are three types. The first is to evaluate the aesthetic value of design decisions made by P- or F-actions. We call it 'E-action'. The second is to set up goals. We call it ‘G-action’. A goal is sometimes set up by being triggered by P- or F-actions, or sometimes as the subgoal of an existing goal. Once a goal is set up, it in turn gives birth to other actions, i.e. G, F, P or physical, in a top-down way. The third is to retrieve knowledge for making inference. We call it 'K-action'.

This coding scheme allowed all of the verbal material produced by the designer in identifying what they were thinking about while they were drawing to be coded. These four categories (and their sub-categories not presented here) can therefore be regarded as identifying four types of design knowledge. The first point to be made is that reasoning from first principles does not appear in this coding scheme just as it does not appear in any of the other design protocols we have collected. The knowledge used in design therefore is not directly based in the various disciplines that can be shown to be related to designed artefacts. This conclusion needs to be treated with some caution as there may be variation between different design disciplines with some, such as engineering, using basic knowledge from the discipline more directly in the process (see Lawson, 2001). The categories of the coding scheme can however be examined to see if they can give indications of what knowledge is involved in design.

The first, the physical, can be seen as reflecting knowledge about what physical representations are meaningful and useful and this issue of the use of design representations will be discussed in a separate section of the paper. It is also apparent that these representations are ways in which physical forms can be developed that relate to the specific design situation. That is it is a way of dealing with moving between the under-specified, conceptual statement of the problem to a representation of a physical form that can be developed.

The second category, the perceptual, can also be interpreted as a form of knowledge. The designer uses the physical representations to identify and operate on visuo-spatial features of the drawings. The knowledge involved here is how to how “look at” such drawings in this way. Teaching someone how to make the various types of visual representations that are used will not necessarily teach them how to “look at” the drawings in a way that allows the progressive development of the specific physical attributes of the final artefact. What they need to be taught is how to notice and use visual features of elements in the sketch such as size, shape and texture; spatial relations amongst elements such as proximity, remoteness, alignment, intersection, connectedness; organisational relations amongst elements such as grouping, uniformity/similarity, contrast/difference and implicit or emergent spaces that exist between elements. Because these perceptual categories are linked to the physical this discussion is also relevant to the later discussion of design representations.

The other two categories – functional and conceptual actions – we would argue represent what we have termed interpreted and embodied knowledge. This type of knowledge has two characteristics. First it has a conceptual component but this is associated with knowledge of the way that concept can be embodied or what it implies in terms of physical form. In the above example the idea of a view is relatively abstract but it is associated with particular physical characteristics that are represented in the drawing and the designer recognises. Presumably this is possible because the
knowledge that the designer has is the association between views and certain physical attributes that create views. In addition the designer must also have as part of this bundle of knowledge, other knowledge relating to why views are important. This is essentially derived from the basic knowledge found in for example environmental psychology about the psychological functions of views. The designer may not be aware of this basic knowledge but may only have the bundle of knowledge that represents its interpretation and embodiment. Similar analyses can be made of the categories of conceptual actions in the coding scheme.

The second characteristic of this type of knowledge is that it is often based on the individuals design experience or on the analysis of precedents. To illustrate this we will use an example from a protocol of an architect who had been engaged in a design activity during which he had not been allowed to draw. Following this session there was a structured interview with the architect part of which involved the him comparing and contrasting his experience during the design session with his usual way of designing. The architect had found designing under these conditions particularly difficult and was unhappy with the result because sketching for him was an essential part of his way of designing. Part of the interview revolved around whether or not he used visual imagery while designing. He was adamant that he did not and that he used what he referred to as memories. To illustrate what he meant he described how he had made a detailed study of Louis Barragan and somewhat unusually particularly of Barragan’s plans. This study resulted in him having a very detailed understanding of how characteristics of Barragan’s plans and the physical characteristics of the resulting buildings produced experiential outcomes that he valued. When he was designing he did not have a visual image of barragan’s plans or particular buildings but the memory that represented this particular type of knowledge he had gained based on his study. Sketching was vital because the memory informed the sketch that was related to specific characteristics of the design problem he was working on. These memories are clearly interpreted knowledge based on precedents and study by the designer. The precedent does not directly enter into the design process but only on the basis of the memories constructed by the designer.

Clearly these are only illustrative examples. However they at least identify what could be a type of knowledge that can be classified as design knowledge and so could form the basis for research to establish whether this type of knowledge has some generality and to characterise it more completely.

Compiled knowledge
While much of the existing design research has focused on the early, conceptual stage of the process, a considerable proportion of a complete design process involves design development and detailing. During this part of the process designers use another type of knowledge, what we are referring to as “compiled” knowledge. This type of knowledge is found in handbooks, workbooks, data sheets and trade catalogues. In one respect this knowledge similar to the interpreted knowledge discussed in the previous section. This is because it is derived from the basic knowledge areas and is embodied in representations of physical forms. However the basis of the compiled knowledge is not the individual designer’s learning and experience. Rather the author takes basic knowledge and develops its application in a specific setting. For example the diagram below presents information about the amounts of space that have to be allocated to accommodate tables seating different numbers of people, arranged in different spatial orientations with allowances for circulation in restaurants and cafes (taken from De Chiara, Panero and Zelnik, 1991).
What lies behind this diagram however is a considerable amount of knowledge in the area of ergonomics and human factors. For example the size of the table is related to how each of the objects is used in the set of activities associated with eating. A typical basic table setting in a restaurant would involve a knife, fork, spoon, main plate and side plate and glass. The ergonomic issues associated with using the knife, fork and spoon and their use (picking up and holding) are shown in this diagram.
Figure 3: Ergonomic issues involved in picking up and holding a knife, fork, spoon or glass

Each of these has to be located on a surface in order to carry out the activity and consequently each would occupy an amount of space. Given that the eating implements are typically arranged in a specific way spatially another set of ergonomic issues become involved. For example the knife and fork go together. In order that the user can pick them up without disturbing the other, they have to be spatially separated. This spatial separation can be based for example on the width of the thumb. If the other elements in a typical table setting, a plate and a side plate, are introduced, further spatial requirements can be identified on the basis of ergonomic data. For example the spoon and the fork have to be sufficiently separated from the plate (again the width of the thumb could be used) so that they can be picked up without striking the plate or side plate. If the dimensions of the plate and side plate are now included, the combination of the spatial requirements of all the elements essentially defines the spatial envelope for a single person eating space. This basic space could then be aggregated to give the basic table dimensions for 2, 4 or six person tables.

This represents the basic spatial requirements for table area. However other sets of ergonomic issues are involved. The diner must sit at the table and so the chair and the diner positioned at the table will occupy space and this dimension has to be added to the spatial requirements of the table. Similarly the diner must move into and out from the table in order to be able to sit at the table. The distance that the chair has to be from the table to allow access (hip to knee dimension, thigh width) must then be included in the spatial envelope associated with the table. Finally circulation space giving access to the tables has to be included. This depends on shoulder / hip width and the number of people who will be moving through the space.

The diagram of the basic café plan shown above could be developed from this type of analysis in conjunction with a source of relevant ergonomic data such as that found in, for example, Diffrient, Tielely and Harman (1981). However while this diagram is based on this information, it is not immediately apparent that this is the case. For example the main dimensions given relate to the combination of the table and chairs located in the seated position. Why the table is that size and the fact that the space taken up by the chair when it is moved out from the table is taken as part of the circulation space except in the main aile is not indicated in the diagram. In other words diagrams such as these that compile existing basic knowledge embody a number of assumptions and decisions and this represents the danger that is associated with their use both by practitioners and students. If they are just accepted and no attempt is made to understand their basis, their use can
lead to faulty design where the specific design situation they are used in does not fit with some of these assumptions and decisions. Designers need to be able to use this type of design knowledge critically and design students need to be taught not only about their existence but how to evaluate them critically by identifying the assumptions and decisions involved. However compiled knowledge of this type clearly represents a form of design knowledge.

**Strategic representations**
Designers use a number of different ways of representing their designs such as diagrams, plans sections, elevations, models, CAD representations. Often in the educational context the emphasis seems to be on teaching how to do each of these types of representation that is as a skill. However one continuing theme in the design research area is the role that drawing and sketching in the design process (Goldschmidt, 1991, 1994; Suwa, Gero and Purcell, 1998, 2000). This research has demonstrated that the use of these types of representation plays a central role in both developing an understanding of the problem that is brought about by the ill-defined nature of design problems. This research also demonstrates that this understanding of the problem co-evolves with the development of solutions to the problem. Further these representations play a central role in unexpected discoveries relating to physical form and the identification of new goals that had not been previously recognised. Design representations therefore play a fundamental role in the design process far more than simply ways of documenting a design. Knowing how to use design representations in this way therefore constitutes another type of design knowledge. While the role of sketch drawings has received considerable attention and resulted in important insights, there is another aspect of the use of these representations that has received much less attention. We would argue that the design protocols on which these insights are based also reveal another important aspect of design knowledge. Designers switch between different forms of representation at different stages of the process and that this switching is strategic.
Figure 4: Part of a set of drawings produced by an architect during a design session
This process can be seen to be operating in the series of sketches taken from a protocol of a design session with an experienced architect engaged in developing a sketch design for a museum discussed above (see, for example, Suwa, Gero and Purcell, 1998, 2000). The order of the sketches is as they occurred during the design session. It is quite clear that the designer is switching between different forms of representation. The first drawing is a very simple plan representing key features of the site. The second drawing is quite different, diagram that represents the different proportions of the areas that are to be associated with building and with external spaces. This is given in the brief but this drawing is a visual representation of the areas given numerically. The designer then switches again to a more detailed but still unstructured and ambiguous (in Goel’s 1995) plan. The designer continues with this form of representation in fact developing two separate versions of the design. In moving from one sketch to the next the designer often transferred some aspects of an earlier sketch to a later sketch by tracing over the earlier sketch. All of the sketches contain annotations which become more detailed as the design develops. Clearly this series of switches is not random but motivated and we would argue that what motivates the changes is a form of knowledge. The interesting question is what is the nature of this knowledge, how can it be elucidated and then how can it be taught.

An examination of a number of other protocols from other design sessions with architects reveals both similarities and differences. The similarities lie in the strategic use of different forms of design representations. The differences lie in the types of design representations that are used. Some designers will move to a physical or CAD model as the design develops. Others use sections and plans and shift the scale at which these representations are drawn. What this indicates is both that the strategic use of design representations is a key part of the design process and that there is variation between designers in specific combinations of design representations that they use. We know from previous research (Goldschmidt, 1991, 1994; Suwa, Gero and Purcell, 1998; 2000) the outcomes associated with design representations but not the knowledge in this sense that drives it.

**Conclusion**

We would argue that the three types of knowledge we have identified do represent potential types of knowledge that can be regarded as design knowledge. What appears to link them all together is that they are ways of dealing with a fundamental problem in design – how to move from the abstract and conceptual to the physical. There are also indications that there may be differences between designers in relation to the particular ways in which the knowledge is deployed. This was apparent in the ways different types of design representations were used. It is also apparent in the results of some recently completed research on how designers start the design process. If design is to be both a area of basic research and have an impact on education and practice, development of a more complete characterisation of design knowledge and how it is used has the potential to make a significant contribution.
References


Modelling the role of the design context in the design process.
A Domain-independent approach

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Abstract

Domain-independent models of the design process are an important means for facilitating interdisciplinary communication and for supporting multidisciplinary design. Many so-called domain-independent models are, however, not really domain independent. We state that, to be domain independent, the models must abstract from domain-specific aspects, be based on the study of several design disciplines, and be useful for many design disciplines and for multidisciplinary design teams. This paper describes a domain-independent descriptive design model that is developed by studying similarities and differences between design processes in a few design disciplines. The model is based on the general theory of state transitions. We modelled a design situation as a state at a certain moment and a design activity as a transition. We also explicitly modelled the role of the design context in design processes. In our empirical studies, we noticed the influence of the design context on the product being designed and the design process and the importance of communication between designers and stakeholders in the design context regularly during the design process. Making designers aware of the role of the design context can improve the quality of both the product being designed and the design process. The role of the design context is, however, often not explicitly taken into account in design models. We modelled the design context as part of the state at a certain moment and interaction with the design context as one of the activities performed by designers.
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Introduction
For facilitating interdisciplinary communication and for supporting multidisciplinary design, domain-independent models of the design process are very important. Because this kind of model abstracts from domain-specific details, it can be used in multidisciplinary teams as a common representation of the design process. The domain-independent concepts and terminology of such a model can be the basis for a dialogue between the members of a design team. The need for domain-independent design theory has been discussed since the beginning of design research. A primary goal of the Design Research Society since its founding in the 1960’s has been a domain-independent theory of design within the context of a science of design. A discussion meeting on the question whether the search for domain-independent theory of designing is a reasonable or realistic goal (McDonnell 1995) led to the issue of the aim of design research. The discussion showed a clear division between those who want to study design per se and those who want to improve design practice and design education. We share the second viewpoint: We believe that domain-independent design models are worth developing when they are aimed at improving the design practice and design education in many design disciplines and multidisciplinary teams. This means that the model should have the right generality, i.e., the general concepts used for describing design processes must be recognisable by designers in a number of disciplines. To be domain-independent, design models must fulfil the following three criteria: abstracting from domain-specific aspects, being based on the study of several design disciplines, and being useful for many design disciplines and for multidisciplinary design teams. Domain-independent models, are, for example, given in (Hybs and Gero 1992), (Korn 1996), (Newell and Simon 1972), (Schön 1983), and (Takeda, Tomiyama, and Yoshikawa 1990).

Many design models, however, are often said to be domain independent but in our opinion do not deserve to be called so. Some theories, for example, do not abstract from all domain-specific aspects and examples given to illustrate these theories are often taken from only one discipline. (For example, Hubka and Eder (1996) take all examples from mechanical engineering and do not consider the existence of non-material products like software.) Many general design theories are also often based on the study of one design discipline or are made with no practical goal in mind. Given the fact that designing in several disciplines has much in common, it must, however, be possible to develop domain-independent design knowledge. Common characteristics of a design process are, for example, the occurrence of design phases and the ill-defined nature of design problems. We have chosen to develop domain-independent design knowledge by studying similarities and differences between design processes in a few design disciplines. This paper describes the resulting domain-independent descriptive design model.

More specifically, this paper describes how we modelled the role of the design context in design processes. Based on an empirical study performed in the design practice (Reymen 2001a), we noticed that the design context plays an important role since it influences the product being designed and the design process during a whole design process. The design context determines constraints of the design process like time-to-market and available budget and influences characteristics of the product being designed like function, price, and quality. Factors in the design context that influence the product being designed and the design process are, for example, users, competitors, trends in the market, environmental laws, patents, and the company director.
Interaction between designers and parties in the design context is necessary so that designers are informed about important external factors and changes in the design context and to discuss the influence of these factors and changes on the characteristics of the product being designed and the
design process. Making designers aware of the design context and its role can stimulate the communication between designers and stakeholders. This may result in an improved product being designed and an improved design process.

The design context is, however, often not explicitly taken into account in design models. In many models, only at the beginning of a design process, some requirements from the design context are taken into account. Also, often a sequence of design activities is discussed, but none of these activities concerns interaction with the design context regularly during a design process. The need for modelling and supporting the interaction with the design context is recently discussed in the literature, for example, in (Dorst and Hendriks 2001), (Glock 2001), and (Mitchell 2001).

In this paper, we propose a domain-independent model of the design process that gives the design context a role in the design process. The paper starts with describing our research approach. It continues with describing the basic theory we used to develop our model. After the model has been described, we discuss its domain independence and its potential usefulness for supporting communication between designers and for supporting interaction with the design context, including some recommendations for further research.

Research approach
To follow a domain-independent approach, we studied design processes in several design disciplines, namely architecture, mechanical engineering, and software engineering. We chose architecture because it has already played an important role in design research and it is the discipline the first author is most familiar with. Mechanical engineering has also contributed much to design research and is a typical engineering discipline. Software engineering is a new evolving discipline that started to reflect on its design processes. Together, these three disciplines are responsible for a wide range of products and for many different design approaches.

The research question we try to answer is “How to describe design processes in a domain-independent way?” We have chosen an exploratory study because design research across several disciplines is a relatively new approach. We started the research process with a literature study in which we explored general design literature and literature specific for the three design disciplines. The goal of the literature study was to find domain-independent characteristics of design processes. We also decided to explore the design practice. For that purpose, we chose qualitative research based on an empirical approach. We performed case studies in the three chosen disciplines. We first interviewed six junior designers at the end of the design process of one of their design projects and we analysed the documents made during these projects. In a cross-case analysis, we compared all junior cases. Then, we performed the same activities for six expert designers: interviewing the expert designers, analysing their documentation, and performing a cross-case analysis. More about the performed case studies can be found in (Reymen 2001a). We compared design processes in each of the disciplines for similarities and differences. The similarities found have been the basis for the development of the domain-independent descriptive design model. In an empirical study that we performed at the end of the research process, expert designers gave feedback on our model in an interview. The feedback was meant to judge the generality (domain independence), the relevance, and the potential usefulness of the model for design practice. At the end of the research process, we performed again a literature study in order to position our model.

State-transition systems
For modelling the design process in a domain-independent way, we use the general concept of state-transition systems. This is a general mathematical theory offering concepts that are independent of a certain discipline; it allows us thus to abstract from domain-specific aspects. A general theory is necessary because similarities between design processes in several disciplines can
only be found on a relatively high level of abstraction. State-transition systems are also appropriate to model the similarities we recognised in the case studies. In state-transition systems, a state is defined as the situation at a certain moment in time; a state is changed by transitions. For the field of designing, we translate this as follows: We let a design situation correspond to a state and a design activity to a transition. A design process can thus be described from a static perspective by a design situation and from a dynamic perspective by design activities. We define the design context as part of the design situation. A design situation and a design activity are the main concepts of our model. Both concepts are explained in the next two sections. In this section, the concept of state-transition systems is explained in some more detail.

The concept of state-transition systems is successfully used in, for example, computer science and control theory. Many processes can be described as state-transition systems: for example, workflow processes, logistics processes, and assembly processes. General literature about state-transition systems can, among others, be found in (Lewis and Papadimitriou 1998) and (Linz 1996) [1]. State-transition systems are a special form of transformation systems: The latter transform something in something else; state-transition systems transform a state into another state. In the design literature, the notion of transformation is widely used: In (Hubka and Eder 1996), a design process is modelled as a process of transforming design information. In (Takeda et al. 1990), a transformation from a functional specification to an artefact specification is suggested. More transformation models in the design literature are summarised in (McMahon, Meng, Brown, and Williams 1995).

The concept of state-transition systems is also already used to model a design process. In (Salustri and Venter 1991) a design process is defined as a series of time-dependent actions that transform the information through a series of states. The theory of Salustri et al. was, however, not taken as a basis for our model because it formalises ‘design information’ rather than concentrating on the description of the ‘design process’ and it does not explicitly take the design context into account.

We use the concept of state-transition systems to describe design processes in a domain-independent way. Only the externally observable behaviour of designers is described, omitting, for example, the cognitive aspects of designing. Also, only the basic concepts and terminology of state-transition systems (state, transition, state space) are used and translated to design processes; the mathematical notation and definitions of state-transition systems are not used. This basic terminology of state-transition systems is extended with terminology commonly used in technical sciences (like entity, property, factor, representation, relation, and process). To establish a consistent set of definitions, some definitions of state-transition systems are adjusted to the other general definitions used. In this paper, only the main concepts and definitions of our model and those related to the design context are described. In (Reymen 2001), a more extensive description of the design model can be found.

A design situation
The first main concept of our design model offers a static perspective on the design process, in the form of a design situation. We define a design situation at a certain moment as the combination of the state of the product being designed, the state of the design process, and the state of the design context at that moment. In the remainder of this section, we first give a definition of a product being designed, a design process, and a design context. Then, concepts to define the state of a product being designed, a design process, and a design context are discussed.

A product is an artefact (that must be designed) satisfying a human need. This need can be defined by the design context. This artefact can be an object or a process. Examples of products are a production machine, a building, a software program, a social process, a design process, a production process, or a logistics process. The life of a product is represented by its product lifecycle. This is a representation of the product evolution, starting from a statement about the need of the product,
continuing with its design, production, use, and reuse, and ending with its decommissioning. Because the product itself does not yet exist during its design process, we use the terminology of a product being designed to indicate the product during the design process.

A design process is defined as a finite sequence of design activities, necessary to obtain the design goal. Note that the design goal may change during a design process. One or more designers can execute these design activities, in sequence or in parallel, using one or more design aids, like theories, methods, tools, time, space, and money. A design context is described by the set of factors influencing the product being designed and the design process at a certain moment. Examples of factors are other processes than the design process in the product lifecycle of the product being designed (for example, the production process, the use process), stakeholders (for example, users and suppliers), a company quality handbook, the company culture (image, vision, brand), competitors, laws, patents, new technology, discipline-specific knowledge, and the situation of the market (politics, economy, environment, culture).

The concepts of a factor and of a property are used to define the state of a product being designed, of a design process, and of a design context. A property describes a characteristic of the product being designed or of the design process. A factor describes an external influence on the characteristics of the product being designed or of the design process. A factor has the ‘potential’ to influence the product being designed and the design process in the present or in the future. A factor can also have a set of values. Examples of factors and their values are ‘company colour: red’, ‘production machines: maximum diameter of 20 cm’, and ‘environmental law: no coating allowed with ingredient ‘X’’. The distinction between properties and factors is based on who ‘determines’ the property or factor and who can ‘influence’ the property or factor. A designer can determine properties but he cannot determine factors, although he might be able to influence some design factors by interaction with the design context.

The state of a product being designed is the set of values for all properties describing the product at a certain moment in time. The state of a product being designed can be seen as a special, second order, property of the product being designed; it describes a characteristic of the product being designed with a set of values as its value. A similar definition can be given for the state of the design process. The state of the design context is the set of values for all factors influencing the product being designed and the design process at a certain moment. In combination, this means that a design situation is the set of values of all properties describing the product being designed, the set of values of all properties describing the design process, and the set of values of all factors influencing the product being designed and its design process. The definition of a design situation is illustrated in Figure 1.
**Design activities**

The second main concept of our design model offers a dynamic perspective on the design process, in the form of design activities. A design situation can be changed into another design situation by one or more actions (causing state transitions). Designers can change the state of the product being designed and of the design process. Stakeholders can change the design context. The design context can also be changed by interactions between designers and stakeholders or it can change autonomously. We model the interaction with the design context as one of the activities that can be performed by designers. In this section, each of these actions is explained in more detail.

*Designers* are actors executing design activities. Designers can change the properties of the product being designed and of the design process. A *design activity* is a transition towards the design goal at that moment, carried out by a designer, causing a change of the state of the product being designed or of the design process. We define a *design goal* as the goal to create one or more desired representations of the product being designed having a desired state. Multiple representations must be made for communication with several stakeholders, like representations for the realisation process of the product being designed and representations for the marketing department. Usually, the goal of a design process also induces desired properties of the design process, like budget, time, moments for presentation of intermediate results, and guidelines for documentation. A design activity can result in a changed product being designed as well as in a changed design process. The above-mentioned definitions are illustrated in Figure 2. A special kind of activity is *interaction with the design context*, i.e. with stakeholders in the design context; this activity can result in changes in the design context that can also cause changes to the state of the product being designed or the design process.
Stakeholders are actors in the design context. Stakeholders have an interest in the product being designed and/or the design process. They can be part of the company, like the production manager who can buy a new production machine or the logistics manager who can change the concept of distribution of the products, or of society, like customers and users. A stakeholder can change the state of the context; he can influence factors and can interact with the designers. Transitions in the design context can be described by transformations or mutations. A transformation can have a goal that may or may not coincide with the design goal. A mutation is an action in the design context with a goal that is independent of the design goal. Mutations take place independently of the lifecycle of a specific product, but can influence this product and its design process. Examples of such mutations are actions of a competitor and the introduction of a new law. Taking into account the effect of such a mutation on the product being designed and/or the design process is a design activity.

Design model
The concepts of a design situation and of a design activity, described in the previous two sections, are combined into a design model. The purpose of this model is to offer concepts and a terminology for describing design processes in a domain-independent way. To explain our model, we first introduce the concept of a design task and its relation to the design context. A design task at a certain moment is a task to meet the design goal at that moment, starting from the current design situation. One or more designers perform a design task by executing design activities. An alternative formulation of a design task is a task to transform the current state of the product being designed and/or the design process into a desired state, taking into account the design context. A design task is often appointed to stakeholders in the design context. Each design task has a specific design context.

Our design model is illustrated in Figure 3. A design process is modelled as a finite sequence of design activities. Designers perform design activities to meet the goal of the design process at a certain moment. To perform their design task, they have to take into account the whole design situation. As explained, a design situation is defined as the combination of the state of the product being designed, the design process, and the design context at a certain moment. A design situation can be transformed by design activities and by actions of stakeholders in the design context. The design context can, however, change the design situation in a direction that does not necessarily conform to the design goal (illustrated in Figure 3 with different ‘stars’). Designers can interact with the design context to exchange information about the design situation, i.e., to get to know and to influence important factors in the design context and to discuss desired properties of the product being designed and of the design process.
Discussion and conclusion

Our design model describes a design process from the viewpoint of state-transition systems, which is one of many different points of view to describe a design process. We made the general theory of state-transition systems suitable for describing design processes by instantiating it with characteristics of design processes like the concept of a design situation and that of a design activity. We also explicitly modelled the role of the design context in the design process to make designers aware of the importance of factors in the design context and of interaction between designers and stakeholders. In (Reymen 2001), a more extensive description of the design model can be found. There, also concepts like a current and desired property, a design alternative, a design relation, a representation of a product being designed, a description of a design situation, a design space, and a definition of designing can be found. Some aspects of design processes in practice, like the designer and the design team and aspects like creativity and intuition, are, however, not explicitly modelled.

Our model is intended to offer a domain-independent description of a design process. To judge if the model is really domain independent, we have to check whether or not it fulfils the three criteria of domain independence we stated in the introduction. The first criterion is met in the sense that our model abstracts from domain-specific aspects. The concepts of our model are understood in each discipline we investigated and are compatible with the concepts in general design theories. Some designers giving us feedback on the model had, however, difficulties with the domain-independent terminology. This difficulty can be overcome by providing examples from several disciplines. We met the second criterion in the sense that we performed research in the disciplines of architecture, mechanical engineering, and software engineering. The third criterion concerns the usefulness for several disciplines and multidisciplinary teams. We found that already only studying similarities and differences in several disciplines is useful for these disciplines, because they have to make explicit their concepts. The comparison of concepts and approaches between disciplines can also offer new points of view for the separate disciplines; a well-known example is software engineering that learns from architecture a way of thinking in design patterns (Gamma, Helm, and Johnson 1995). Our model may be used as a basic representation of a design process both in design practice and design research. In design practice, it can stimulate and improve communication between designers and between designers and stakeholders in the design context. The communication may...
result in an improved product being designed and a more efficient and effective design process. In (Reymen 2001), our domain-independent representation of a design process is already used for developing domain-independent support for reflection on design processes.

To be really useful for supporting communication between designers (from several disciplines) and for supporting interaction between designers and stakeholders in the design context, the model must be refined and extended. A major extension should be the explicit modelling of the designers and the stakeholders and their characteristics as individuals (like personality and skills) and as groups. For the extension of the design model, further research can be based also on multidisciplinary teams instead of only on individual designers in a number of disciplines as we did. For supporting communication between designers of a multidisciplinary team, support to make a common (domain independent) representation of a design situation would be useful. Further research can concentrate on such prescriptive representations. For supporting interaction between designers and stakeholders, types of interaction and communication between designers and several types of stakeholders in the design context can be studied. A topic of further research can also be the influence of the design team composition on the interactions with the design context.

Acknowledgements
The research was part of the Ph.D. research of the first author, performed for the Stan Ackermans Institute, Center for Technological Design of the Technische Universiteit Eindhoven.

[1] Literature about state-transition systems in general (not applied to a specific domain) can be found in books and articles about ‘finite automata’. The definition of finite automata includes all important concepts about state-transition systems.
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A comparative study of iconic influences amongst British and Canadian design students

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Abstract

Design students encounter a wide variety of influences and inspiration during their education. Moreover, the knowledge and skills required and utilised whilst studying design encompasses both explicit and implicit knowledge, and iconic and canonic knowledge types. This paper explores, comparatively, the iconic influences amongst sets of British and Canadian undergraduate design students. Using naturalistic experimentation techniques, the study’s main objective is to investigate whether a student’s design influences, and subsequent artifact creation activities, are affected by their educational context, their economic situation, their gender or age, and their geographical conditions amongst others. With this in mind the study will seek to explore the ramifications of this comparative study in terms of undergraduate design curriculum development and the culture and sociology of designers and design practice, in general, in the future.
A comparative study of iconic influences amongst British and Canadian design students

Inspiration, influences and the design student’s context
Design students’ input into artifact creation is influenced by their educational context, their economic factors, their gender, their geographical conditions, their social constructs and their political interests. Design is known to be a creative activity that involves the production of something ‘new’, the result of recombining, referencing and transforming within a specific context. Recognising that design is not conducted in a “sensory deprivation chamber” vacuum (Frayling in Kwint et al. 1999: xiv) demonstrates the need to take both quantitative and qualitative approaches in design research in order to explore the influences and inspirational sources within the context of design.

Design inspiration and influences, and the way designers utilize them is widely acknowledged and well documented. Recently, there have been a number of research projects involving creativity in design (Oxman 1994, 1999; Vihma 1998), inspiration in design (Rodgers and Milton 2001; Eckert 2000; Eckert and Stacey 2001), analogy in design (Leclercq and Heylighen 2002) and memory in design (Goldschmidt 1994). Primarily, this work and other research in the area of creativity takes the theoretical position of cognitive psychology (Liep 2001:2) whereby there is a desire to formalize design thinking which focuses largely on the ‘minds’ of the individual creator(s).

Creativity and inspiration in design is explored through several disciplines including: architectural design (Heylighen 2000; Leclercq and Heylighen 2002; Goldschmidt 1994; Oxman 1994, 1999), graphic design and advertising (Nixon 2002; Heller and Pettit 1998), engineering design (Vincenti 1990), and knitwear design (Eckert 2000; Eckert and Stacey 2001). These studies represent a wide variety of ethnographical approaches including laboratory experiments (Leclercq and Heylighen 2002) and naturalistic experiments (Heller and Pettit 1998; Rodgers and Milton 2001). Leclercq and Heylighen (2002) explore analogical thinking used by architectural design students by providing a set of variables that are measurable quantitatively. Naturalistic experiments use combined methods of data collection to collect information under relatively natural conditions (Bernard 1995). Heller and Pettit (1998) and Rodgers and Milton (2001) both utilize informal and formal interview procedures that are open-ended to differing degrees, to collect non-specific and specific information respectively. In laboratory and naturalistic experiments, the measurable traits are reduced in order to simplify the design process to recognizable, more quantifiable details.

The multi-dimensionality of design learning and design knowledge are difficult to measure however, and thus a more holistic, contextualised approach which includes the aspects of social mediation in the context of design is required (Ashton and Durling 2000: 12).

Industrial design context
Industrial design has been commonly treated as a satellite discipline to architecture (Julier 2000: 35) and/or engineering. Industrial design can be described as being a deeply complex design discipline, particularly within the formal education process. Industrial design instructors need to provide a breadth of different design situations in order to prepare students with the variety of design problems they will face in the future. In other design disciplines, such as in architecture, an architect will always design a structure involving land, location, structural integrity and human interface. Those structures may be used for differing purposes such as public venues or private dwellings. The result is a number of common, teachable variables in architectural education. A second example is graphic design, which typically manifests itself into two-dimensional information that communicates visually and/or textually. The elements of design (i.e. colour, texture, form) in
graphic design can be deconstructed and continue to form the foundation of graphic design education.

It is understood that all design disciplines are complex, have multiple levels that interact, and involve a hierarchical problem solving process (Dormer 1990). Vincenti (1990: 8) describes “normal” design and “radical” design, and states that the bulk of engineering design can be categorized as “normal”. It is clear that the knowledge-base required for all disciplines of design are enormously diverse and complex. However, the nature of industrial design varies from other design disciplines in that the majority of design problems, especially within an educational context, can be considered “radical”. Rittel and Webber (1984: 136) develop the concept of radical problems by describing unique problems as being “wicked”. In industrial design the majority of problems encountered weigh heavily towards being “radical”. This is because industrial design does not have constants such as a specific location in architecture design or textual information in graphic design. Therefore, the teachable aspects of industrial design require an extreme breadth of knowledge in order to prepare future industrial designers for the variety of tasks they may encounter in contemporary design practice such as the design of a lamp, the design of an artificial limb, a running shoe design, or vehicle design.

Essentially there is no definitive prescriptive approach to creating solutions to extremely complicated problems. There may be similarities with previous problems encountered in industrial design, but a classical systems approach will not necessarily work. With an increased level of complexity in teaching industrial design, the sources of inspiration that drive individual design projects forward necessitate a cross-fertilization of perspectives. Industrial design education is the combination of formal education and social agents (i.e. economic factors, gender, geographical conditions, and political interests) that informs all design decision making.

Explicit and implicit knowledge in design
The knowledge-base of each individual can be simply described as diverse and complex but is intimately bound up with economic, political, gender, social, personal and environmental experiences. For the purpose of this paper, the idea of knowledge has been interpreted broadly to include explicit and implicit knowledge, and canonic and iconic analogical reasoning. The following working definitions have been established in order to explore the variety of inspiration sources among industrial design students.

According to Vincenti, (1990: 195) explicit knowledge can be put down in words, tables, diagrams and pictures, and implicit knowledge involves skill, judgement, intuition and associated knowledge. Explicit knowledge includes the tangible aspects of design that are easily taught in formal situations (e.g. lectures, seminars). Implicit knowledge can be considered the intangibles of design that are less easy to express and difficult to measure because this type of knowledge is generally related to personal experiences. Implicit knowledge is typically developed and transferred through social situations. It is the combination of explicit and implicit knowledge that the industrial design student integrates towards a finished concept.

Canonic and iconic analogy in design
Canonic analogy is based on abstract systems, prefabricated elements and geometric correspondences and can be seen as the tangible elements of design. These analogies have formed the basis for traditional architectural design and graphic design education as they fall into the category of explicit knowledge. Iconic analogies, on the other hand, are objects from the natural world or from outside of the discipline of study that may contribute to the design process (Heylighen 2000: 17-22). Iconic analogies can be explicit or implicit but comprised of individual
aspects, typologies and categories outside of a specific design discipline. Canonic and iconic knowledge can be further subdivided into two categories, direct design transference and indirect design transference. There is an emphasis on iconic knowledge in this study.

**Direct design transference and indirect design transference**

Design transference is when an element, material, method of production, aesthetic or any other piece of design information is taken from one designed object to another. There are many observable examples of design transference in history, such as the use of Gothic arches and rose window architectural details on furniture design during the Renaissance. Direct design transference is when canonic devices or same-type artifacts directly inform design decisions. For example, Eckert’s (2000) discussion on the sources of inspiration within the knitwear industry can be considered direct design transference. In the knitwear example, elements and specific characteristics within this discipline of design are described as the primary influences in the creation of a new garment (Eckert 2000; Eckert 2001). Direct design transference can be explicit, implicit or canonic.

Indirect design transference is described by Leclercq and Heylighen (2002) in their recent research experiment with architectural students. Here, they are searching for explicit iconic analogies that are presented unconsciously to a group of design students. Indirect design transference can be explicit or implicit, canonic or iconic. Indirect design transference is much more difficult to trace in the educational process since students are not often fully aware of their personal knowledge-base. Indeed, even the seasoned designer may not be conscious of his/her design influences to a level where it can be articulated (Sudjic 1999). For example, Heller and Pettit’s interviews with graphic designer Paul Rand (1998: 8-13) illustrates Rand’s awareness of his sources for inspiration. Rand describes the use of a rebus for the design of his IBM logo in the late 1970s. In his interview he articulates direct design transference by referencing rebus as a communication form and Lewis Carroll’s use of rebus as a form of dramatization. Later he describes indirect design transference for a Yale poster where he used a step motif and refers to the Ziggurat as a reference point for this imagery.

Indirect design transference is less easily pin-pointed, especially after an artifact is completed. The designer may have not been aware of the influences and/or forget references without deep reflection on this point. At the completion of the design project, the transference becomes a process of speculation and contemplation by design critics or historians to re-construct the said design process. This research project attempts to get to the core of design inspiration at the earliest possible stage within an educational context.

It is important to remember that implicit/explicit, canonic/iconic, direct/indirect design transference occurs to varying degrees during the artifact development phases. It therefore becomes significant to explore which architects, artists, musicians, movies or items from the natural world influence and ultimately manifest themselves in the industrial design student’s end solution. Despite Vincenti’s (1990) claim that implicit knowledge is inexpressible, implicit knowledge is measurable through indirect design transference by observation, discussion and documentation whilst students engage with the designing of artifacts. Studio instructors provide experiences, situations, experiences and communities for the student to engage with during the design process. Increasingly, students are asked to engage with ‘design research’ that reflects all levels of information gathering through explicit/implicit, canonic/iconic, direct/indirect design transference. Students must perform market research, historical research, consumer demand issues amongst others whilst continually engaging with the world around them.
Preliminary comparative study

Two separate research studies were conducted using naturalistic experimentation techniques. All information gathered considered indirect design transference sources of inspiration since there was no attention given to the particular projects that the students were engaged with at the time of the studies. The research methodology employed was an informal interview and questionnaire procedure with a sample of undergraduate students at two formal educational institutions in two different countries, the Britain and Canada. The students were interviewed independently in a semi-structured manner within their studio environment. There was an attempt to balance gender when choosing students for their independent and direct interviews. Each student was asked a total of 8 questions with several control questions. They were asked to relate one example from the past or present that inspires or informs their present design work. The questions were a reflection of both explicit and implicit knowledge sets. The category, their relationship to either explicit or implicit knowledge and whether they are made occasionally (◊), average (◊◊), or strongly (◊◊◊) in the educational context is detailed in Figure 2.

<table>
<thead>
<tr>
<th>Inspirational Source</th>
<th>Explicit</th>
<th>Implicit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 building</td>
<td>◊◊</td>
<td>◊◊</td>
</tr>
<tr>
<td>2 three-dimensional product</td>
<td>◊◊◊</td>
<td>◊◊◊</td>
</tr>
<tr>
<td>3 author</td>
<td>◊◊</td>
<td>◊◊◊</td>
</tr>
<tr>
<td>4 automobile/vehicle</td>
<td>◊</td>
<td>◊</td>
</tr>
<tr>
<td>5 movie</td>
<td>◊◊</td>
<td>◊</td>
</tr>
<tr>
<td>6 music</td>
<td>◊</td>
<td>◊</td>
</tr>
<tr>
<td>7 magazine</td>
<td>◊◊</td>
<td>◊◊</td>
</tr>
<tr>
<td>8 designer including architect</td>
<td>◊◊◊</td>
<td>◊◊◊</td>
</tr>
</tbody>
</table>

◊◊◊ = strong  ◊◊ = average  ◊ = occasional

Figure 2: Explicit and implicit iconic inspiration knowledge

Two studies took place in 1999-2000 and 2000-2001 at the School of Design and Media Arts at Napier University, Edinburgh. In these studies, Rodgers interviewed a total of 29, and 35 first year students respectively. The primary objective was to explore whether a relationship could be found between a design student’s level of design awareness and their design degree performance (Rodgers and Milton 2001).
The second group of studies took place January 2002 at the University of Alberta in Edmonton, Alberta, Canada. Strickfaden interviewed 18 third year, and 23 fourth year industrial design students at the University of Alberta. The primary objective of the second studies was to cross-reference and compare iconic sources of inspiration among British and Canadian students.

The responses of the students involved in the preliminary comparative studies were recorded into spreadsheets where gender, age, country of origin, and frequency of responses were noted. It became clear that in general, year 3 and 4 undergraduate students answered with a more specific and detailed response. Responses from each student in all cases were wide ranging, as expected, and showed a varying degree of awareness of the subject area of each question. There were some similarities between responses in each group despite different geographical locales and different degree programmes. These similarities can be attributed to the industrial design context being embedded predominantly with ‘Western’ societal values, the result of increased globality (Beck 2000), and mass media’s “visual encyclopaedism” which includes imagery from many cultures, past and present, from all over the globe at a touch of a button (Woodham 1997: 190). Examples of the common responses from both the British and Canada studies include high profile building design such as Frank Lloyd Wright’s *Falling Waters*, the *Eiffel Tower*, and the *Guggenheim Museum* (NY and Bilbao); well known “high design” products (Julier 2000: 69-71) such as Starck’s *Juicy Salif*, Apple’s *iBook* and *iPod*, and Alessi’s salt and pepper shakers; popularized and cult movies such as *Bladerunner*, *Star Wars*, *Pulp Fiction* and *Braveheart*; and popular culture designers such as Ron Arad, Frank Gehry, and Philippe Starck.

**Explicit knowledge and educational context**

The design programme at Napier University in the UK is a 4 year degree programme based within the School of Design and Media Arts in the Faculty of Arts & Social Sciences.

The students interviewed were all of a similar age range, between 18 and 20 years old (*see Figure 3*), with a balance of gender (*see Figure 4*) and with the majority of the students being from the immediate locality (*see Figure 5*).
The industrial design programme at the University of Alberta is a 4 year BDes degree programme in the Department of Art & Design, Faculty of Arts and Humanities. The BDes is a liberal arts degree whereby students choose a ‘design pathway’ (e.g. engineering, computers, social sciences or general). Students have a wide range of personally chosen options from a number of departments in addition to the Department of Art & Design. The students interviewed were between the ages of 20 and 37 with a high percentage being mature students (+25) \( (see \ Figure \ 3) \), a proportional balance of gender \( (see \ Figure \ 4) \), and a majority of local students \( (see \ Figure \ 5) \).
Corbusier, Ron Arad, Frank Lloyd Wright, and Philippe Starck from the Napier students. The students had been exposed to these designers in formal lectures and seminars prior to the interviews.

<table>
<thead>
<tr>
<th>Inspirational Source</th>
<th>Explicit</th>
<th>Implicit</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 building</td>
<td>31</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>2 three-dimensional product</td>
<td>29</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>3 author</td>
<td>1</td>
<td>54</td>
<td>9</td>
</tr>
<tr>
<td>4 automobile/vehicle</td>
<td>12</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>5 movie</td>
<td>10</td>
<td>49</td>
<td>5</td>
</tr>
<tr>
<td>6 music</td>
<td>2</td>
<td>60</td>
<td>2</td>
</tr>
<tr>
<td>7 magazine</td>
<td>17</td>
<td>35</td>
<td>12</td>
</tr>
<tr>
<td>8 designer including architect</td>
<td>42</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>144</td>
<td>309</td>
<td>59</td>
</tr>
</tbody>
</table>

Figure 6: Breakdown of explicit, implicit and no responses in Napier University students

The same patterns were discovered among Canadian students who responded with Piet Mondrian, Gerrit Rietveld, Van Gogh, and Charles and Ray Eames; all of which they had learned through a required design history module prior to the interview. Further examples of explicit knowledge were demonstrated through references to Droog design (Marcel Wanders and Jurgen Bay), and to sustainability (William McDonough, *The Ecology of Commerce*, and the Eco-house). Karim Rashid was referenced most frequently (5 of 40) with the University of Alberta students since he had visited the University as a guest lecturer the previous month.
### Table: Breakdown of explicit, implicit and no responses in University of Alberta students

<table>
<thead>
<tr>
<th>Inspirational Source</th>
<th>Explicit</th>
<th>Implicit</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 building</td>
<td>18</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>2 three-dimensional product</td>
<td>3</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>3 author</td>
<td>5</td>
<td>31</td>
<td>4</td>
</tr>
<tr>
<td>4 automobile/vehicle</td>
<td>3</td>
<td>32</td>
<td>5</td>
</tr>
<tr>
<td>5 movie</td>
<td>5</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>6 music</td>
<td>0</td>
<td>36</td>
<td>4</td>
</tr>
<tr>
<td>7 magazine</td>
<td>17</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>8 designer including architect</td>
<td>26</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>77</strong></td>
<td><strong>193</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

Figure 7: Breakdown of explicit, implicit and no responses in University of Alberta students

By providing a relatively structured interview procedure within a naturalistic setting, each student is triggered to respond so that there can be a reliable comparison among the students. Because of this procedure, the responses were mapped according to what was perceived being explicit or implicit (see Figures 6, 7). Within the British student group, it estimated that 28% of the responses were explicit and within the Canadian group, approximately 24% were explicit (see Figure 8). The explicit responses from both the British and Canadian students are intrinsically connected with the individual students’ definition and understanding of design based on their educational context.

<table>
<thead>
<tr>
<th></th>
<th>Explicit</th>
<th>Implicit</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Napier University</td>
<td>28%</td>
<td>60%</td>
<td>12%</td>
</tr>
<tr>
<td>University of Alberta</td>
<td>24%</td>
<td>60%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Figure 8: Distribution of explicit, implicit and no responses

### Implicit knowledge through design culture

Implicit knowledge is explored through the design cultural context, the student’s gender, their geographical conditions, and other factors (e.g. personal interests, economic factors, and political interests). Design culture has been described by many researchers, critics and historians over the past several decades, and includes the conception, discussion, and planning of artifacts before they are made. While these objects are the result of human decisions, the subject of design itself is not fixed: design is constantly undergoing exploration and continually evolving. Creating a design culture in the classroom is known to be very important as this provides a forum for students to explore design (Ashton and Durling 2000). It is expected that the design culture will be dynamic in relation to specific location. For example, design culture can be present in the studio, in the pub and through the private and social interactions of the students. For the purpose of this study, design culture is explored through industrial design.
Increasingly, a variety of design researchers describe design as searching for a problem through identification and questioning (Heller and Pettit 1998; Rittel and Webber 1984). The ability to conceive and develop questions is an integral part of the design process. It is speculated that the more “radical” or “wicked” the problem, the quality and quantity of questions increase. This is due to the need to explore levels of knowledge that are less tangible and more difficult to access.

Within a more open-ended interview process, it became apparent that the question-posing approach towards resolving design issues in industrial design was one that most students relied on heavily. The interviewers were constantly questioned about the questioning process. For example, a number of students asked how designer was defined within the context of the interview. They wanted to know if an artist like daVinci should be defined as artist, designer or inventor. The number of questions posed by the students increased directly with the year of study. The result of the students question-posing approach was most apparent with the Canadian group where the 4th year students took nearly double the time to interview as the 3rd years.

It was clear that the senior 4th year students had a better grasp on the idea of industrial design through their ability to engage with the study and the interviewer. An example of this was one student responded to the query “designer” by saying that he could “spout off a number of designers” but that his response had to be “God”. This response was then supported with the statement that “nature was the best source of inspiration”. In addition, the student referred to the book Biomimicry—Innovation Inspired by Nature by Janine Benyus, and wrapped-up with a barrage of designers names.

From a different perspective, the student’s grasp on design culture was demonstrated through responses in all categories that were directly relevant to design. The most design relevant responses were in the categories of designer, building and magazine, with the majority of these being categorized as explicit. The incidence of design relevance across all categories was very rare, however, two different Canadian students replied with design related movies (The Power of Ten and Microcosmos), and design related authors (Paul Hawkins and Kenji Ekuan). These responses can be considered to be highly contextualized within design. These students seemed to understood the purpose of this study and design culture, particularly compared with others who provided responses reflecting their design awareness and personal likes and dislikes. Overall, the awareness of their sources of inspiration appeared to be relatively unconscious to these design students.

Implicit knowledge through gender

Gendered responses can be separated into two categories, stereotypical responses and design-oriented responses. Stereotypically gendered responses can be described best through the categories of automobile/vehicle, movies and magazine, however others were also present. In response to the automobile question, the male students typically replied Porsche and Ferrari. Fewer females knew particular model descriptors and numbers and most frequently referred to an automobile they owned presently or one they had owned in the past. All creative responses in this category came from the female students, examples of which were from the 4th year Canadian group. These include: “my feet”, “Kona bicycle”, “go-cart”, “Raymond Loewy buses” and “stretch-limousines”. To the query of movie, males typically responded in the genre of Science-fiction, and females responded with Disney or romance movies. For the category of magazine, males responded with masculine examples such as Scientific American, GQ, Muscle International, and Road and Track; whereby females responded with feminine examples such as Cosmopolitan, Canadian House and Home, and People. These stereotypically male and female responses reflect known gendered Western societal values.
Gendered responses that were design oriented were rare. Several female students chose three-dimensional products from the fashion and perfume industry, such as Issey Miyake. Male students did not hesitate to the query designer, whereby female students had more ‘no’ responses, more personal references such as “my friend”, and more general responses such as “Ikea” and “Ideo”. Several female students replied that this question was unfair in that they simply did not feel inspired by individual designers. One 4th year Canadian student stated that she did not “believe in the media star approach to individual designers”, she was more interested in “ideas embodied in objects” and in “groups of designers that worked with specific philosophical beliefs”. Of all 105 students interviewed, only 2 responded with the names of female designers. These were, Vivien Westwood and a reference to the interviewer Megan Strickfaden, who is known locally for her design work.

The most interesting example of a gendered iconic inspiration source was a response to the query of three-dimensional product from a 4th year female Canadian student when interviewed by the female interviewer. The student’s response was the “Keeper menstrual cup”. Not only is this a highly gendered response, it is intensely linked to the value system that this individual likely employs. “Keeper” is an alternative re-usable product used during menstruation. It is considered to be a healthy alternative to sanitary napkins and tampons, and is primarily used by the “health conscious”, “home birth”, “environmentally conscious”.

It is clear that the design student’s implicit knowledge-base is highly influenced by their gender. Both the male and female students show interest in a wide range of inspiration sources, however, the context of gender within Western society must be considered as influential in the design process.

**Implicit knowledge through geography**

Exploring the notion of implicit knowledge through geographical locale necessitates the gathering of personal information from the sample groups. The students were asked to provide their permanent home city (e.g. parents address), their place of birth and with the Canadian students, travel experiences. From this information, the researchers were able to determine additional outside influences and the broader context of the student.

The majority of responses of all students showed a very typical Western design attitude. Particularly the British students who follow a relatively narrow art and design curriculum at pre-degree level in the secondary school system. The younger students (i.e. age) with little past experience responded more frequently with local examples of architecture. The Napier students indicated Scottish architecture such as the National Museum of Scotland, Edinburgh and Buchanan Galleries, Glasgow; and the University of Alberta students indicated architecture in Alberta such as the Grant MacEwan Downtown campus, Edmonton and the University of Lethbridge building, Lethbridge. For the category of ‘author’, British students replied with Iain Banks and Terry Pratchett; and Canadian students replied with Margaret Atwood, and Thomas Wharton, all well-known local novelists.

Replies that reflect growing globality were demonstrated best to the queries of movie, music and magazines. It is speculated that these forms of popular culture are easily accessed through the media, the internet and the 24-hour information world. Responses to all categories represents the global diffusion of ideas and messages. These are shown through the examples previously discussed in the sections Preliminary Comparative Study and Explicit Knowledge and Educational Context. Obvious examples were J.R.R. Tolkien and J.K. Rowling for authors of recent movies; the movies Lord of the Rings, The Matrix and Star Wars; Canadian music group The Barenaked Ladies from a British student; and magazines such as ID and Wallpaper.
The most interesting example for implicit knowledge through geography was a female Japanese student who responded with Megan Strickfaden, to the query of ‘designer’. This response may interpreted as being an attempt to win favor with the interviewer. However, in this situation this student had been taught by Strickfaden in design history and as a studio instructor over the past several years. It was clear that the student was genuinely responding to the question. Furthermore, it is well known that in the Japanese culture, teachers are highly revered due to their overt influence. The response of this student represents the intense relationship that an individual student has to his or her value system established by their geographical influences.

Locating implicit knowledge through geographical locale provides an interesting forum for discussion in the context of design particularly due to increased globality and cross-fertilization between separate cultural forms and environments. Iconic inspirations relative to geographical origins can provide a rich environment for the student to develop artifacts. The cross-fertilization of values and typologies among students enriches implicit knowledge. This is supported by national and international exchange programmes that have existed for decades in design education.

Implicit knowledge through other factors
Implicit knowledge explored in multiple-dimensions from a social perspective is a complex, but more holistic approach towards a design student’s sources of inspiration. The personal details of the individual students is also a factor. For example, one Canadian student is an internationally acclaimed athlete. This immersion in a particular lifestyle is distinctly reflected through responses to the queries. This student responded with Kona bicycle for vehicle, Nike running shoe for product and had ‘no’ responses to popular culture categories (i.e. movie, music). Getting to the root of inspiration means that the researcher must spend time and get to know individuals in order to sort out the extent of their implicit knowledge-base and how this is applied to the design of artifacts.

There are, of course, many other factors that contribute to implicit knowledge not explored due to the constraints of this paper and the preliminary stages of this study. Some of these include economic factors and political interests. These factors and others are being examined using a variety of information gathering techniques, and will be a topic for discussion in the future.

Conclusion and future recommendations
Discovering iconic inspirational sources in undergraduate industrial design students is a process that requires a multi-dimensional research gathering approach. It is clear that in order to track such references, the researchers must use a variety of methods including interviews, observational studies, active participation and protocol analysis under naturalistic conditions. Further research is required in this area in order to get to the roots of the design process as a collective, social process, not just one that is enacted by individuals. Iconic references in industrial design are not limited to the examples explored in this paper, but include many aspects of what is known in the academic realm as popular culture.

The implications for this kind of exploration and research will inform design curriculum development and the culture and sociology of designers in the future. For instance, implicit knowledge needs to be recognized as the primary source of inspiration especially among industrial design students. By recognizing that design education occurs within University studios and outside in all social situations, formal education can better support knowledge that is personally - and socially - based. Educational settings need to support this through providing a breadth of experiences in theory, history and practice. In addition, design students need to be challenged to generate their knowledge-base through creative, abstract design research. Finally, design education requires a liberal University setting where students with a variety of backgrounds can share their expertise and experiences. Louridas (1993) describes the designer as using an inventory of semi-
defined elements such as experience, knowledge and skills to create an artifact. It is the synthesis of explicit and implicit; and educational and social contexts that orchestrate the diverse activities of industrial designers to create artifacts of value.
References


a (x 4): Combining ethnography, scenario-building, and design to explore user experience

P. Rothstein Arizona State University, USA

Abstract

In today’s marketplace, developing new user experiences significantly influences success. Like never before, it has become vital to connect with consumers in experiential ways. “Recognizing experiences as a distinct economic offering,” note Joseph Pine and James Gilmore (1999), authors of *The Experience Economy*, “provides the key to future economic growth.”

This paper describes *a (x 4)*, a new method for designing user experiences. Drawing from elements found in market research, ethnography and design, *a (x 4)* is an effective tool that features a unique emphasis on visual and narrative communication.

The paper includes:

- background information about the emergence of user experience as a critical design challenge.
- a full description of *a (x 4)*, including theory and the application process.
- results from a research project conducted to explore and evaluate the effectiveness of *a (x 4)*.
a (x 4): Combining ethnography, scenario-building, and design to explore user experience

Introduction: A new economic offering
One of the most intriguing developments in contemporary business and design is the recognition of a core relationship between user experience and products, communications and services. A variety of factors are fueling this recognition, including: a fundamental redefinition of human/artifact interaction (made possible by digital technologies and internet-based communications) and the emergence of a genuinely global marketplace and new economy (Nussbaum 1999: 17).

However, commoditization is perhaps the greatest factor responsible for shifting attention from artifacts to experience. As noted by Hirasuna, O’Leary, and Lawrence (2000), the battle over quality in the product and service arenas has largely been fought and won. Though not universally evidenced, a high degree of quality has become common in contemporary products and services. Consider, for example, automobiles, home appliances, or commercial furniture. In all cases, quality (as measured by some combination of cost, aesthetic appeal, and performance) has become ubiquitous. Tom Peters, author of In Search of Excellence, notes that quality no longer plays a significant role in why one product or brand is selected over another. While referencing the success of the Six Sigma methods (which focused on helping companies achieve zero product defects), Peters notes: “The success of Six Sigma has turned quality into a “commodity,” so much so that it is no longer the determining factor for which brand to buy” (Hirasuna, O’Leary, and Lawrence 2000: 3). With quality assured, companies are often left waging price wars as the only means to compete for consumers’ dollars.

However, the commoditization of products and services should not, according to some, be seen as a limitation to succeed and prosper in the new marketplace. Joseph Pine and James Gilmore (1999) note that commoditization occurs with all types of economic offerings and that it is part of an “evolutionary” process. In fact, they argue that the commoditization of product and service offerings has opened the door to the emergence of a new, distinct economic offering: experience, which they define as an offering that focuses on engaging individual consumers in unique, personal and memorable ways (Pine and Gilmore 1999: 3). Citing examples like Disney, the contemporary “coffee experience,” and staged birthday parties, Pine and Gilmore assert that experience has become a major source of economic value in the new economy. “Experience,” they note, “represents an existing but previously unarticulated genre of economic output. Decoupling experiences from services in accounting for what businesses create opens up possibilities for extraordinary economic expansion - just as recognizing services as a distinct and legitimate offering led to a vibrant economic foundation in the face of a declining industrial base” (Pine and Gilmore 1999).

In the design professions - where one might reasonably expect some resistance to the devaluation of artifacts - there is a growing recognition that the design of experience is a major challenge in the twenty-first century. In the inaugural issue of Gain: AIGA Journal of Design for the Networked Economy, the AIGA (American Institute of Graphic Arts) asserts that the design of experience has emerged as a new discipline. “Experience design is a discipline created by the reality of communication today, when no point of contact has a simple beginning and end and all points of contact must have meaning embedded in them . . . ” (Grefe’: 2001). Industrial design has also steadily recognized the importance of designing experience. During the past decade, articles and essays about topics closely linked to the design of user experience have appeared regularly in the IDSA’s (Industrial Designers Society of America) Innovation magazine.
Some have focused on the emergence of anthropology as a valuable tool for studying daily experience (Wilcox 1996, Nims and Robinson 1996). Others have explored how design scenarios can be used to communicate user experiences with new products and services (Welker, Sanders and Couch 1997, Joe 1997, Nakhtsen 1997).

**Definition of \(a \times 4\)**

Based on this evidence, it seems plausible that the design of experience has become a significant challenge for contemporary business and design groups. As a consequence, new methods and processes are being developed. One of these -- a scenario-building tool called \(a \times 4\) -- has been created to explore and communicate stories about user experience. The method is loosely based on a definition of scenario-building put forth by Suri and Marsh: “By “scenario-building” we mean the development of a series of alternative fictional portrayals -- stories -- involving specific characters, events, products and environments, which allow us to explore product ideas or issues in the context of a realistic future” (Suri and Marsh 2000: 152).

\(a \times 4\) is organized around the “. . . characters, events, products and environments” referred to in this definition. This particular quartet of elements is, in fact, identified by other individuals (Hasdogan 1996) though often defined with other words. Christopher Ireland and Bonnie Johnson, for example, define the quartet as “. . . people, places, things and processes” (Ireland and Johnson 1995: 59)

As shown in Figure 1, \(a \times 4\) consists of actors, activities, artifacts and atmosphere and can be defined as: a framework based on the relationship between actors, activities, artifacts and atmosphere, and used for exploring, developing and communicating scenarios about consumer experience.

![Diagram of \(a \times 4\)](image)

**Figure 1**

**Origins of \(a \times 4\)**

\(a \times 4\) draws from a variety of elements found traditionally in ethnography and scenario-building. From ethnography, it borrows the following:

**A Research Attitude**

As presented elsewhere (Rothstein 1999), ethnography has become a common method employed in business and design for studying culture and human behavior. It features a variety of individual methods -- such as, interviews, observation, and trace analysis -- that researchers use to study people and daily life. Developed originally by anthropologists to assist in the study of “primitive” human groups, ethnography has been appropriated by many disciplines, including design, each of which has found it effective for exploring human behavior, values, and beliefs.
A Research Method

*(x 4)* is also based on the coding schemes or frameworks that ethnographers and other researchers have developed to focus and organize qualitative data. Colin Robson (1993), notes that coding schemes “. . . contain predetermined categories for recording what is observed. They range from simply noting whether or not a particular behavior has occurred, to complex multi-category systems” (Robson 1993: 206). *(x 4)* features four categories or elements. By focusing an inquiry on these elements, researchers and designers can economically organize and identify information about users’ everyday experiences.

*(x 4)* also borrows a number of key elements found in scenario-building:

An Understanding about the Focus and Goal of Stories
Scenario-building, or storytelling, has been commonly used by business planners and strategists. Peter Schwartz (1991) defined scenario-building in a business context as follows: “. . . a tool for ordering one’s perceptions about alternative future environments in which one’s decisions might be played out. Alternatively: a set of organized ways for us to dream effectively about our own future” (Schwartz 1991: 4).

Three key concepts are embedded in this definition and are critical to effective scenario development:

• scenarios are tools for perceiving, not predicting. Good scenario developers focus on describing what might happen, rather than what they think will happen.
• multiple scenarios are required to explore the future. This is necessary because the future is uncertain. Scenario-building starkly contrasts with other planning methods that result in a single vision. As Schwartz notes: “Most other tools assume that in some way or another that if you get the model right you can actually predict the future. Scenario planning assumes that . . . we live in a time of fundamental uncertainty” (Schwartz 1991: 140).
• scenarios lead to decisions and concrete action.

An Understanding about the Value of Research
*(x 4)* relies on a foundation of research and is, thus, consistent with the way in which business scenarios are created. Schwartz argues that effective business scenarios must be based on excellent research. He suggests that scenarios are only accepted by people when they recognize some truth in the story. “The story resonates in some ways with what they already know, and then leads them from that resonance to repreceive the world. Observations from the real world must be built into the story. The only way they can emerge there is for the storyteller to sample evidence from the world before spinning the tale” (Schwartz 1991: 61).

The need for this type of empirical data from daily life is, in fact, the primary reason that *(x 4)* adopts ethnographic theory and methods. Although very limited in scope, *(x 4)* provides researchers and designers with a simple tool to gather some of the information Schwartz regards as essential for effective scenario-building.

In short, *(x 4)* integrates ethnographic and scenario-building methodologies. It specifically focuses on telling of stories about people’s experience, an activity that both ethnography and scenario building share. As suggested in Figure 2, ethnography tells stories about the past or the present. Business and design scenarios tell stories about the future. By bringing the two together, *(x 4)* helps create stories that integrate the past, present and future of user experience.
Theoretical Foundation of a (x 4)
a (x 4) is based on two theoretical assumptions relating to the design of experience.

Four Elements of Experience
a (x 4) is based on the assumption that experience is comprised of an interaction between actors (people), activities (tasks), artifacts (things) and atmosphere (context). a (x 4) emphasizes the interaction that occurs between the elements. That interaction is active or dynamic and constitutes what is meant by “experience.”

The Two Dimensions of Experience Design and Scenario-building
Telling stories about new user experiences requires knowledge of the present as a means to guide and fuel speculations about the future. In other words, scenario-building and experience design include both descriptive and prescriptive dimensions. a (x 4) was developed to address both of these dimensions, functioning as both a descriptive and prescriptive tool (as shown in Figure 3). Each specific part of the method is designed to either explore the present, speculate about the future, or some combination of the two.

Application Process
a (x 4) is applied in a relatively linear fashion (though this can be modified according to the constraints of specific projects or assignments). The process (see Figure 4) includes four “deliverables,” each of which corresponds to a different part of a three-phase development process:
The first step is to gather information about users and their everyday lives. This type of field research, often supported by secondary research into trends, technology development, etc., is identified by many experts as critical in the scenario development process (Suri and Marsh 2000; Moggridge 1993; Rhea 1992; Ireland and Johnson 1995; Couch, Sanders and Welker 1997). Suri and Marsh, for example, note: “The process begins by identifying the range of users, goals, tasks and activities which need to be considered. Ideally this exercise is based upon detailed research of users in context interacting with products, and using methods such as user profiling, field observation, contextual inquiry, protocol analysis and interviews” (Suri and Marsh 2000: 152).

During this early phase, a (x 4) is used fundamentally as a data collection and “learning tool.” It results in a highly useful body of knowledge (see Figure 4) about the users, activities and artifacts relevant to a specific project. Collecting and managing this type of “messy” data is a significant challenge which can quickly become overwhelming. a (x 4) helps address challenge because by focusing the research on a set of essential elements.
Snapshots
With a body of knowledge established, the next task is to make sense of the data. Snapshots can be effective in this process. Snapshots involve organizing, summarizing and communicating essential information that has been learned about the four key elements. Text-based or visual illustrations, constructed with a variety of media (e.g., photo/video, collages, hand drawn pictures, etc.), are commonly employed.

The following examples (see Image 1 and Image 2) were developed by a group of students to communicate information about different actors. As shown, the Snapshots were composed with different techniques and materials. Additional Snapshots were developed for each element of the a (x 4) framework, resulting in a comprehensive set of images to describe key information the students had learned about actors, activities, artifacts and atmosphere.

Snapshots are effective in the analysis process in three key ways:

• they compel researchers to organize, summarize and communicate information in the form of a “deliverable.” Focusing on the fabrication of a deliverable is helpful during analysis since qualitative data is notoriously “messy” and difficult to manage. Specific tasks or assignments help reduce this problem.
• *Snapshots* promote effective communication and understanding. This is important since analysis results are often the foundation upon which new development projects are built. Effective communication is, therefore, critical if analysis results are to be applied.

• *Snapshots* remain useful throughout the development process as quick references to refocus researchers and designers on important findings and conclusions.

**Visualizations**

The third part of a (x 4) involves speculating about the future of user experience by creating a highly descriptive image or set of images. Created before the development of more specific and highly defined scenarios and concepts, *Visualizations* help individuals and groups break free from overly restrictive constraints and limitations. If done properly, *Visualizations* create a broad, somewhat abstract image from which specific scenarios and concepts about user experience can later be constructed. The importance of this step should not be underestimated. As noted by Bill Moggridge (1993), effective scenario-building is based on a willingness to suspend real world concerns, free from constraints that often limit creativity.

Like *Snapshots*, *Visualizations* can be created in a variety of ways using different types of media (e.g., text, image, video, drawings, etc.). A few common principles need to be considered:

• *Visualizations* are structured around the interaction actors, activities, artifacts and atmosphere. The goal is to illustrate or describe this interaction.

• *Visualizations* are broad and speculative. As such, it is important to avoid developing the image(s) with too much specificity and detail. As shown in Image 3, *Visualizations* express a general tone, structure and attitude from which more detailed scenarios can later be developed. In effect, *Visualizations* provide an opportunity to dream about a new experience and speculate about the future without addressing immediate design problems or logistical issues.

• *Visualizations* are presentational. The ultimate function of a *Visualization* is to communicate a vision that provides guidance and meaning. As illustrated by Image 4, creating a final image about user experience requires clarity, decisiveness and imagination.

Image 3
Scenarios
With the previous steps completed, specific and detailed scenarios about user experience can be developed. Researchers and designers start this activity with considerable knowledge and insight about actors, activities, artifacts and the context (atmosphere) in which these all interact. They will have conducted field research, created detailed profiles or Snapshots, and developed a visionary, speculative image (or set of images) about a new experience. The form of the scenario can vary greatly depending on circumstances, time constraints and/or other needs and expectations. Common types include: written stories, illustrated stories, comics, storyboards, plays and, increasingly, multimedia productions.

Evaluation of a (x 4)
As a part of the development of a (x 4), a research project funded by Thomsom multimedia, Inc. was conducted to explore the effectiveness of a (x 4) as a research and concept-generating tool for developing scenarios and designing experience. A special upper-division course, offered at Arizona State University and called Interdisciplinary Conceptual Prototyping, was developed to introduce undergraduate students (juniors and seniors from business, industrial design, graphic design and interior design) to a (x 4) and experience design. As a part of the course, the student teams were required to apply a (x 4) in the development of conceptual scenarios about user experience. Two assignments were specified, giving the student teams ample opportunity to become familiar with a (x 4). The assignments required the students to do the following:

- complete Facts & Observations and create Snapshots and Visualizations.
- develop detailed scenarios, using storyboards to define characters, plot and setting.
- perform their concept (i.e., a new user experience) in front of a public audience.


**Topics/Questions**

The major question this research project explored was: Is a (x 4) an effective method for teaching and developing scenarios about user experience? For this project, effectiveness was measured by evaluating a (x 4) in terms of the following questions:

1. Was a (x 4) understandable?
   This question explored the students’ comprehension of a (x 4) as a group of elements and a process for gathering and analyzing data, and visualizing solutions in the form of scenarios about consumer experience.

2. Was a (x 4) useful?
   This question explored how the students define and describe the usefulness/utility of a (x 4) in terms of immediate and future needs or circumstances.

3. Did a (x 4) produce a significant change in awareness and capability?
   This question probed how/if exposure to a (x 4) changed the students’ awareness of development/design and their capabilities as future members of development teams.

**Methodology**

The project featured six phases:

1. Instruction
   During this phase, students were equipped with the basic knowledge and skill required to use a (x 4) in the development of scenarios about user experience. Field research exercises, lectures, presentations and readings were included during this four-week section.

2. Application Exercises
   The students were required to complete two application exercises. The first involved using a (x 4) and storyboarding to develop a specific scenario which was play-acted in front of a public audience. The exercise required students to create characters, props and a plot - all of which were derived from field research. The second exercise involved the students using a (x 4) to reinvent a common experience. The project included field research at local sites (e.g., a mini-putt site, gas station, etc.) and the development of drawings, written stories and Visualizations to describe a detailed user experience concept.

3. Data Collection
   To probe the primary topics/questions, semi-structured interviews were conducted with the students (a total of twelve interviews). The interviews were based on an interview guide and lasted approximately one hour. Consistent with semi-structured interviewing strategies (Robson 1993), the students’ were encouraged to “lead” the conversation, with the interviewer (an ASU research assistant hired to conduct the interviews) providing occasional probes and redirection to keep the conversation relevant to the research topics. The interviews occurred after the students had completed the second application exercise.

4. Analysis
   Three methods were used to analyze the data from the interviews:

   **Key Word and Phrase Identification:** words, phrases and patterns were identified and organized according to students’ comprehension of a (x 4), their sense of the usefulness of a (x 4) and any change a (x 4) had caused in their knowledge and attitudes.
Content Analysis: a content analysis was performed which led to the development of a coding structure comprised of four categories: about the elements of a \(a \times 4\); about the process of using a \(a \times 4\); about the value of a \(a \times 4\); and other.

Summarization: based on the key topics/questions, individual “summary memos” were composed for each of the interviews.

5. Observations and Conclusions
With analysis of the data complete, observations and conclusions were articulated.

Observations and Conclusions
The results of this research project suggest that \(a \times 4\) is reasonably effective in teaching and developing scenarios about consumer experience. Though differences were evident, the majority of students clearly understood \(a \times 4\) as a process or method comprised of a framework (actors, activities, artifacts and atmosphere) and a set of exercises (Facts and Observations, Snapshots and Visualizations). Most were also generally able to articulate the purpose of \(a \times 4\) and gave highly relevant examples of projects or disciplines (outside the scope of the class) where \(a \times 4\) would be useful. Finally, a number of the students said that exposure to \(a \times 4\) and the design of experience had expanded their capabilities and understanding of design.

Was \(a \times 4\) understandable?
“...to put it in an equation form was just so clear” (Klamrzynski 2001). The use of a common, simple framework (comprised of actors, activities, artifacts and atmosphere) clearly helped students conduct their projects. Some noted, for example, that the four-element framework made it easy to recall and use. As one student said: “It really is an easy way to remember the four things you need to remember and then go into more detail.” (Lulling 2001). Or as another noted: “...it just made it so clear to have this diagram (of \(a \times 4\)) that we could always refer to.” (Klamrzynski 2001).

“All four make one system” (Johnson 2001). Most of the students referred to \(a \times 4\) as a system that involved four interrelated elements and a process. The majority of students understood that the integration of the four elements was an essential feature of the system. They indicated that \(a \times 4\) helped them focus on this interaction rather than on discrete parts of an experience.

“I think there are some good tools here” (Krise 2001). Most of the students understood \(a \times 4\) as a “tool” for designing experience. They defined or described it with a variety of words, including: practical, realistic and easy to use.

Was \(a \times 4\) useful?
“I’m very structured and detail-oriented, so it really helped me” (Lulling 2001). Forty percent of the students used the word “structure” to describe the usefulness of \(a \times 4\). Their comments suggest that \(a \times 4\) helped them manage a relatively complex development process. Interestingly, the structure of \(a \times 4\) appealed to both structure-oriented and more intuitive students. For the former, \(a \times 4\) supported common behavior patterns. For the more intuitive students, \(a \times 4\) enabled them to overcome the confusion and uncertainty that commonly accompanied their work. As one of these students noted: “You didn’t feel like you’re just blindly going into a project” (Gilman 2001).

“It gives you more ways to get in contact with the user” (Johnson 2001).
All of the students identified *a (x 4)* as an effective way to learn about users and to explore design solutions from a user’s point-of-view. In fact, the emphasis on users was identified as the primary purpose of *a (x 4)*. “It forces us,” one student said, “to go through the process of really getting in the user’s head and try to actually be that person or that group of people” (Krise 2001).

“*a (x 4)* notched it up another level as far as creativity” (Jepson 2001).

Thirty percent of the students emphasized that *a (x 4)* helped them imagine more ideas or concepts. They emphasized that their creativity was stimulated during each step of the process. “Out of the research,” one student noted, “come a lot of ideas, but then those ideas double when you start getting into the scenario-building because you start realizing that maybe one of the ideas runs into some other idea also and then you have these two ideas work in synthesis. It kind of builds on itself” (Jepson 2001).

“I thought it was a really good way to test what you had theorized about” (Gilman 2001). Nearly half of the students stated that *a (x 4)* was useful in helping them evaluate and test ideas. They emphasized that storyboards and scenarios were effective tools for refining ideas and correcting mistakes. As one student said: “If I was just designing . . . without *a (x 4)*, I wouldn’t have gone through the testing as thoroughly and finding out the experiences of the person. It’s a better way to test all aspects of what you’re doing” (Gilman 2001). Another noted: “… when you have to actually go through the scenario you start to realize the mistakes you made by the quick judgments.” (Krise 2001). These observations were somewhat surprising since applying *a (x 4)* as a testing method was not a major goal nor emphasized in the course.

“… I do think that I got some principles and some tools to help me in presenting an idea better” (Mosley 2001).

The students also highlighted the communicative value of *a (x 4)*, indicating that it helped them present their ideas from a user’s point-of-view. They felt that this was a particularly powerful way to convey the most important aspects of a concept. “I think it’s a more effective way,” one student claimed, “to put the user in the space so that the audience can see things from the user’s perspective” (Mosley 2001).

“When I go to work, I will for sure think about *a (x 4)* and how I can apply what I learned. . .” (Gilman 2001).

Perhaps the most significant finding about usefulness was that many of the students easily identified other classes or projects that would benefit from *a (x 4)* (one individual had, in fact, already successfully applied parts of *a (x 4)* in a final presentation in another course). Others identified a variety of professional areas where *a (x 4)* might be useful, including training exercises in the business sector, exhibit design and events coordination. In each case, the students noted that the focus on users and the combination of research, analysis and testing would improve the likelihood of a successful design and/ or experience.

**Did *a (x 4)* produce a significant change in awareness and capability?**

“… it’s almost like designing in three dimensions for the first time” (Gilman 2001).

Most students credited *a (x 4)* with expanding their capabilities and awareness. Some referred to the fact that they had learned how to conduct research better; others noted that they had gained skills in storyboarding and brainstorming. Interestingly, most of the students (seventy percent) indicated that learning about *a (x 4)* and experience design changed how they defined the scope of design and their roles as designers. The words they chose to describe the change were revealing:
“It kind of broadens our outlook” (Pettibone 2001).
“This class kind of opened my eyes” (Johnson 2001).
“It’s changed my perspective” (Jepson 2001).
“Design has kind of opened up” (Gilman 2001).
“It’s changed me” (Klamrzynski 2001).

The most consistent theme was that a (x 4) and experience design had compelled the students to reconsider the meaning and value of skills, artifacts and experience. By focusing on experience, students saw beyond basic skills and concentrated on arguably higher level issues. “This is really so far out there,” one student noted, “as far as what we’ve been taught (in previous classes) . . . it’s so different, it’s really hard to reel yourself in from all that we’ve been taught and start thinking about how somebody is going to experience this concept” (Jepson 2001).

a (x 4) and experience design also changed how many of the students regarded the significance of artifacts (i.e., products, environments or communications). Increasingly, students viewed the creation of artifacts as secondary to the development of user experiences. This response was shared equally by students from business, graphic, industrial and interior design. As one product design student noted: “… products aren’t always the means of making money, it’s also the experience behind it” (Krise 2001).

Final Observations
Based on the results of this small study, a (x 4) seems to meet some of major criteria that a useful research and design method requires. First, it was readily understandable to the students who participated in the course. Without prompting, most were able to define and describe a (x 4) in great detail. In addition, they defined a (x 4) as an integrated system or method and regarded it as a practical (as opposed to theoretical) tool for accomplishing tasks.

Students also clearly felt a (x 4) provided tangible benefits and was, thus, “useful.” As Figure 6 illustrates, the students indicated that a (x 4) helped them focus and structure their thinking, expand their creative output, and present or communicate results.

Finally, learning about a (x 4) and the design of experience produced identifiable and generally positive changes in the students’ awareness and understanding of design (see Figure 7). The changes compelled the students to reconsider the meaning and value of artifacts and skills. While recognizing their importance, the students came to realize that showcasing skills and focusing on artifacts were secondary concerns which only gained meaning when used to support a more
comprehensive user experience. In sum, exposure to \( a (x \, 4) \) and the design of experience encouraged the students to consider what are arguably higher or more advanced design concerns relating to usefulness and experience.

<table>
<thead>
<tr>
<th>Before a ((x , 4))</th>
<th>After a ((x , 4))</th>
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<tbody>
<tr>
<td>demonstration of skills</td>
<td>search for usefulness</td>
</tr>
<tr>
<td>focus on artifacts</td>
<td>exploration of experience</td>
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<tr>
<td>remedial concerns</td>
<td>advanced concerns</td>
</tr>
</tbody>
</table>

Figure 7
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Putting it all together: bringing interdisciplinary research to the practice of designing interactive learning tools

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Abstract

Working within an interdisciplinary, collaborative context to bring research into design practice offers both challenges and opportunities in building strategic alliances for a common purpose, integrating methods of research, and transferring or translating the resulting knowledge into action. Integrating multiple methods requires an iterative, complementary approach to the design of research, characterised by the need for effective communicative strategies throughout the process. Two of the responsibilities inherent in applied research are to undertake useful research and to report it in ways that are accessible to people working in different disciplines, and usable in practice. We centre our discussion on three of our learner-centred studies, in which we integrated methods from applied developmental science, information design and instructional technology and to explore the design and use of Web sites and an interactive encyclopedia.
Putting it all together: bringing interdisciplinary research to the practice of designing interactive learning tools

Introduction
Designing appropriate and effective learning environments must include the consideration of the learner, the content and the learning media. Collaboration among researchers and designers with expertise in developmental science, information design and learning is essential to a successful process and outcome.

The nature of collaborative work among different disciplines is complex, as each discipline brings its own concepts, methods, structures and critical aspects. The phases of a collaborative process include building strategic alliances, integrating methods, and transferring or translating knowledge. Each phase carries its own challenges and opportunities. The process may be initiated in the public, practice or research spheres, and have a cyclical or interactive aspect, as the sharing of knowledge may prompt more questions, or the application of design guidelines to a product may require more testing. Critical input from practitioners and the public ensures useful activity.

Building strategic alliances
Strategic alliances have been formed between researchers and practitioners for benefits that include expanded boundaries of individual investigation (Klein 1996), enhanced funding opportunities (Herz 1994) and enriched process and practice (Hofmeester and de Charon de Saint Germain 1999).

Valuing a common goal of studying the learner clarifies our purpose, and allows for new opportunities for collaborative research and learning that could benefit design practice. Our team-based approach involves undergraduate and graduate students and faculty members in the design of research studies and interpretation of data, and features an iterative process towards the design, interpretation and presentation of research. Regular meetings take place in the Instructional Technology and Resources Lab in the Department of Psychology at the University of Alberta. Although we are all interested in the design of optimal learning materials, at this point, there is only one trained information designer on the team, who teaches on campus, and who entered the PhD program in Applied Developmental Science to learn more about how children learn with technology. Developmental psychologists draw upon a plurality of approaches to study development and learning, including those from the cognitive and socio-cultural domains. Cross-functional design teams, which may include psychologists, also use an iterative process, and multiple methods to develop multimedia commercial or educational products.

The work of researchers and practitioners alike can benefit from challenging popular ideas and assumptions (even our own) about learning with technology, and the design of learning tools. One such notion is that introducing technology in the classroom was the catalyst for a learning revolution. Another is the idea that the structure and function of hypermedia, with its links and nodes, parallels the structure and function of the human mind. These ideas do not appear to be strongly supported by research (Tergan 1997a), and in fact, because of deficiencies in design and research, we may even have vastly underestimated the potential of interactive learning media (Tergan 1997b).

The design of interactive media may have a critical effect on the use of learning tools, but not in the ways we might expect. The results from our learner-centred studies suggest that learners prefer easily-accessed, clearly presented information in an interactive encyclopedia and a non-confusing, familiar structure in Web sites. Our complementary approaches have provided a powerful opportunity to focus on learners’ motivations, preferences and learning strategies, which appear to
be more critical factors affecting the optimal design and use of learning tools, than the presentation of information.

Collaborative research allows participants, through learning, to become more effective practitioners (Bray, Lee, Smith and Yorks 2000). Successful integration of key elements in interactive design (information structure, instructional design, interaction possibilities and interface structures) is possible only through a collaborative team approach (Hedberg and Sims 2001). Interdisciplinary collaboration is like Mok’s (1996) description of interactivity design: finding a way for different systems (human plus other) to work together.

**Integrating methods**

Collaborative research is enabled through defining priorities, critically assessing methods, communicating effectively throughout an iterative process, and agreeing on how to make sense of the results. A collaborative research process, like any group work, is characterised by tasks of organisation, creation and negotiation. This process needs to be designed effectively (Heller 2001).

Rhetoric differs between and among research and practice cultures, and in addition to affecting how knowledge will be transferred, it can affect the communication during collaboration. It can be difficult to find a common language for communication (Flower, Gordon, Kolenda and Souder 1997), even if all team members are speaking English. For example, the word “design” is found in the literature of many disciplines, and is often used to identify the processes and products of planning for action and communication. Many interpretations are possible. An undergraduate design student at the University of Alberta recently surveyed two hundred people – students and non-students, designers and non-designers – for a definition of design. She received two hundred different answers (Moffat 2002).

The question of evidence is critical to research, especially where disciplinary boundaries are less-defined (Chandler, Davidson and Harootunian 1994). It is challenging to confront with critical questions of validity in terms of evidence, and relevance in terms of practical significance. Critical assessment of methods and approaches strengthens the value of research (Bray et al 2000). There may be irreconcilable worldviews, but even confronting these makes clearer the location of common ground. The coordination of different rigorous methods can help to validate common findings. It must be remembered, however, that results from a study are not necessarily generalisable or transferable to a specific population or situation. Rather, the methods may serve as models for studying a particular phenomenon. Rapid research is done by some designers as an effective means to get immediate answers. Yet, although undertaking research may take time due to ethics approval (a good thing), actually conducting a well-organised study may not take as long as may be perceived.

A multitude of quantitative and qualitative methods is available to design researchers (Hofmeester and de Charon de Saint Germain 1999) in categories such as direct design experience (e.g. user as developer), co-design (e.g. rapid prototyping and usability testing), co-research (e.g. visual anthropology and think-aloud protocols), expert observation (e.g. video ethnography and direct observation) and stimulus and interview (e.g. individual interviews, focus groups and conjoint techniques).

Our team has worked to integrate qualitative and quantitative research methods in our learner-centred work. Each method can be assessed in terms of validity and relevance, and the approach of integrating these methods may also be assessed. Our research methods include tracking navigational strategies, measuring recall from presented information, recording and analysing structured and semi-structured surveys and interviews regarding user experiences and preferences, using a think-
aloud protocol during children's representation of presented information, and observing children's participation in the conception and rapid prototyping of an interactive encyclopedia. Tracking navigation on the computer can verify participants' descriptions of their exploration of a Web site. Statistical tests help to describe participants and signal areas of significant relationship and possible effects that can bear further exploration. Finding themes through content analysis can enrich quantitative results, and confirm potential guidelines. There is still much to be learned about how to interpret and integrate verbal and visual data from the three studies described here.

**Study one: Children's representation of information presented in print and CD-ROM encyclopedias**

In this study (Sadler Takach, Varnhagen and Daniels 2002), we looked at how information presentation in print and CD-ROM encyclopedias affects children's retrieval of information and their visual representation of that information in research posters. Forty-three children, 26 girls and 17 boys, from three grade five classes participated in this study. The children were aged about 10 or 11 years. The materials consisted of a four-volume set of the "Junior version" of the *Canadian Encyclopedia*, and a Macintosh PowerBook laptop computer displaying the starting interface for "Student version" of the *Canadian Encyclopedia* on CD-ROM. Topic entries within each encyclopedia had similar content, images and text, within a slightly different presentation. The CD-ROM version offered sound files, dictionary listings and a quiz. We completely crossed media (print versus CD-ROM) and topic (lemming versus ptarmigan), and used a within-subjects research design to control for effects of topic and media order. Participants were randomly assigned to four different conditions. In individual sessions of 30 minutes, using a think-aloud protocol, participants searched for information about lemmings and ptarmigans using both encyclopedias, and sketched a small poster to show the life cycle of the lemming and of the ptarmigan. Participants then responded to semi-structured questions about their experience using encyclopedias, topic knowledge and attitudes towards searching for and presenting information.

We measured participants' time to search encyclopedias and to create the posters. Using a taxonomy chart developed from an analysis of characteristics in the encyclopedias, we scored features, such as words, images and composition, in the posters to compare participants' representation of knowledge in research posters to the information presented in the encyclopedias. We also counted the number of posters containing any visual or verbal reference to "life-cycle." Responses to three of the interview questions were coded and counted to examine the effects of prior experience, topic knowledge and attitudes towards using encyclopedias.

All participants reported some prior experience with encyclopedias (print, 88%; CD-ROM, 77%; on-line, 21% and with the Internet (95%). Over half (56%) of the participants preferred the CD-ROM version (print, 28%; no preference, 16%). The print encyclopedia was "more hands-on" and "gives more information." The CD-ROM version was "easier to read" and "easier to find [the topic]" since "you can type in what you want and it takes you there with no page-flipping."

On average, participants spent almost twice the amount of time to search the CD-ROM encyclopedia (7.0 min) as the print version (3.3 min). Children who had more experience using CD-ROM encyclopedias took less time to search for information, but there was no significant relationship between print encyclopedia experience and search time. Nor were there significant relationships between topic knowledge and search time (although very few children had any knowledge of the topics used in this study), or between preference for either encyclopedia and search time. It may be more difficult or even more interesting to search using the CD-ROM because there are more options. Some participants suggested that the CD-ROM encyclopedia was not well designed, as it wasn't clear where to type in a search term. In fact, the visual interface for this version was much more complex than the adult version, and seemed to be overloaded with features.
Even children with previous media experience were temporarily confused. Other effects may explain the difference in time.

On average, participants spent about the same amount of time to create posters after the print version (9.1 min) as after the CD-ROM (8.7 min). This may support children's having prior mental models of how to present information in research reports. Regarding comparison of features found in the posters with those present in the encyclopedias, there were only two features of significance: the use of comfortable margins, or white space, and the inclusion of paragraphs or paragraph-like chunks of textual information. Comfortable margins, or white space is a characteristic found only in the print encyclopedia, but we can't be sure this is a direct effect of information presentation in the print encyclopedia. Paragraphs were found in both encyclopedias. There was no significant relationship between prior media experience and the inclusion of information features in the posters. Verbal comments by many of the participants, during the research and poster tasks, and in the interview that followed, focused on the need to have easily-accessed, relevant, readable information, with images close to related text. Many participants had preferences for specific types of layout, mainly for the purposes of visual appeal and attracting attention to the title.

Only 18 out of the 43 participants represented "life cycle" in their posters. Children had to decide whether, or how to represent the concept of "life cycle" as there were no life-cycle diagrams for either topic in either encyclopedia, and only a textual reference to population cycle in both media entries about lemmings. They used a variety of visual strategies, from circular life-cycle diagrams with images, captions, and linking arrows to text and images with just a reference to "cycle" in headings. Some students commented that they had learned about animal life cycles in earlier grades, so it is possible that they had a prior mental model about how life cycles could be visually represented.

From the preliminary results from the first study, it appears that children may come to a research task with flexible strategies and mental models. They do not necessarily use the task to construct new knowledge and representation but may fit the new information to pre-existing mental models. Ease, convenience and speediness of use, and the availability and relevance of different types of information appear to be at least as important as the specific arrangement of the information.

Study two: Children's participation in the design of an interactive encyclopedia
In this study (Sadler Takach and Varnhagen 2002), we worked with children to explore appropriate methods to explore children's participation in the design of interactive educational media, and how these participatory experiences can inform the design of interactive learning media. We investigated a method that has been adapted from the methodologies of cooperative design, participatory design and contextual inquiry. This method, called "cooperative inquiry" (Druin, 1999), is a design approach to creating new technologies for children, with children, and involves discussion and hands-on working groups in the rapid iterative creation of prototypes. Participatory design processes have generally involved adults, but cooperative inquiry employs intergenerational teams. Using a scaled-down version of cooperative inquiry, we consulted with children only as learners, users, experts, researchers and designers to gain their insights about the kind of interactive encyclopedias that would be useful and usable for them. Although rich data were collected from the participants, the process of the cooperative inquiry, rather than the outcome (a prototype of an interactive encyclopedia), was the focus of this study.

Five grade five children, aged about 10 or 11 years, were chosen at random by their teacher and participated in three sessions for a total of two hours over three days. The first part of the study involved a 30-minute individual session. Participants searched a CD-ROM encyclopedia for information on lemmings and ptarmigans, using a think-aloud protocol, and then responded to
structured interview questions about how they found information, how the design of the encyclopedia affected their ability to do so, and how they would present what they found in a research poster. They were also asked about their attitudes towards different ways of finding and presenting information. In a second 30-minute session, the group of five participants responded to semi-structured interview questions about their experiences in the first session. They were asked how CD-ROM encyclopedias should be designed to help the user find information, and who should be on the design team. Responses were audiotaped for later comparison with written notes in the first two sessions. In a third, 60-minute session, the five participants worked collaboratively to design a rapid paper prototype of what they considered to be an effective CD-ROM encyclopedia in the form of sample ‘pages’. Comments were noted, and the working process was documented with sketches and photography. Several different types of verbal and visual data were collected, including self-reports and responses to questions, and observational notes, photographs, and sketches and notes done by the researcher to document the process. Data produced by the participants included a written schedule, brainstorming notes and drawings, and their presentation of the process, featuring screen templates and samples on a three-panel cardboard display.

Participants’ comments were similar to those in the first study regarding the need for easily accessible, clear information and with images close to related text. They insisted on the need for features that provide easy navigation to get at desired information. The students were also quite concerned with the appropriateness of features and their functions ("no weirdo stuff," must be "easy to understand if you don't speak English," must have "access for all ages" and we should "add voice button, in case people can't read"). They felt that the search function should be easier to use (it was labeled "smart" for smart search, and wasn't set apart from the other buttons ranging across the top), and they were surprised to find that they had trouble using the help function. They incorporated into the design of the prototype what they considered to be essential functions: search function, back button, bookmark and a place to store notes and documents.

We believe that being involved in this type of research-based, design-centred learning was enjoyable and beneficial for the participants. They were delighted with their efforts, and asked to present their prototype to their classmates. Although the children found it "frustrating to work this quickly" during the design activity, they were highly flexible, effective and innovative in thought and action, and want to continue the task to use authoring tools to design an improved interactive encyclopedia. We think that research and design teams could learn a lot from their collaborative process. We will analyse all of the verbal comments using content analysis, to look for themes that would support the development of guidelines for design. From our observations, it appears that combining methods that directly and actively involve children enrich our knowledge base.

Working with children in an interdisciplinary, collaborative context provides a powerful opportunity to focus not only on information presentation and other aspects of design, but on learners' motivations, preferences and learning strategies, which are critical factors affecting the optimal design and use of learning tools. Working with children as research and design partners is an essential part of developing useful design guidelines for interactive learning tools. We would like to continue to study the design process with children, and compare existing encyclopedias with one designed using guidelines from children.

**Study three: Web site structure and active learning**

In this study, we investigated how the design, in terms of structure, of a Web site can impact navigation and the recall of content (Daniels, Sadler Takach and Varnhagen 2002). We collected data from 93 undergraduate students (58 females and 35 males) enrolled in introductory psychology classes at the University of Alberta. Most (85%) were aged 18 to 20 years and the majority (66%) were in their first year of study. Participants were asked to evaluate the design of one of two Web
sites (one text-based, the other, metaphor-based) on IBM-compatible computers equipped with 17-inch monitors (1024 x 768 resolution). The browser control was hidden from view by using full-screen mode with auto-hide selected so the participants had to rely on the navigational structure of Web site to maneuver.

Participants were also asked to complete an on-line questionnaire about their backgrounds (age range, gender, year of study, experience with computers and the Internet) and their evaluations of the Web site (were they confused, did they like the Web site, was the text understandable). The questionnaire featured radio buttons for easy selection, with questions presented as statements in a Likert format. Participants submitted the completed questionnaire by clicking a button labeled “submit.” After the questionnaire, participants completed a free recall task by typing in as much information as possible from the Web site into a text box on screen. As before, they submitted their answers by clicking on a submit button. There was no time limit, but participants were generally finished viewing the Web site within five minutes, and were finished the study within 25 minutes.

The two Web sites viewed by the participants provided information about the imaginary “SouthWestern University” with the same content, but with different structure and offering different levels of familiarity. The text-based site was designed to include as many text conventions as possible to satisfy some expectations of users. This site contained a choice of three different text links (“getting in,” “academics,” and “sports & rec”) on the first level and offered two sub-headings for each topic on the second level and descriptive paragraphs under each sub-topic on the third and final level. The home page featured a logo and photograph of the university, and back and home functions were linked to the words “back” and “home” respectively.

The metaphor-based site substituted image or icon for type wherever possible, providing alternatives to text conventions and thus possibly disrupting some expectations for use. The structure of the Web site was designed to represent links metaphorically, through the function of the image, and therefore was not immediately obvious to viewers without prior experience. There were no obvious text cues, other than those provided by roll-overs that told the viewer where the links led, so participants had to rely on internal navigation in the Web site. The fictitious University was situated in the prairie lands of southern Alberta, a Canadian province. This area is known for the discovery of petroglyphs in a now-protected area called Writing-on-Stone. The first page featured a photographic image of a wheat field (symbolic of the Alberta landscape) on which are situated three petroglyphic characters with abstracted items. The first character is riding a blue scooter into the image (“getting in”). The other two figures are already in the image; one is reading a red book (“academics”) and the other is bouncing a yellow ball (“sports & rec”).

We assumed the unstructured nature of the Web would promote active learning, and that the metaphor site would afford higher recall than the text site. Thus, if participants had to work through it to understand it, they might internalise the information in a meaningful manner, which allowed them to recall more. We thought that participants might not remember as much from the text site because they didn’t have to work so hard to navigate. We wanted to see if how well participants liked the design of the Web sites was related to their experiences using the sites. We wanted to find out how much of the content they could recall, in terms of idea units, and how much time they spent navigating the site.

Participants in the text condition rated the Web site more understandable than those in the metaphor site, liked the Web site more, thought it was easier to navigate and found that the content was more understandable, than did the participants in the metaphor condition. Participants in the metaphor condition rated the Web site more interesting, and more confusing, and spent more time on levels one and two, than those in the text condition. Participants spent about the same amount of time on
level three, which contained all of the content information. Contrary to our expectations, there was no significant effect for the amount of recall based on the structure of the Web site. Participants in each condition recalled about the same amount of content, which suggests that structure had no effect on recall. These results do not seem to support the perspective of active learning.

Rather than assume the Web is a revolutionary pedagogical tool, we need to look at its unique aspects and at how people are using the Web as a tool, and see if it is possible to find principles that can help people make more effective use of the Web. These principles would be useful for educators and end-users, as well as designers. Further work will address users’ situational awareness (Ensley 1995) and the types of cues they require in the face of inordinate amounts of information in to avoid getting lost in hyperspace.

**Transferring knowledge**

Working to inform design practice is a cyclical process, from the identification of a need in society, to the development of a research-based practice, to further evaluation of designed products and services; all of which create a catalyst for more research. Integrated into this process are the other ways in which knowledge can be transferred or even translated to researchers, practitioners and the public. Unlike situations of commercial development, there need not be any proprietary issues that complicate the transfer of knowledge. Rhetoric differs between and among research and practice cultures, and this affects how knowledge will be translated. It also affects how it will be perceived by the public, which should be made aware of the of the value of research knowledge (Willinsky 2000).

The way in which results from statistical analysis are presented and “read” is different than that of the listing of themes that might result from a phenomenological study. Presenting knowledge as guidelines provides an interpretative summary that might appear to be applicable to design problems, and would make it difficult to critically evaluate the methods used to arrive at the guidelines. We could deliver a type of simultaneous translation. To provide a research report to satisfy as many users as possible may be a challenging problem of information design, but it would be useful in showing the complex aspects of the problem, and the approach and limitations of the research. We really need to determine the form in which designers need information.

We may all approach both design research and practice with some assumptions about the design of such things as learning tools that need to be challenged. In studying the user of learning tools, we have discovered that we must also consider the users of our research results. We must clarify and translate our knowledge to share it, and this activity not only provides a record of the process of our “meaning-making” but allows for a critical review of our ideas and methods which can enhance validity and value (Bray et al 2000).

For our actions to have impact, we must also promote public knowledge of the benefits of research. Interdisciplinary research can offer a rich knowledge base which is useful and accessible not only to researchers and designers, but to others interested in seeking knowledge about well-designed learning tools. Working within such a framework, for example, we can equip teachers, already challenged by the complex realities of integrating technology, with criteria for evaluating learning tools. We can also provide suggestions for meeting curricular goals, such as the development of critical thinking skills and the effective use of information and communication technologies, using the unique characteristics of interactive learning media. We will strive to make the information from our studies accessible to anyone seeking study results for whatever purpose.

There is a responsibility to promote research literacy through professional development and design education. There exists a huge amount of research knowledge published in print and electronic
form. How can design practitioners learn to access, assess and apply this knowledge, and even contribute to the bank of design-related research knowledge? Through the process of our own research, we may begin to understand the nature of the research literacy that must be acquired, and the value of interdisciplinary collaborations that must be understood by design students to become effective, responsible practitioners. Even non-design students (and other citizens) would need to be equipped with broad, interdisciplinary problem-solving skills to learn and work in a post-industrial society (Herz 1994).

**Putting it all together**

Through interdisciplinary collaboration, we are gaining an enriched understanding of how interactive learning can be designed and used more effectively, as well as how to put this research knowledge into best design practice. There are still many approaches to explore within this type of collaboratory relationship, such as investigating through practice-based research and the development of scenarios to visualise best practices in an interdisciplinary context. Our common ground lies in building strategic alliances, integrating research methods and finding ways to translate research knowledge into a form that is useful and accessible to researchers and practitioners in a variety of disciplines interested in designing media to empower learners with varying abilities, preferences and needs. In challenging our assumptions about learning, technology, disciplinary boundaries and the collaborative process, we are presented with the opportunities of a new question: How can we improve the design of the process and methods of interdisciplinary research and the translation of the forms of knowledge for use by a wider range of researchers, practitioners and the public?
References


Images of forces

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Abstract

The paper discusses how courses in mechanics can be taught to industrial design students and architectural students in a manner aimed at presenting concepts in such a way that mechanics becomes an inspiration for the design process rather than a limitation to it. In the courses of this sort that have been held, emphasis has been placed on the use of software for facilitating an intuitive understanding of physical matters related to mechanics and how that understanding can be transformed into design sketches. ForcePAD is a comprehensible software for making sketches and investigating patterns in mechanics. Its aim is to enhance the conception of such factors as balance, weight, stability, rest and movement, support forces, stress fields, and deformation. The paper is based on experience with classes of this sort taught both at Chalmers University in Gothenburg and at Lund University, the weekly tasks students have been given in courses of this type being discussed.
Images of forces

Introduction

Within industrial design and architecture the structural properties arrived at in the buildings and objects produced are often a consequence primarily of artistic intuition, of strict topology or use of readymade solutions. Their function however is often to carry a load. The aim of teaching should be to make the pattern of abstract forces involved both inspiring and readily accessible to the student of design so that the structure, rather than simply being a functional necessity, provides an image of forces.

Both Mechanics and Structural Mechanics introduce abstract symbols, conceptions and contexts, such as those of forces, mass, equilibrium, friction, centre of gravity, stability, tension, compression, and fracture, to mention but a few. Conceptions of this sort, which provide a means of better understanding the action of structures, are a consequence of the science paradigm, being based on objective qualities that are independent of our subjective interpretation of them. Courses here have the immediate practical goal, of course, of providing the understanding and the tools needed for the designing of structures. However, courses should also be taught in such a way that they become a source of inspiration in matters pertaining to design. Although the conceptions of mechanics are abstract, they relate to our understanding of how constructions form a well-functional structural system. It is also one of the great strengths of mechanics that both the conception and context exist in physical shapes, mechanics allowing us to experiment with materials and shapes so as to create the basis for an intuitive interpretation of the abstract content of the conceptions. We readily understand what is heavy, light, stable, in equilibrium or seems to be out of balance, or when the structure seems to be at the boundary of what it can withstand in term of exterior forces. The abstract, absolute thinking of science is related to our intuitive understanding since it takes as its reference the world around us, which we can observe and interpret in everyday life. Since the abstract ideas of mechanics exist in the form of physical shapes or are related to these, students can be trained to use them as sources of inspiration in design tasks and in preliminary sketches for these.

The context of mechanics provides a language, one that constitutes the basis for precision in design experiments. Design tasks can also be coupled to inner abstract ideas, the context of which is not a direct consequence of our immediate interpretation of shapes and is to a considerable degree independent of what our eyes alone can perceive. These experiments in shapes enable both analysis and synthesis to be carried out, an abstract content being transformed into actions by the hand. Thus, mechanics can also provide training in areas where abstract language does not necessarily take on a physical shape; it is serving as a metaphor for how we interpret such non-tangible systems.

In the following, two tasks students were given are described. Brief accounts of discussions with students are presented to indicate how the processes referred to above influenced them and allowed them to use elements of mechanics as a source of inspiration.

Examples - weekly tasks

Life-drawing

The mechanics of rigid bodies provides us only some few parameters by which such bodies can be controlled. In two dimensions, there is the centre of gravity together with three conditions of support. In three dimensions, there is an additional three conditions of support. Can this provide the basis for non-trivial reflections regarding a particular context and for exploiting the precision of
scientific methods? If we leave the context that interests us, even in only a very slight way, through becoming so preoccupied by precision that we find ourselves completely within a neutral engineering frame of reference, the physical experiencing of this context and our possibilities of investigating how we perceive it may readily become lost.

This first example starts in our perception and ends with a precise physical aspect of that perception. The volume, the density and the location of a collection of individual elements that possess mass govern the location of the center of gravity in a body or a system of bodies. One of the first exercises in rigid body mechanics that students of architecture at Chalmers University of Technology carry out aims at providing insight into this, and to train students in the use of the principles involved as a means of expression in the designing a building. After a brief introduction concerning the physical concepts of gravity and centre of gravity and use of them as metaphors in painting, students are ready to gain their own experience in such matters. They are given a piece of grey cardboard and a stick of white chalk, as well as a stick of black chalk, and gather around a living model. The goal of the exercise is to express, through use of the concept of centre of gravity, the balance inherent in the model. The white chalk is used to draw two types of abstract entities: a vertical line through the centre of gravity and the support or supports involved. The black chalk is used to indicate the balance around the vertical line through describing and interpreting the volume, the density and the arm movement. Twice during the exercise students are interrupted in their work to take part in a group discussion of how the balance the model demonstrates can be expressed, and how the physical entities involved can be interpreted.

![Figure 1: Life drawing with focus on balance around the centre of gravity](image)

The initial instructions are as follows: Use the white piece of chalk to look for the abstract entities, and use the black piece of chalk to examine the balance, either with areas of varying greyscale or with straight lines of varying length. Despite these instructions most students work with outline drawing and assembling a body configuration – not with density, levers, and moments. The discussion after the first intermission takes as a starting-point the difference between instructions and what is done. Most of the students then wipe out their black coal drawing, see the middle drawing above, and start all over.
This part of the exercise deals primarily with reflections on human perception and on physical necessities and principles. Students are asked, so as to strengthen the insights they have gained into the physical appearance of a balanced state, to analyse their drawings and make the center of gravity visible on the computer screen by the use of the computer program ForcePAD. They can also experiment with their drawings by adding or subtracting some particular mass or masses and tracing the consequences this will have on the force-of-gravity arrow, see Figure 2 (a-c) below.

The global equilibrium, which is governed by Newton's second law, requires in the two-dimensional case that three equilibrium equations be fulfilled, two for translation and one for rotation. The direction and magnitude of the reacting forces, if these are statically determinant, are dependent upon the position and direction of the movements that are prevented from occurring.

![Figure 2](image.png)

Figure 2: The green arrow shows the computed position of the resulting gravity force. (d) The blue bars indicate the position and direction of support and orange arrows represent the computed reaction forces.

The exercise also aims at enabling students to investigate the physical meaning of a movement's being prevented from occurring. They are to ask themselves what the supports are and what the consequences would be for the reacting forces if the position and/or the direction of a support were changed. On the computer screen, students can also carry out their own experiments in adding support or supports to the human body they have drawn, see Figure 2 (d). The actions and supports that they provide a living model with are to a considerable degree obvious, whereas in the exercises students take part in following this, dealing partly with natural and partly with built objects, they can have greater difficulties in grasping the supports involved and how they act.

The statics of rigid bodies is a small part of classical mechanics and is primarily an extension of Newton's first law. In textbooks on engineering mechanics, this part of the theory usually occupies only a few pages, partly because of the simple mechanism governing it – that of equilibrium – and partly because of the trivial mathematical tools available for solving predefined problems that are presented there. Nevertheless, it is the basis for very essential decisions to be made in the design process, those regarding the contact the body in question is to have with the external environment, requiring that one consider carefully the consequences that different types of contact – involving
the position and the directions of the support – would have. Choices made here affect the overall behaviour of the body, including the shape that is optimal, the need of external forces, the size of the forces of contact between the body and the surrounding material, and the like.

A tripod

One task given to first-year students of industrial design at Lund University is described for students as follows:

"Three points are defined in a horizontal plane and form an equal sided triangle. The side length is 1400 mm. A fourth point is defined 600 mm above this plane. At this position in space you shall be able to place an item weighing at least 5 kg. The size of the base area of item is 100×100 mm. The material is corrugated paperboard in sheets of the size 1000×600 mm. You can assemble the material by using glue, staples, or by knitting. But you have to choose only one of these means. The support of the structure must be within a circle with the diameter of 100 mm. The structure will be judged by the way it expresses how the load is carried, including how the load is transmitted from loading position to the support positions in the corners of the triangle. The structure should be as light as possible and a volley ball should be able to roll under it."

The major question for the student to consider here is how the solution arrived at expresses the external load and the path of the internal load, i.e. how the visible structure reflects the stresses present in the material, and how the material is utilized to accommodate these stresses. Students are to make sketches of the design of the structure intended. They are also to present arguments in support of their solution. To illustrate this, consider how two of the students presented and developed their arguments. Their brief sketches are presented in Figure 3 below. The drawing to the left, (a), represents their first suggestion. The basic idea was to have the loading position encircled by the structure. Since large parts of the structure do not contribute to the load-bearing capacity, one can ask whether it is possible both to let their intention of encircling the load be fulfilled and to let each part contribute to supporting the load. Allowing the structural parts to meet above the loading position would be one solution.

Figure 3: The first suggestion for the tripod that the structure should encircle the load, (a). Two suggestions for one leg of the tripod, (b)-(c)

(b) shows their first proposal along this line, in connection with which they argued for letting all the structural elements have the same visual direction. One could call the three parts involved the long element, the lower element, and the connector. Visual interest in the junction between the connector and the lower element is created here. It is not evident, however, that this is favourable from a
Their third proposal is shown to the right, (c). Here the connector shows the flow of forces in the external load instead, interest being directed at where the load is placed. Quick simulations also indicate the flow of the internal forces here to be different.

Figure 4: Stresses in one of the legs of the tripod, blue indicates compression and red indicates tension stresses, (a) first attempt, (b) final solution, (c) stiffeners have been attached, and (d) only high levels of stress are shown.

Whereas the proposal at the left in Figure 4, (a), gives rise to an unclear and mixed stress field, the connector and the lower element having both tensile and compressive states, the proposal (b) is better coordinated. The lower element and the connector are both exposed to tensile forces, which of course is favourable (remember, the tripod is constructed of corrugated cardboard). The compression evident in the long element needs to be dealt with by use of additional stiffeners (c-d), which were introduced in the final solution.

The tripod ready for testing is shown in Figure 5. Loads were applied until the structure collapsed. This particular tripod yielded with grace under the ultimate load, its rotating downwards as the legs collapsed. Even after the collapse the solution selected looks interesting, since the failure tells such a clear history, see Figure 6.

Figure 5: The final solution for a load-carrying tripod.
One can conclude, on the basis of the results of these brief tasks, that the experiment the students conducted and their discussion of it made them aware of the qualities of the material involved and how these can be used to express and articulate the shape of the structure created and to design and link together its various parts. These qualities are not readily apparent without a tool to make them visible.

**Reflections on force and form**

An industrial designer picks her pencil and starts drafting. What you expect to see is either a soft sketch grasping the outer shape imagined, or an abstract diagram indicating the inner functional relations and technical interactions. The two different modes of drafted form seldom meet. They represent two diverse paths of specialisation within the profession.

Some industrial designers emphasise the art of giving form to matter. Design is regarded as a semi-free expression of art, “to sculpture with a purpose” or “to mould a complex synthesis into a simple form”. Other designers favour the analytical approach. The design process is described in terms like “the problem comes first” or “to solve a problem”.

However there is a third way for the designer to practise in between the pure shape moulding or the simple problem solving.

Design is inventing. It is about finding shapes that not only have an interesting appearance but also actually are able to contain certain tangible properties. Streamlining is the classic case. Design is about finding solutions to precisely stated problems too, that results in expressive and original products. The Walkman is such an example.

Designing force-carrying structures is about inventing too. A structure that integrates strong spatial qualities with effective use of its material is second to none. Think about the Gothic cathedrals from eight hundred years ago. The delicate stone ribbons embrace the interior space like fan-shaped laces. They are true minimal structures that should be compared to the most efficient aeroplane construction and yet they allow their space to be penetrated by the light from the sun and the sky and allow their space to be cooled by natural ventilation through the open ribbons.

The seams of vintage yacht sails follow a similar structure. They function as a stiffening reinforcement of the sail to prevent sacking. Today, yacht sails are cast in polyester or similar plastic materials with reinforcement of stiffer textiles placed in the same fan-shapes like the seams
in the old sails. And in different products from the simple disposable cardboard cups for lunch break coffee to the most advanced communication satellites in outer space the art of achieving the highest stiffness from the smallest amount of material is the essential challenge for the industrial designer.

The method at hand, using ForcePAD, gives the inventive industrial designer an efficient tool to obtain immediate feedback from her sketches, when structural efficiency is of main concern. The feedback of ForcePAD is a two dimensional grid-map where the direction and intensity of the highest stresses suggest a structural pattern where material could be condensed in order to obtain most stiffness. The method is not a magic box, and there are no automatic solutions. The classic image of the stress trajectories from Carl Cullman’s grafic-statics from the 1860s only suggest and never define the optimal material efficient structure. And the contemporary computer algorithms that robotically design the most efficient structure do not invite dialogue in the model-man interface. However with the open structure of ForcePAD the industrial designer has a chance to impose her other constraints and play with the possibilities in the design process. And step-by-step the designer builds an experience by herself that enables her to integrate structural shapes with efficient force carrying abilities, with forms and spaces that are both interesting and expressive.

**ForcePAD**

ForcePAD is an educational software programme developed at the Division of Structural Mechanics at Lund University in collaboration with the Division of Building Design at Chalmers. Although it was conceived for use by students of industrial design and architecture, we believe it can be useful for other categories of students as well, due to its unique features. ForcePAD deals with a variety of different matters of physical character within the area of mechanics, such as the centre of gravity, loads, support reactions, deformation, and internal stresses.

A unique feature of it is its simple interface, which clearly mirrors the physical constituents involved. The interface mimics the conditions that sketching on a sheet of paper represents. The immediate consequences of adding material or a line or removing material by scratching, in terms of changes in form, adds to the simplicity of working with it, allowing ForcePAD to become an intimate part of design sketching in an educational context. Our experience with it is that it supports in a very genuine way a reflective process on the part of the user, providing both insight and inspiration in forming materials into shapes for creative and constructive ends. The programme supports an iterative process of reflective optimisation that the user is guided through, rather than its being software for simply an automatic optimization of shapes. Despite its not being software for advanced mechanical analysis, hidden within it are in fact some advanced finite element tools having optimizing characteristics computationally.

The figure below shows the interface. Through moving the cursor across the screen one can build up the shape desired. The grey scale is the metaphor for the amount of material or the stiffness. By adding support conditions and forces the student can launch computations that provide information about the internal stresses and deformation patterns. It is simple also to scan a picture or a drawing and paste it in on the ForcePAD working screen.

The ForcePAD application is implemented by use of a single-document interface (SDI). Thus, only one document or model can be opened at any given time, reducing the complexity of the interface. To make the interface as direct and as easy to use as possible, it was decided to remove the pull-down menus found in most standard applications. Instead, toolbars with large and multicoloured icons are employed. The left toolbar contains tools for creating and modifying the model, whereas the right one contains archive and cut-and-paste functions. The visualisation of displacements and stresses is controlled by use of a tabbed property page at the bottom of the window.
ForcePAD is implemented in C++. User-interface components are implemented by use of the FLTK 1.1.x library [1]. OpenGL [2] is used to implement ForcePAD’s 2D drawing functions. OpenGL is a software interface to 2D and 3D hardware which enables the direct and rapid visualisation of displacements and stresses to be performed.

Figure 7: The transition from a physical object to a photo or sketch that is pasted in on the ForcePAD-window so as to display the object’s non-tangible qualities.
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http://www.byggmek.lth.se/bmresources/forcepad/forcepad.htm
Images of forces

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Abstract

The paper discusses how courses in mechanics can be taught to industrial design students and architectural students in a manner aimed at presenting concepts in such a way that mechanics becomes an inspiration for the design process rather than a limitation to it. In the courses of this sort that have been held, emphasis has been placed on the use of software for facilitating an intuitive understanding of physical matters related to mechanics and how that understanding can be transformed into design sketches. ForcePAD is a comprehensible software for making sketches and investigating patterns in mechanics. Its aim is to enhance the conception of such factors as balance, weight, stability, rest and movement, support forces, stress fields, and deformation. The paper is based on experience with classes of this sort taught both at Chalmers University in Gothenburg and at Lund University, the weekly tasks students have been given in courses of this type being discussed.
Images of forces

Introduction
Within industrial design and architecture the structural properties arrived at in the buildings and objects produced are often a consequence primarily of artistic intuition, of strict topology or use of readymade solutions. Their function however is often to carry a load. The aim of teaching should be to make the pattern of abstract forces involved both inspiring and readily accessible to the student of design so that the structure, rather than simply being a functional necessity, provides an image of forces.

Both Mechanics and Structural Mechanics introduce abstract symbols, conceptions and contexts, such as those of forces, mass, equilibrium, friction, centre of gravity, stability, tension, compression, and fracture, to mention but a few. Conceptions of this sort, which provide a means of better understanding the action of structures, are a consequence of the science paradigm, being based on objective qualities that are independent of our subjective interpretation of them. Courses here have the immediate practical goal, of course, of providing the understanding and the tools needed for the designing of structures. However, courses should also be taught in such a way that they become a source of inspiration in matters pertaining to design. Although the conceptions of mechanics are abstract, they relate to our understanding of how constructions form a well-functional structural system. It is also one of the great strengths of mechanics that both the conception and context exist in physical shapes, mechanics allowing us to experiment with materials and shapes so as to create the basis for an intuitive interpretation of the abstract content of the conceptions. We readily understand what is heavy, light, stable, in equilibrium or seems to be out of balance, or when the structure seems to be at the boundary of what it can withstand in term of exterior forces. The abstract, absolute thinking of science is related to our intuitive understanding since it takes as its reference the world around us, which we can observe and interpret in everyday life. Since the abstract ideas of mechanics exist in the form of physical shapes or are related to these, students can be trained to use them as sources of inspiration in design tasks and in preliminary sketches for these.

The context of mechanics provides a language, one that constitutes the basis for precision in design experiments. Design tasks can also be coupled to inner abstract ideas, the context of which is not a direct consequence of our immediate interpretation of shapes and is to a considerable degree independent of what our eyes alone can perceive. These experiments in shapes enable both analysis and synthesis to be carried out, an abstract content being transformed into actions by the hand. Thus, mechanics can also provide training in areas where abstract language does not necessarily take on a physical shape; it is serving as a metaphor for how we interpret such non-tangible systems.

In the following, two tasks students were given are described. Brief accounts of discussions with students are presented to indicate how the processes referred to above influenced them and allowed them to use elements of mechanics as a source of inspiration.

Examples - weekly tasks

Life-drawing
The mechanics of rigid bodies provides us only some few parameters by which such bodies can be controlled. In two dimensions, there is the centre of gravity together with three conditions of support. In three dimensions, there is an additional three conditions of support. Can this provide the basis for non-trivial reflections regarding a particular context and for exploiting the precision of
scientific methods? If we leave the context that interests us, even in only a very slight way, through becoming so preoccupied by precision that we find ourselves completely within a neutral engineering frame of reference, the physical experiencing of this context and our possibilities of investigating how we perceive it may readily become lost.

This first example starts in our perception and ends with a precise physical aspect of that perception. The volume, the density and the location of a collection of individual elements that possess mass govern the location of the center of gravity in a body or a system of bodies. One of the first exercises in rigid body mechanics that students of architecture at Chalmers University of Technology carry out aims at providing insight into this, and to train students in the use of the principles involved as a means of expression in the designing a building. After a brief introduction concerning the physical concepts of gravity and centre of gravity and use of them as metaphors in painting, students are ready to gain their own experience in such matters. They are given a piece of grey cardboard and a stick of white chalk, as well as a stick of black chalk, and gather around a living model. The goal of the exercise is to express, through use of the concept of centre of gravity, the balance inherent in the model. The white chalk is used to draw two types of abstract entities: a vertical line through the centre of gravity and the support or supports involved. The black chalk is used to indicate the balance around the vertical line through describing and interpreting the volume, the density and the arm movement. Twice during the exercise students are interrupted in their work to take part in a group discussion of how the balance the model demonstrates can be expressed, and how the physical entities involved can be interpreted.

![Figure 1: Life drawing with focus on balance around the centre of gravity](image)

The initial instructions are as follows: Use the white piece of chalk to look for the abstract entities, and use the black piece of chalk to examine the balance, either with areas of varying greyscale or with straight lines of varying length. Despite these instructions most students work with outline drawing and assembling a body configuration – not with density, levers, and moments. The discussion after the first intermission takes as a starting-point the difference between instructions and what is done. Most of the students then wipe out their black coal drawing, see the middle drawing above, and start all over.
This part of the exercise deals primarily with reflections on human perception and on physical necessities and principles. Students are asked, so as to strengthen the insights they have gained into the physical appearance of a balanced state, to analyse their drawings and make the center of gravity visible on the computer screen by the use of the computer program ForcePAD. They can also experiment with their drawings by adding or subtracting some particular mass or masses and tracing the consequences this will have on the force-of-gravity arrow, see Figure 2 (a-c) below.

The global equilibrium, which is governed by Newton's second law, requires in the two-dimensional case that three equilibrium equations be fulfilled, two for translation and one for rotation. The direction and magnitude of the reacting forces, if these are statically determinant, are dependent upon the position and direction of the movements that are prevented from occurring.

Figure 2: The green arrow shows the computed position of the resulting gravity force. (d) The blue bars indicate the position and direction of support and orange arrows represent the computed reaction forces.

The exercise also aims at enabling students to investigate the physical meaning of a movement's being prevented from occurring. They are to ask themselves what the supports are and what the consequences would be for the reacting forces if the position and/or the direction of a support were changed. On the computer screen, students can also carry out their own experiments in adding support or supports to the human body they have drawn, see Figure 2 (d). The actions and supports that they provide a living model with are to a considerable degree obvious, whereas in the exercises students take part in following this, dealing partly with natural and partly with built objects, they can have greater difficulties in grasping the supports involved and how they act.

The statics of rigid bodies is a small part of classical mechanics and is primarily an extension of Newton's first law. In textbooks on engineering mechanics, this part of the theory usually occupies only a few pages, partly because of the simple mechanism governing it – that of equilibrium – and partly because of the trivial mathematical tools available for solving predefined problems that are presented there. Nevertheless, it is the basis for very essential decisions to be made in the design process, those regarding the contact the body in question is to have with the external environment, requiring that one consider carefully the consequences that different types of contact – involving
the position and the directions of the support – would have. Choices made here affect the overall behaviour of the body, including the shape that is optimal, the need of external forces, the size of the forces of contact between the body and the surrounding material, and the like.

A tripod

One task given to first-year students of industrial design at Lund University is described for students as follows:

"Three points are defined in a horizontal plane and form an equal sided triangle. The side length is 1400 mm. A fourth point is defined 600 mm above this plane. At this position in space you shall be able to place an item weighing at least 5 kg. The size of the base area of item is 100×100 mm. The material is corrugated paperboard in sheets of the size 1000×600 mm. You can assemble the material by using glue, staples, or by knitting. But you have to choose only one of these means. The support of the structure must be within a circle with the diameter of 100 mm. The structure will be judged by the way it expresses how the load is carried, including how the load is transmitted from loading position to the support positions in the corners of the triangle. The structure should be as light as possible and a volley ball should be able to roll under it."

The major question for the student to consider here is how the solution arrived at expresses the external load and the path of the internal load, i.e. how the visible structure reflects the stresses present in the material, and how the material is utilized to accommodate these stresses. Students are to make sketches of the design of the structure intended. They are also to present arguments in support of their solution. To illustrate this, consider how two of the students presented and developed their arguments. Their brief sketches are presented in Figure 3 below. The drawing to the left, (a), represents their first suggestion. The basic idea was to have the loading position encircled by the structure. Since large parts of the structure do not contribute to the load-bearing capacity, one can ask whether it is possible both to let their intention of encircling the load be fulfilled and to let each part contribute to supporting the load. Allowing the structural parts to meet above the loading position would be one solution.

Figure 3: The first suggestion for the tripod that the structure should encircle the load, (a). Two suggestions for one leg of the tripod, (b)-(c)

(b) shows their first proposal along this line, in connection with which they argued for letting all the structural elements have the same visual direction. One could call the three parts involved the long element, the lower element, and the connector. Visual interest in the junction between the connector and the lower element is created here. It is not evident, however, that this is favourable from a
structural point of view. Their third proposal is shown to the right, (c). Here the connector shows the flow of forces in the external load instead, interest being directed at where the load is placed. Quick simulations also indicate the flow of the internal forces here to be different.

Figure 4: Stresses in one of the legs of the tripod, blue indicates compression and red indicates tension stresses, (a) first attempt, (b) final solution, (c) stiffeners have been attached, and (d) only high levels of stress are shown.

Whereas the proposal at the left in Figure 4, (a), gives rise to an unclear and mixed stress field, the connector and the lower element having both tensile and compressive states, the proposal (b) is better coordinated. The lower element and the connector are both exposed to tensile forces, which of course is favourable (remember, the tripod is constructed of corrugated cardboard). The compression evident in the long element needs to be dealt with by use of additional stiffeners (c-d), which were introduced in the final solution.

The tripod ready for testing is shown in Figure 5. Loads were applied until the structure collapsed. This particular tripod yielded with grace under the ultimate load, its rotating downwards as the legs collapsed. Even after the collapse the solution selected looks interesting, since the failure tells such a clear history, see Figure 6.

Figure 5: The final solution for a load-carrying tripod.
One can conclude, on the basis of the results of these brief tasks, that the experiment the students conducted and their discussion of it made them aware of the qualities of the material involved and how these can be used to express and articulate the shape of the structure created and to design and link together its various parts. These qualities are not readily apparent without a tool to make them visible.

**Reflections on force and form**

An industrial designer picks her pencil and starts drafting. What you expect to see is either a soft sketch grasping the outer shape imagined, or an abstract diagram indicating the inner functional relations and technical interactions. The two different modes of drafted form seldom meet. They represent two diverse paths of specialisation within the profession.

Some industrial designers emphasise the art of giving form to matter. Design is regarded as a semi-free expression of art, “to sculpture with a purpose” or “to mould a complex synthesis into a simple form”. Other designers favour the analytical approach. The design process is described in terms like “the problem comes first” or “to solve a problem”.

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Extending the design problem-solving process model: requirements and outcomes

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Abstract

In this paper we extend existing design problem-solving models by the explicit inclusion of requirements and evaluation outcomes. We emphasise the importance of the notion of an evaluation outcome, arguing that it is not simply the term 'negative' or 'positive'. Rather it is a relation between a solution and a requirement(s) expressing whether, why, and to what extent the anticipated effect of the proposed solution is positive or negative. Like requirements and solutions, evaluation outcomes function as objects of reasoning (e.g., ideation). We describe an empirical study of four design dyads engaged in a design task, in which designers’ talk provides evidence for the productions and relations posited in the model. The results show that the explicit consideration of requirements figures in 77.6% of utterances coded, that evaluation outcomes represent 42% of all utterances, and that evaluation outcomes are involved in 21.4% of all solutions uttered. We conclude that we need to understand how design reasoning utilises requirements, solution and evaluation outcomes to achieve design goals.
Extending the design problem-solving process model: requirements and outcomes

Introduction
Design requirements are a product planning team’s characterisation of the perceived needs around the product environment, whether in terms of a device, user, process, software, system, organisation, marketing environment, etc. (Suh 1990). Usually, these initial perceived needs are transferred to the goals of product development. In order to work practically with goals, it is useful if they are characterised into one or more statements. Any characterised statement about a goal is called an objective. A design requirement is an objective that has to be met by the design (Roozenburg and Eekels 1995).

A number of studies have stressed the importance of customer requirements as a source for new product ideas (Logan 1997; Wood 1996). Many studies (Cooper 1987; Davidson 1976; Maidique and Zirger 1985; Bruce and Rodgus 1991; Montoya-weiss and Calantone 1994; Walsh et al. 1992) have found that the factors that distinguish new product success from failure are the consideration and understanding of user requirements. Darnell, Howell and Collins (1989) also argue that the most frequent cause of project failure during the design stage is a failure to properly define at the outset the objectives and design requirements.

Given the recognised importance of design requirements we set out to investigate whether the representation, or form, of design requirements influenced the extent to which they were considered during the design problem-solving process. With this in mind we sought a design problem-solving model which captured the role of design requirements in the design process as a basis for predicting how representational format might facilitate, or otherwise, the consideration of design requirements. A review of design problem-solving process models in the literature revealed that the potential role of design requirements in the process had not been fully represented.

In this paper, we first present a model of the design problem-solving process that extends earlier models through the inclusion of both design requirements and evaluation outcomes as inputs to and products of cognitive processes. We then describe a protocol analysis study undertaken in order to obtain evidence of designers’ reasoning about the productions and relations represented in the model. We will argue that the results of this study support the extended model and demonstrate the importance of requirements and evaluation outcomes in design reasoning. We will conclude that future research should focus on understanding how design reasoning utilises requirements, solution and evaluation outcomes to achieve design goals.

Design problem-solving process models
Many design researchers have explored the process of design (Archer 1969; Groot 1969; French 1985; Kim 1990; Lawson 1990; Suh 1990; Pugh 1991; Roozenburg and Eekels 1995; Ulrich and Eppinger 1995; Pahl and Beitz 1996). The models discussed here have been selected because of their historical significance and because they make a contribution to understanding the role of design requirements in the design problem-solving process.

![Figure 1: Mental process of gaining experience (Source: Groot 1969)](image-url)
De Groot (1969) proposed the fundamental problem-solving process by which humans gain experience (Figure 1). Through the continuous repetition of the process, the human’s experience or proficiency is increased. The process begins with observation through which the problem to be solved is perceived and confronted. Having learnt from the experiences of earlier cycles, the problem-solver proceeds on the assumption that the problem-solver can act, or can learn to react, differently with respect to the problem observed. De Groot (*ibid.*) argues that one of the important notions in learning from experience is that the problem-solving process must include a process of observation. The problem solver is not merely trying to achieve the end, but is also ‘trying out’ something to ascertain if it is correct. In other words, a problem solver conceives of a supposition in which he entertains the possibility of certain connections and relationships in the task situation to actions that might solve the problem. This view of the situation generates expectations with regard to the effects of problem-solvers’ actions in the problem situation which reflect on the goal or criteria. Subsequent action of the problem-solver is followed by a process of testing to see whether expectations are met and whether the anticipated effect is positive or negative (‘good’ or ‘bad’). The information in respect to the value of the results obtained is then assimilated to evaluate how to utilise the experiences gained, in the next cycle.

Kim’s (1990) model characterises the iterative thought process in creative problem-solving, Figure 2. This model starts with the term ‘Problem’. This term refers in a general sense to any mental activity having some recognisable goal to be satisfied. This ‘Problem’ expression represents the result of the observation stage in De Groot’s (1969) model. This stage involves the clarification of the design task, analysis of available information and initial exploration of the ill-defined design problem space. Many of the design requirements that emerge in this stage can be used later in evaluating solution proposals.

![Figure 2: Components of the creative problem-solving process (Source: Kim 1990)](image)

Since, typically, a design problem is ill-defined the obstacles are not obvious at the beginning, and designers tend to apply solution-focused strategies to generate a provisional solution to remove these obstacles. Therefore, ideation relates to the actions designed to move forward and create a response to the problem and the design requirements. Essentially, it is the generation of a solution or solutions. Evaluation involves the critical testing and assessment of proposed solutions against the goals, constraints and criteria identified in the problem exploration or observation phase to see whether the outcome is positive or negative (‘good’ or ‘bad’). If the outcome is negative, the process moves back to the ideation stage to look for new solutions.

Hence, the fundamental problem-solving phase consists of a sequence of ideation-and-evaluation cycles reflecting De Groot’s (1969) processes of supposition, expectation and testing. According to Kim (1990), potential solutions or intermediate results are connected, evaluated for their utility, and examined to guide the next cycle of idea generation. The new solution idea may represent a minor variation to an existing solution candidate. This procedure usually continues until an acceptable
solution is found. Kim’s (*ibid.*) model implicitly identifies a role for requirements in both ideation and evaluation.

Roozenburg and Eekels (1995) develop an iterative, spiral-like design process, see Figure 3. The cycle begins with the term ‘Function’, which is essentially the same as the term ‘Problem’ in the Kim’s model referring to the obstacle to be removed between the undesirable initial state and a desired goal state. ‘Spec’ refers to design requirements in the design specification that the solution should fulfil (the numbers associated with each ‘Spec’ indicating that this is developed as the process develops). The ‘Design’ step, following review of the design specification, refers to the generation of proposed solutions. The ‘Properties’ of each solution fulfils one or more functions. The properties of the proposed solution are then compared to the requirements in the specification to evaluate the extent to which they are satisfied by the solution.

Generally, a design proposal is consistent with one or more requirements and in conflict with others, thus the design solution must be developed further to reduce the conflicts and inconsistencies. Therefore, the process will return to the ideation stage to iterate further. This model represents design as a spiral-like process in which the design solution is continually generated while considering the design requirements and assessing the match between the solution properties and the requirements of the design specification. The development cycle is not completed until an ‘approved’ design is found. Hence, the design process can be conceptualised as a series of solution-evaluating cycles carried out by designers to integrate the design requirements to increase the optimality of the solution (Bailetti and Litva 1995).

![Figure 3: Iterative design process structure (Source: Roozenburg & Eekels 1995)](image-url)

Roozenburg and Eekels (1995) explain that experience not only feeds back to the design proposal but also to the formulation of the problem and the list of design requirements. Through the development, in the light of newly discovered solution variants, one will gain more understanding of the initial design problem and design requirements, more observation or analysis may be conducted to reformulate the design problem. Thus, the design and design specification are developed in successive cycles, interacting strongly until they fit one another. Roozenburg and Eekels’s (*ibid.*) model makes explicit both processes and products. It shows that requirements feed
into both designing and that comparing involves both solutions and requirements, and that comparing may generate new requirements.

From the above three models, it can be determined that there are three primary cognitive processes that relate to design requirements in the design problem-solving process: observation/analysis (De Groot 1969; implicit in Kim, 1990, and Roozenburg and Eekels, 1995), supposition/ideation/design (De Groot 1969; Kim 1990; Roozenburg and Eekels 1995) and testing/evaluation/comparison (De Groot 1969; Kim 1990; Roozenburg and Eekels 1995). The outputs of the three cognitive processes are the problem/function (Kim 1990; Roozenburg and Eekels 1995), solution/properties (Kim 1990; Roozenburg and Eekels 1995) and evaluate/compare (De Groot 1969; Kim 1990).

Of these models, Roozenburg and Eekels’ is the most complete in the sense that it depicts processes, outputs, and the relations between them. What their (ibid.) model fails to represent, in terms of the entities postulated, is the observation/analysis function and positive/good or negative/bad outcome. For our purposes it was necessary to develop a model that was fully representative of current understanding and which incorporated any entities and relationship not represented in these existing models.

**An extended design problem-solving process model**

It has been established from the consideration of the three models above that three primary cognitive processes are accessed: analysis, ideation and evaluation. These are presented in Figure 4 by black rectangles. The ‘Observe or Analyse’ process produces the ‘Function or Problem’ as the output of investigating and clarifying the key design issues and problems involved in attaining the goal in the task situation (outputs are represented by grey rectangles in Figure 4). This output also provides input for the ideation/supposition process (requirement input/outputs being represented by black arrows).

![Diagram of the design problem-solving process model incorporating requirements and outcomes](image-url)

Figure 4: The design problem-solving process model incorporating requirements and outcomes
The ‘Ideate or Suppose’ process produces a ‘Solution or Design’ as output, and the ‘Evaluate or Compare’ process can produce an ‘Outcome’. The idea of an outcome is not described or represented in earlier models. In the following we will present the rationale for its inclusion.

The ‘Solution or Design’ is depicted as the input to the ‘Evaluate or Compare’ process. An evaluation is negative if the proposed solution conflicts or is inconsistent with a design requirement(s) creating a sub-problem or new problem. If the proposed solution is confirmed as consistent with a design requirement(s), the result of the evaluation is positive. A negative outcome, in a sense, indicates that further work on the proposed solution is required. Of course, a positive outcome does not mean that the design process is complete.

However, the result of evaluation is not simply the term ‘negative’ or ‘positive’. Instead, we posit that it is a relation between a solution and a requirement(s) expressing whether, why, and to what extent the anticipated effect of the proposed solution is positive or negative. When a solution is evaluated negatively the design process must iterate, the designer searching for an enhanced or alternative solution. But a solution enhanced or alternative with respect to what? The answer to this is the previously evaluated solution: but not simply the solution. Evaluation relates requirement(s) to solution and assesses the quality of the relation. We posit that the next phase of ideation is developed with respect to a description of this relation and its assessment. Hence, just as a solution is explicitly represented as a product of ideation because it functions as an object of reasoning (e.g. ideation) then an ‘Outcome’ needs to be represented as the overall output of the evaluation process, since it too can function in subsequent reasoning. Although a design proposal may satisfy some design requirements, some may remain to be satisfied. Hence, regardless of whether or not an evaluation is negative or positive it will contribute an outcome to the pool of those available for subsequent reasoning. (The white arrows in Figure 4 represent the input action, while generative actions are represented using grey arrows.) Figure 5 illustrates how outcomes appear in actual discourse between designers. This outcome might be written more abstractly as ‘a solution having vertical bars close to the wheel is desirable as it satisfies the requirement of being easy to load because it is positioned at a low height’.

“Quite low because we’ve set vertical bars as close as possible to the wheel [solution] so it’s quite low [why it is easy to load] and not difficult to load [requirement = easy to load].”

Figure 5: Fragment of a transcript of a design task

The fundamental elements of the design problem-solving process have now been established and related in the above model. Next we consider the role of requirements in the process. First, since requirements may be determined with respect to the original function or problem, they can be presented as the output of the observation process. Additionally, requirements may be perceived or generated not only through the evaluation but also in the ideation process, where designers are able to detect and understand important issues and requirements of the function or problem (Lawson 1997; Suwa et al. 1998; Suwa et al. 1999). Cross (1994) argues that proposing solutions is a means of understanding the problem and exposing many assumptions about the problem, and specific areas of uncertainty that could not be otherwise uncovered. As a consequence, the formulation of the requirements may or may not be changed. Figure 4 shows the production of requirements (REQs) within the design process as the output of the observation, ideation, and evaluation processes. Requirement generation activities are represented using arrows pointing towards the REQs symbol.

In essence, it is argued that design requirements provide the designer with guidelines for creating a feasible design concept, a set of criteria against which to evaluate alternative solution proposals.
(Walsh et al. 1992), and a means by which the ‘value’ or ‘quality’ of the design solution can be judged. Moreover, as revealed in the discussion of existent process models, the process is continually developing. The ‘Outcome’ of an evaluation may feed into (also shown as black arrows in Figure 4) the ‘Ideate or Suppose’ process and a new or modified solution is proposed. Requirements may then feed into the ‘Evaluate or Compare’ process where the solution is further tested yielding an ‘Outcome’.

From the proposed model, it is evident that the requirements play a primary role in the cognitive processes of ‘Observe or Analyse’, ‘Ideate or Suppose’ and ‘Evaluate or Compare’. Equally important, in our view, is the representation of outcomes in the process model, because these outcomes capture the relationship between solutions and requirements, and which may thereby impose a guiding influence on the design process, both in terms of suppressing and stimulating lines of thought.

Validating the model

The Liang-Scrivener-Ball model of the design problem-solving process presented above extends previous models by explicitly representing requirements and evaluation outcomes. The model predicts that the cognitive processes of ‘Ideate or Suppose’ and ‘Evaluate and Compare’ will draw on, respectively, outcomes and/or requirements and solutions and requirements. In this section we describe a study designed to uncover evidence of the new relationships represented in it. In particular, we sought evidence of:

1. requirements, solutions and outcomes (i.e., productions);
2. solutions related to outcomes and/or requirements, and outcomes related to solutions and requirements (i.e., relationships).

Many methods for researching design thinking have been described by Cross (1992), including interviews with designers, observation and case studies, protocol studies, controlled tests, and reflection and theorising. Cross, Christiaans and Dorst (1996a) argue that of all the empirical, observational research methods for the analysis of design activity, protocol analysis has become to be regarded as the most likely method for uncovering design cognition. We concluded that protocol analysis would be appropriate for our purpose because of the theoretical link between thought and language that underpins the method. If the objects and relations represented in the model were involved in thinking then they should be evident in designers’ talk during design.

Task, participants and procedure

The task and information sources used in this study were the same as those developed by Cross, Christiaans and Dorst (1996b) for an international workshop on the use of protocol analysis in design research - ‘Research in Design Thinking II – Analysing Design Activity’ held in Delft, in 1994. In our study, two groups of four design dyads worked for two hours on the same design task to develop a product concept for a product to fasten and carry a backpack on a mountain bike.

In order to confirm the expectation that new requirements would emerge during the design process it was necessary to elucidate the requirements of the brief. The design requirements written into the brief for the study were produced by the following analyses:

1. identification of those written into the original Delft brief,
2. identification of those reported in papers analysing the the study (Cross et al. 1996b) and other Delft information,
3. application of the IDEO Scenario Method (Fulton-Suri et al. 1993), a visual confrontation method, to capture additional requirements.
The original Delft brief included the additional requirements derived from 2 and 3, thus producing the study brief.

Four design dyads participated in the study. The eight participants were all final year BSc Industrial Design students. A design studio was equipped with audio and video recording facilities. The drawing materials provided to the designers included A4 and A3 layout pads, pencils, black pens, marker pens, pastels, coloured pencils, a ruler and measuring tape. They were also provided with a mountain bike and the backpack for use as necessary during the design assignment. The verbal discourse of each design dyad was recorded and transcribed for protocol analysis.

**Coding**

The encoding process was designed to capture the different relations and products identified in the design problem-solving process model described above. Hence, the turn-structured protocol data of the design discourse activities were encoded in terms of the design process model (see Figure 4). The transcripts were coded as follows:

An utterance was coded as a **REQUIREMENT** if it:
1. matched a pre-determined design brief requirement, for example, ‘by law the maximum width of anything attached to a bicycle is 25.6’;
2. was a requirement implicit in the other information in the brief. For example, this information included a drawing of the backpack as a single object that conveyed an implicit requirement for a single backpack. So when the designers uttered the phrase ‘it’s only one pack’ when viewing this drawing we took this to be recognition of this implicit requirement; or
3. expressed a need or want generated by the designers themselves.

The latter two were expected to arise during solution proposition or evaluation.

An utterance stating a possible or provisional design proposal in response to the brief, particular requirements, or a problem was coded as a ‘**SOLUTION**’. For example, ‘the bag could be put at the sides of the wheels’.

An utterance was coded as an ‘**OUTCOME**’ if it expressed:
1. a ‘Problem’ arising from an appraisal in which a solution is recognised as being in conflict or inconsistent with a requirement, for example, ‘Perhaps it is too big to put inside’;
2. an ‘Agreement’ if it acknowledged a solution as consistent with a given requirement(s), for example, ‘Using the frame of the backpack will make it easier to position the bag’.

Each utterance was thus coded as requirement (R), solution (S), problem (P) or agreement (A). Having coded the transcripts, requirements, solutions, and outcomes, were transcribed to a coding form, shown in Table 1. Here the first column shows consecutive turns of the discourse. The design process model (see Figure 4) predicts that new requirements can be generated during the ‘Ideate or Suppose’ and ‘Evaluate or Compare’ processes. Hence, the second column, coded ‘B’ (in the brief) and ‘NB’ (not in the brief) signifies whether a verbalised requirement is in the brief or not, i.e. generated by the designers. The third column shows requirements. Similarly, solutions are recorded in the fourth column. The solution turns may contain information as to whether the solution generated in the ‘Ideate or Suppose’ process was in response to a particular requirement or outcome. In this case, the inputs are shown in parentheses (see, for example, Turn 99 in Table 1). The Outcome column records outcomes. The preceding column, labelled A, records whether the outcome was an ‘Agreement’, where the solution is confirmed as consistent with requirements, represented by an ‘A’ in the A/P column. A solution that conflicts with a requirement produces a ‘Problem’, represented with by a ‘P’ in the A/P column. Outcome utterances always refer to a
solution and requirement as inputs. These are represented in parentheses in the Requirement and Solution columns in the appropriate Outcome row. This means that when an outcome is identified, a requirement and a solution relevant to this outcome is also determined. Table 1 shows an example of this transcription scheme.

Table 1: A fragment of the coding form for a session

<table>
<thead>
<tr>
<th>Turn</th>
<th>Requirement</th>
<th>Solution</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>Attach to the seat post</td>
<td></td>
<td>P The reflectors might get in the way</td>
</tr>
<tr>
<td>79</td>
<td>(A reflector legally)</td>
<td>(Attach to the seat post)</td>
<td>P The reflectors might get in the way</td>
</tr>
<tr>
<td>82</td>
<td>Keeping that triangle</td>
<td></td>
<td>A It will create the strength</td>
</tr>
<tr>
<td>85</td>
<td>(22kg luggage)</td>
<td>(Keeping that triangle)</td>
<td>A It will create the strength</td>
</tr>
<tr>
<td>89</td>
<td>(Easy to access the backpack)</td>
<td>(The bag flap lays facing up on the back)</td>
<td>A Backpack can get access to it</td>
</tr>
<tr>
<td>93</td>
<td>(Easy to access the backpack)</td>
<td>(Design solution LB3.1.1)</td>
<td>A Bag flap at the end could reach inside and get things</td>
</tr>
<tr>
<td>95</td>
<td>(Backpack with square frame)</td>
<td>Use the straps, clamp the backpack into place</td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>(Backpack with square frame)</td>
<td>Following the arch of the wheel</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>(Backpack with square frame)</td>
<td>Cutting the rack off</td>
<td></td>
</tr>
<tr>
<td>105</td>
<td>(Good stability when fastening backpack)</td>
<td>(Cutting the rack off)</td>
<td>P It’s gonna be too unstable</td>
</tr>
<tr>
<td>109</td>
<td>(Good stability when fastening backpack)</td>
<td>Using the buckle to fix bag</td>
<td>(It’s gonna be too unstable)</td>
</tr>
</tbody>
</table>

To illustrate how the coding form may be interpreted, let’s consider Turn 77. This shows that a solution was proposed, but there was no evidence in the turn itself or the immediately preceding discourse of either a requirement or an outcome being implicated in its production. In contradistinction, in Turn 100 a solution was proposed in which a requirement matching one of those in the brief was implicated. Finally, Turn 79 shows an outcome and its associated solution and requirement, the latter being one generated by the designers themselves.

Results
Having prepared the data in this way, instances of explicit requirement, solution and outcome statements and sub-categories (capturing relations between them) can be computed, Table 2. The first thing to observe from Table 2 is that all of the predicted productions and relationships were observed in the data, that is:

- requirements were voiced (i.e., R, 11.4% of all explicitly uttered productions)
- solutions were voiced (i.e., S, 46.6% of all explicitly uttered productions)
- outcomes were voiced (i.e., Ox, 42.0% of all explicitly uttered productions)
- ideation involved requirements (i.e., Sx, 52.0% of all explicit solution utterances)
- ideation involved outcomes (i.e., Sox, 21.4% of all explicit solution utterances)
- ideation yielded new requirements (i.e., Sxn)
- evaluation yielded new requirements (i.e., Oxn)
As we can see, evaluation occurs almost as frequently as ideation (as measured by outcome utterances). Earlier we argued that evaluation is not simply a judgement as to whether a proposed solution is desirable or not. Instead, evaluation relates solutions to requirements. The outcomes that emerge from evaluation are statements about the strengths and/or weaknesses of solutions in relation to requirements, comprising matter about which designers can reason as the task progresses. As anticipated, their function in ideation is evident in the production of solutions (i.e., Sxo).

Table 2: Frequency of explicit requirement, solution and outcome statements and implicit interactions

<table>
<thead>
<tr>
<th>Groups</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>R: an explicit requirement statement</td>
<td>20</td>
<td>11</td>
<td>29</td>
<td>69</td>
</tr>
<tr>
<td>S: an explicit solution statement</td>
<td>26</td>
<td>32</td>
<td>45</td>
<td>135</td>
</tr>
<tr>
<td>Sxr: an explicit solution in which a requirement is implied</td>
<td>16</td>
<td>35</td>
<td>23</td>
<td>86</td>
</tr>
<tr>
<td>Sxo: an explicit solution in which an outcome is implied</td>
<td>24</td>
<td>14</td>
<td>14</td>
<td>60</td>
</tr>
<tr>
<td>Sxnr: an explicit solution in which a non brief requirement is implied</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Oxr+s: an explicit solution evaluation outcome in which a requirement and a solution are implied</td>
<td>69</td>
<td>53</td>
<td>75</td>
<td>253</td>
</tr>
<tr>
<td>Oxnr: an explicit outcome in which a non brief requirement is implied</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>15</td>
</tr>
</tbody>
</table>

Although only a few new requirements were generated by each dyad, the data support the idea that they can be discovered both through ideation and evaluation. The small number of new requirements uncovered is probably explained by the fact that the requirements of the task had been very thoroughly established, as described above. The data further suggest that evaluation plays a dominant role in uncovering new requirements.

The data also indicate the importance of requirements in the design problem-solving process, since they were implicated in 77.6% of the utterances coded. In theory it may be possible to generate solutions without reference to requirements. Within the data, the 48.0% of solution utterances lacking implicit requirements at least allow for this possibility. However, evaluation cannot occur without requirements and evaluation is important for a number of reasons, including:

1. it produces outcomes that enable informed correction and development to be made. It is only through evaluation that one can know whether and why a proposal is good or bad;
2. it produces outcomes that potentially connect multiple requirements to a specific solution thus building up evidence for and/or against it;
3. it plays an important role in discovering new requirements.

Thus evaluation outcomes serve as a means of steering ideation through moves, for example, to build on the strengths or correct the weaknesses of a promising solution, or to open up a new line of enquiry when the evidence against a solution indicates that it is not worth pursuing further. The greater the number of requirements the greater the potential for evaluation and outcomes, and hence control over ideation.
Conclusion

We have extended existing design problem-solving models to explicitly represent requirements and evaluation outcomes and their relationships to cognitive processes. We have emphasised the importance of the notion of an evaluation outcome, which is not simply the term ‘negative’ or ‘positive’. Rather it is a relation between a solution and a requirement(s) expressing whether, why, and to what extent the anticipated effect of the proposed solution is positive or negative. Like requirements and solutions, evaluation outcomes function as objects of reasoning. We have sought and found evidence in designers’ talk for the (new and old) productions and relations posited in the model. The results of this empirical study show that the explicit consideration of requirements figures prominently in the utterances coded. Likewise, the importance of the role of evaluation outcomes seems clear (representing 42% of all coded utterances). Although less prominent, evaluation outcomes are involved in over one fifth of solution utterances. It is reasonable to conclude from this evidence that requirements, solutions and evaluation outcomes feature prominently in design reasoning. But how are these facts weighed, balanced and integrated, and how do they contribute to decision-making, e.g., whether to ideate, evaluate further, or undertake new analysis of the problem? The study reported here can contribute little to answering these questions. Hence, future research should focus on understanding how design reasoning utilises requirements, solution and evaluation outcomes to achieve design goals.
References


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Three orientations of weaving design

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Abstract

This study investigated expertise in the process of professional-level weaving design. A working hypothesis of the study was that the weaving-design process is best considered as a dual-space search between the visual, composition space and the technical, construction space, subject to external (environmental, contextual) and internally generated constraints. The study analyses expertise in weaving design by examining how professionally experienced designers (n=4) and advanced students (n=4) of weaving design solved a professional weaving-design task. The participants were asked to solve the task while thinking aloud in two design sessions. The data consisted of (1) verbal protocols, (2) video protocols, and (3) written and drawn material produced by the participants. We analyzed the data through qualitative content analysis and problem-behavior graphs (PBGs). The present results indicate that weaving design shared many prototypical characteristics of design process. An examination of the nature of weaving design indicated that the participants, regardless of the level of expertise, focused on composition design in the first design session and construction design in the second design session. There were, however, substantial differences within the groups of participants concerning the role of different design spaces during their problem solving. An analysis of the relative importance of the composition, construction and constraints in the participants’ designing indicated that they followed identifiable design orientations (i.e., composition orientation, composition-construction orientation, and constraint orientation).
Three orientations of weaving design

Introduction
Any design task requires a very complicated process of searching for a workable (i.e., aesthetic as well as functional) solution that can be reached in a practical and effective way. Generally, the design space is ill-defined in the sense that there are no definite criteria for testing whether a proposed solution is successful or not (Simon 1977; Akin 1986; Goel & Pirolli 1992). Moreover, the design space cannot be defined unambiguously. The designer has to structure and limit the huge design space by using external and internal constraints (Goel 1995). Designing involves various elements that must be considered and related to each other, within the constraints in order to create a functional and aesthetic solution (Goel 1995).

In general, the design-task environment in the professional context of textile design is typically specified in a customer's brief. The design tasks provide information of both the design constraints and design elements (Seitamaa-Hakkarainen 2000). The design constraints specify the context of the textile by answering questions: what kind of textile, to whom, where and for what purpose the textile is going to be designed. In other words, user, place, function (i.e., purpose) of the textile and resources available (time, money, equipment or legislation) define the context of the entire artifact to be designed and thus they constrain the design context (Goel & Pirolli 1992; Lawson 1991).

In the present study, it is proposed that the weaving design process may be characterized as a dual-space search through composition and construction spaces (Seitamaa-Hakkarainen 2000; Seitamaa-Hakkarainen & Hakkarainen 2001), like many other areas of problem solving (Goel & Pirolli 1992; Goel 1995; Goldschmidt 1997). Composition space, which is seen as a domain-independent design process, consists of the organization of the visual elements and principles selected and manipulated during design process. The visual elements consist of shape design, color design, and pattern design elements. Construction space, which is seen as a domain-specific design process, consists of organization and manipulation of the technical elements and principles. The technical elements include material design, structure design (e.g., weave and density) and design of production procedures (e.g., technique, yarn floats). Technical design strongly influences textiles’ surface. The selection of the visual elements requires a search through the composition space, and the selection of technical elements requires search through the construction space. The pivotal aspect of the weaving design process is the gathering and utilization of domain-specific knowledge, in conjunction with the visual and technical characteristics of the desired textile. Given this as a starting point, the knowledge of traditional weaves, models and techniques of weaving, the study of materials and their interrelationships and the organization of visual elements then become crucial in bringing the textile into the realm of the tangible (Seitamaa-Hakkarainen & Hakkarainen 2001).

Our previous analysis of the novices’ design process by using problem-behavior graphs showed that novices started to design from the composition space and only occasionally manipulated visual and technical design elements in a parallel way (Seitamaa-Hakkarainen 1997; Seitamaa-Hakkarainen & Hakkarainen 2001). A very important feature of the novices’ design process was the dominant role of the development of the composition of the textile. Due to the complexity of the weaving design problems and the many levels of detail that had to be considered, the novices’ designing occurred mostly in the composition space; design of a composition was the novices’ focus until the end of the design process. Due to the limits of the novices’ domain-specific knowledge and lack of an iteratively developed understanding of the principles of weaves, they could not control the technical elements nor manipulate them together with visual elements. Unlike the novices, the experts did not start by considering one design element at time; rather, the experts connected many of the design elements together from the very beginning. In the middle of the process they did move back and
forth between composition and construction spaces. By revising design elements cyclically and iteratively, the experts incrementally developed the design and effectively carried previous ideas into the other design space (Seitamaa-Hakkarainen 1997; Seitamaa-Hakkarainen & Hakkarainen 2001).

The dual-problem space model provides a plausible way to account for a variety of expert-novice differences (Bereiter & Scardamalia 1987; Klahr & Dunbar, 1988). Seitamaa-Hakkarainen & Hakkarainen (2001) made a corresponding prediction concerning the nature of expertise in weaving design. However, working with different spaces can also be seen to reflect on different design orientation. Given the rationale outlined above, the investigators pursued research objectives of the present study through the following approach, 1) analyze the role of the underlying design constraints and the relationship between composition and construction design elements; and 2) examine the different design orientations of the weaving design.

Method

Participants and experimental task
Eight participants, four professional weaving designers, and four advanced students of weaving design participated in the study. Each participant had quite similar educational backgrounds, specializing in weaving design having at least some professional working experience. However, the experts had extensive professional expertise, and two of them were highly regarded weaving designers in Finland. The participants were asked to solve an authentic, small-scale weaving-design task selected to represent general and stable features of the professional design tasks, but, it differs, however, in one respect from the characteristics of a full-scale design task and that difference was necessitated by the logistics of data collection. The task was to design a wall-hanging textile for a planned day-care centre called ‘Little Prince’. The participants were given a design brief containing some background information and an architectural plan including some information about the intended location of the textile to be designed. They took part in two design sessions, both of which had time limits. They were allowed to use one-and-a-half hours for designing the textile in the first session and one hour in the second session. In the second design session, the participants were asked to continue their previous design at a more detailed level and produce working instructions for the weaver.

Method and data analysis
The study was carried out by using the thinking-aloud method, i.e., protocol analysis, following closely to Ericsson and Simon’s (1984) protocol-analysis technique. Accordingly, each participant was asked individually to think aloud from the beginning of the problem solving to the end of it. The data were from 1) verbal protocols, 2) video protocols, and 3) written and drawn material produced by the participants during design sessions. Following data collection, the recorded protocols were transcribed according to the audiotapes. Further, in order to increase the reliability and validity of analysis, the verbal protocols were cross-referenced with the observed activities seen in the video recording as well as with notes and sketches produced during the design sessions. The systematic observations of the video protocol were coded manually in two-minute intervals.

We applied qualitative analysis of the contents to the protocols and used the data to construct problem-behavior graphs (PBGs). For the qualitative content analysis, the transcribed protocols were segmented into statements identifying single thoughts or main ideas, i.e., the meaning of the content (regarding segmentation of data for content analysis, Chi 1997). Each statement was coded along several independent dimensions. The focus of qualitative content analysis consisted of the design development phases, design activities, type of sketches, and design content variables.
The coding schemata consisted altogether of 29 variables but only design content variables will be reported here (for complete classification see Seitamaa-Hakkarainen 2000).

For each statement the nature of content was identified (a) constraints, (b) composition design or (c) construction design. The constraints of design form a general frame for the design, and they are identified or inferred from the external source or internal aspect of the design situation. The constraints can reflect some of more external issues about (a) users, i.e., aspects of the persons for whom the textile will be designed; (b) environment and atmosphere i.e., aspects of the local place and the atmosphere of the environment. In general, constraints involved consideration of desired aspects of the quality of the day-care center and its intended atmosphere. Nevertheless, the designer could generate more internal constraints during design, which were classified (d) function of the textile, which reflects desired properties for the textile. The function of textile may support certain purposes (hiding, function for touching and softness). Finally, the constraints may be connected to (d) finishing, installation, resources and maintenance aspects.

Each verbalized statement was further classified according to the elements of composition and construction design it contained. The elements of composition design were (a) shape or form; (b) pattern; (c) color or color scheme. On the other hand, each statement was coded on the basis of the elements of technical design. Construction design consisted of three elements: (a) material, including warp and weft or figure shot; (b) structure, including weave, profile draft/motif, long draft, density; and (c) production procedure, i.e., finger-manipulated techniques, yarn floats, Finnish ryij ryya pile, thread grouping, weaving plan etc. To analyze the reliability of the classification, two independent coders classified a sample of the participants’ transcribed protocol statements (f=268) together with corresponding videotapes. The agreement coefficient between ratings given by two independent raters was as high as .92 in the case of main content, .85 for constraints, .94 for composition and .96 in the case of the construction design elements.

After completing the qualitative content analysis, problem-behavior graphs (PBGs) were constructed for each participant. The analysis of the problem-behavior graphs generally captures well temporal aspects of a subject’s design activity and domain content and helps to examine the interaction between composition and construction designing in each participant’s design process (see also Chi 1997; Suwa & Tversky 1997). Design elements were described graphically as a set of moves from one knowledge state to another (i.e., propositions connected with particular design elements). It also represents unsuccessful attempts at reaching a solution, i.e., dead-ends. Following the segmentation of the protocols into statements (i.e., the unit of analysis reminded the same), each subject’s solution process was analyzed by using special problem-behavior graphs developed by one of the present authors (Seitamaa-Hakkarainen 1997; 2000). Every design element considered during that episode was represented as a trace of moves in the graphs. Each of a given participant’s verbalized statements was coded according to the design element or their relationship represented. This method made it possible to analyze whether the participants were processing design elements serially or in a parallel way i.e., within and between design spaces.

Results
The nature of the experts’ and the advanced students’ design protocols was studied qualitatively, using qualitative content analysis. Data from the protocols were examined by analyzing frequencies of the participants’ design statements. The total number of protocol statements produced by the participants was 3185, which consists in 1986 statements produced in the first session, and 1199 in the second session. The mean number of words in a statement was ten (M=10.3, SD= 7.4) in the first session, and nine (M=9.0, SD= 6.5) in the second session. The number of participants’ protocol statements varied from less than 200 to over 250 in the first design session, and from less than 90 to about 250 in the second session.
Each participant differed in her design proceeding and producing different types of sketches, notes, and working instructions with varying degrees of completeness. Furthermore, each participant processed her design problem in an individual way, and subsequently, designed a unique plan for a weavable textile. Participant 1 designed a Finnish ryjy (i.e., rya rug) during her design sessions by relying on finger manipulation technique. While analyzing the design task, she rapidly produced many different design ideas, generating five thinking sketches, one prescriptive sketch and three final alternatives in the first design session. Participant 2 relied on more complex weave techniques, and her design was based on a loom-controlled technique (weft-faced compound type of summer and winter weave) with Finnish rya technique in the middle area. She constructed five thinking sketches, two prescriptive sketches, and one final alternative during the first session. Table 1 illustrates the participants’ individual weaving design projects in the first and second design sessions, the number of protocol statements, the time they used, the episodes and the type of the textile being designed.

<table>
<thead>
<tr>
<th>Participants</th>
<th>First Design Session</th>
<th>Second Design Session</th>
<th>Type of Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (min)</td>
<td>Statements*</td>
<td>Design Episodes</td>
</tr>
<tr>
<td><strong>Students</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant 1</td>
<td>68</td>
<td>234</td>
<td>12</td>
</tr>
<tr>
<td>Participant 2</td>
<td>64</td>
<td>260</td>
<td>18</td>
</tr>
<tr>
<td>Participant 3</td>
<td>63</td>
<td>228</td>
<td>13</td>
</tr>
<tr>
<td>Participant 4</td>
<td>66</td>
<td>275</td>
<td>7</td>
</tr>
<tr>
<td><strong>Experts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant 5</td>
<td>62</td>
<td>236</td>
<td>13</td>
</tr>
<tr>
<td>Participant 6</td>
<td>53</td>
<td>191</td>
<td>13</td>
</tr>
<tr>
<td>Participant 7</td>
<td>58</td>
<td>286</td>
<td>16</td>
</tr>
<tr>
<td>Participant 8</td>
<td>57</td>
<td>276</td>
<td>12</td>
</tr>
</tbody>
</table>

Note: Total number of statements (propositions) verbalized includes silence statements. Type of production of textile (LC = Loom controlled; FM = finger manipulated)

Table 1: Individual weaving design projects in the first and second design sessions

Participant 3 designed a textile in which the ground consisted of weft-faced compound weave and half rya rug piles. During the first design session, participant 3 produced five thinking sketches, one prescriptive sketch together with a small demonstration, and one final alternative. Participant 4’s design theme was based on an abstract colored-surface design of the Finnish rya (i.e., half-rya) and she produced four thinking sketches, one prescriptive sketch and one final alternative in the first design session.

Participant 5’s design was based on weft-faced compound weave (loom controlled), although certain color areas required pick-up. She used 15 minutes to structure the design task and the design brief, and ended up with an idea of an abstract form of colored-surface design. She produced two sets of thinking sketches, prescriptive sketches, and final alternatives. Participant 6’s design process in the first session took 53 minutes and consisted of 13 episodes. She, like some of the others, designed a textile with a complex type of weft-faced compound weave, in which the pattern and color areas (i.e., figures) are to be done by pick-up between the shed. Because the ground consisted of different weave structures (tabby, twill, and rep, for example), this kind of textile requires extensive use of the pick-up technique. The participant 6 produced two very complex and detailed alternatives in the first design session that differed substantially from one another. Participant 7’s design was also based on weft-faced compound weave, although certain color areas
required pick-up. Her design was based on abstract color and pattern designs. She produced only one thinking sketch, one prescriptive sketch and a final alternative. Participant 8 designed a weft-patterned textile, completely based on a loom-controlled technique. Her design theme comprised abstract colored areas and patterns. Participant 8’s design output consisted of a thinking sketch, a prescriptive sketch, a final alternative, and a demo drawing, along with some extra copies of sketches of the shape related to them.

Analysis of the frequency distribution of the contents of the participants’ design process showed that composition design was a very important part of the first design session regardless of the level of expertise. Constraint represented aspects to be used to define the design context. These constraints limit designing, but they are not the focus of designing. While composition space referred to the principal meaning of the visual design, the construction space referred to the technical aspects of the design. By selecting and manipulating these composition and construction elements the designer actually constructs the artifact to be designed. Table 2 presents the proportions of design statements representing these three design aspects in the first and second design sessions.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Design Space in the First Design Session</th>
<th>Design Space in the Second Design Session</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constraints</td>
<td>Composition</td>
</tr>
<tr>
<td>Participant 1</td>
<td>.17</td>
<td>.77</td>
</tr>
<tr>
<td>Participant 2</td>
<td>.14</td>
<td>.57</td>
</tr>
<tr>
<td>Participant 3</td>
<td>.38</td>
<td>.34</td>
</tr>
<tr>
<td>Participant 4</td>
<td>.13</td>
<td>.82</td>
</tr>
<tr>
<td>Students Total</td>
<td>.21</td>
<td>.63</td>
</tr>
<tr>
<td>Participant 5</td>
<td>.27</td>
<td>.61</td>
</tr>
<tr>
<td>Participant 6</td>
<td>.15</td>
<td>.47</td>
</tr>
<tr>
<td>Participant 7</td>
<td>.29</td>
<td>.42</td>
</tr>
<tr>
<td>Participant 8</td>
<td>.36</td>
<td>.31</td>
</tr>
<tr>
<td>Experts Total</td>
<td>.26</td>
<td>.46</td>
</tr>
</tbody>
</table>

Table 2: Proportion of design statements representing the three design aspects in the first and second design sessions

The analysis suggests that the designing related to constraints played an important role in the first design session. Both the advanced students’ (M=.09; SD=.05) and the experts’ (M=.12; SD=.06) dealt with constraints designing, which reduced substantially towards the second design session. Further, out of all verbalized protocol statements produced during the first session (f=1686), a substantial proportion (.53, f=893) were focused on composition space. The composition elements consisted of shape, pattern, and color design. The mean proportion of the advanced students’ protocol statements representing composition design (M=.63, SD=.22) was higher than that of the experts (M=.46, SD=.12) in the first design session. In the second design session, however, the mean proportion of composition design decreased substantially in the advanced students’ design process (M=.29; SD=.19), and even more in the experts’ (M=.17; SD=.12) designing. The proportion of protocol statements representing construction design was somewhat higher in experts’ than the advanced students’ designing, in the first design session. In the first design session, construction design did not play a dominant role in the subjects’ verbalized protocol statements. The mean proportion of construction space design increased in both of the groups from the first design session to the second.
Participants 7 and 8 from the expert’s group appeared to equally consider all of the design spaces in the first design session, whereas participant 5 considered composition space relatively more in the first design session than did the other experts. Moreover, participant 6 appeared to consider to a greater degree construction design space, moving more and more towards the construction design space as the main aspects of designing in the second design session. We can conclude that while the subjects considered both design spaces (composition and construction spaces) and related aspects of designing i.e., design constraints, nevertheless, within-group differences were relative larger than the differences between the groups of advanced students and experts. Since both of the groups have extensive backgrounds in weaving design, the differences between the groups were, in fact, smaller than differences between the sessions. Even starting with the same motif, all unique art and craft works differ in style due to the craft person’s individual perspective, interpretation and the characteristics of the technique used. Moreover, each artist or craft person has his/her individual style and sources of inspiration. Such diversity of approaches extends to all areas of art and has been well documented (von der Wert & Frankenberger 1995; Eisentraut & Günther 1997). Thus, one possible explanation for the observed patterns of designing may be found in the different design orientations, which reflect an individual’s design style.

To better understand the processes of design that the different subjects engaged in, the present investigators decided to carry out a further analysis focused on examining how the designers’ personal orientations affected the relative importance of the composition, construction, and constraint design spaces. Thus, the next step was to construct a group of characteristic variables that might specify a designer’s way of working. In order to examine whether the subjects’ designing represented an identifiable design orientation beyond the level of expertise, a K-means cluster analysis (see Aldenderfer & Blashfield 1984) was conducted by using SPSS for Windows (7.5). Through cluster analysis the researchers were able to form homogenous groups and identify highly similar cases by analyzing patterns of relationship between the design elements. Variables used in the cluster analysis were the proportions of constraint, composition and construction statements in the first design session. The analysis focused on the first design session because it was hypothesized that the design orientation would have the strongest effect when the designer begins to develop his or her design ideas and begins to structure the problem space. Table 3 presents the final cluster centers that emerged from the analysis.

<table>
<thead>
<tr>
<th>First Design Session</th>
<th>Cluster centers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Composition</td>
<td>.80</td>
</tr>
<tr>
<td>Constraints</td>
<td>.15</td>
</tr>
<tr>
<td>Construction</td>
<td>.05</td>
</tr>
</tbody>
</table>

Table 3: Final cluster centers in the first design session

Cluster 1 refers to as composition orientation; cluster 2 is composition-construction orientation; and cluster 3 is as constraint orientation. The first cluster emphasized the composition orientation as the main content of design. In addition to composition design, construction design was also emphasized in the second cluster. This second cluster is therefore called composition-construction orientation. Characteristic of the third cluster was a rather equal emphasis on all of the design spaces. The emphasis on the constraint design was substantially stronger in the third orientation than in the other two orientations, therefore it was termed constraint orientation. Table 4 presents the cluster memberships of each participant.
Participants 1 and 4 represented the composition orientation, and both of them were advanced students designing a Finnish rya rug and relied on finger-manipulation techniques. The second orientation type was called composition-construction orientation indicating that both composition and construction design elements were emphasized. Participant 2 from the advanced students’ group, as well as the experts 5 and 6 represented composition-construction orientation. All of these participants relied on more complex weave techniques than did the composition-oriented participants; the designs were mainly intended to be produced by loom-controlled techniques.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Level of expertise</th>
<th>Orientation Cluster</th>
<th>Distance from the cluster center</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Advanced student</td>
<td>Composition</td>
<td>.04</td>
</tr>
<tr>
<td>2</td>
<td>Advanced student</td>
<td>Composition-Construction</td>
<td>.05</td>
</tr>
<tr>
<td>3</td>
<td>Advanced student</td>
<td>Constraint</td>
<td>.05</td>
</tr>
<tr>
<td>4</td>
<td>Advanced student</td>
<td>Composition</td>
<td>.04</td>
</tr>
<tr>
<td>5</td>
<td>Expert</td>
<td>Composition-Construction</td>
<td>.16</td>
</tr>
<tr>
<td>6</td>
<td>Expert</td>
<td>Composition-Construction</td>
<td>.13</td>
</tr>
<tr>
<td>7</td>
<td>Expert</td>
<td>Constraint</td>
<td>.08</td>
</tr>
<tr>
<td>8</td>
<td>Expert</td>
<td>Constraint</td>
<td>.06</td>
</tr>
</tbody>
</table>

Table 4: Cluster membership of the participants

Participants 1 and 4 represented the composition orientation, and both of them were advanced students designing a Finnish rya rug and relied on finger-manipulation techniques. The second orientation type was called composition-construction orientation indicating that both composition and construction design elements were emphasized. Participant 2 from the advanced students’ group, as well as the experts 5 and 6 represented composition-construction orientation. All of these participants relied on more complex weave techniques than did the composition-oriented participants; the designs were mainly intended to be produced by loom-controlled techniques.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Composition construction</th>
<th>Constraints</th>
</tr>
</thead>
</table>
| • There was a very short period of problem structuring (about 2 minutes) in the very beginning of the first design session.  
• There was an immediate production of a number of thinking sketches.  
• Composition design was the main focus of the whole first design session, and color design was the main composition element.  
• The construction design and construction elements are not considered in separate design episodes.  
• There was a short consideration of the production procedure which implicitly direct the development of design idea but does not refer to weave structures.  
• The design process was mainly serial in nature | • All participants had a separate problem-structuring phase lasting 5 to 15 minutes.  
• External design constraints were considered in a relational way i.e., through connecting design constraints with design elements.  
• After the beginning of the design session the external design constraints were not considered very intensively.  
• Composition design was the main aspect of designing from the beginning of the session but, somewhere in the middle of the session, the process started to move between composition and construction design spaces.  
• Moving between composition and construction spaces transformed the designing towards a parallel process. | • All participants had a long separate problem-structuring phase lasting almost 20 minutes.  
• The constraints related to the environment and the users were investigated extremely carefully.  
• After the beginning of the design session, the external design constraints were also considered once and a while.  
• The composition and construction design were given an equal consideration, and participants started continuously to jump between the composition and construction design spaces somewhere in the middle of this session.  
• The design process was parallel in nature. |

Table 5: Typical features of three different orientation

Participant 3 from the advanced student group, and the experts 7 and 8, represented the constraint orientation and their design processes appeared to represent a more equal processing of all the aspects of design. These constraint-oriented participants typically proceeded through the design spaces in a balanced way; i.e., they focused equally on all aspects of designing. Yet their design
process focused more on the external constraints than that of the participants representing composition orientation or composition-construction orientation. Both expert participants’ designs relied on complex weaving techniques, which were mainly produced by loom-controlled methods. In participant 7’s design, some pattern areas were designed for finger-manipulated pick-up techniques. Participant 3’s design was based on finger-manipulated technique (i.e., half rya rug), and the ground of the textile consisted of summer and winter weave. Table 5 present typical characteristics of design of participants representing each of the three orientations. The problem-behavior graphs had important role in the emergence of these orientations.

Discussion

In the present study four advanced students and four professional weaving designers participated, and they solved a representative professional weaving design task by thinking aloud. The design task, however, took only 1-2 hours to solve so that it may not represent all aspects of real-life weaving design assignment. Further, the participants were allowed to select the type of production (e.g., finger-manipulated or loom-controlled) themselves so that the types of designed, woven textiles varied between the participants. Regardless of these methodological limitations, the study material provided content-rich and detailed information about advanced students’ and professional experts’ weaving design process.

Goel and Pirolli (1992) argued that the structure of "design problem space" and task environment is similar across various prototypical design areas. Although there are general features that are common for all design processes, there are, however, also substantial differences concerning domain-specific knowledge and design elements used within a particular field of design. The interaction between domain-general and domain-specific aspects of designing was specifically addressed in the present investigation. Design research indicates that there is a great deal of variation between individual designers in their ways of approaching and solving design tasks, not only between different disciplines but also within the same one (see, for example, Eisentraunt & Günther 1997; see also Akin 1986). However, the special nature of the prototypical design tasks, design processes and the role of the visualization in the design process represent the prototypical aspects of the all design fields.

The present investigators provisionally identified two fundamental problem spaces of designing: composition space, and construction space. However, while designing composition and construction design elements one must always deal with external and internal constraints, which frame the entire task environment. As stated in the previous section, the designing related to the constraint space played an important role in the first design session but, apparently, decreased in the second design session. The overall analysis of the role of the design spaces suggests that the participants focused strongly on the composition design during the first design session. The composition space had a more dominant role in the advanced students’ designing than that of the experts, in the first design session. In the second design session, construction design was generally more emphasized in both groups’ design process. To conclude, in general, the participants’ design process apparently started by identifying design constraints, continued through developing a visual design idea, and ended by considering the technical possibilities of giving the visual idea a more concrete form.

Our expectation had been that subjects having an extensive background in specializing weaving would not differ substantially from each other in terms of working with the composition or construction spaces and dealing with design constraints. Therefore, it appears to be understandable that differences between the groups of advanced students and experts were not statistically significant. It was proposed that designers might represent different types of design orientations according to relative importance, for them as individuals, of processes related to the composition,
construction and constraint spaces, which is to say, their design orientation. The significance of design orientation appears to arise from the fact that all participants had a large amount of specialized weaving design knowledge, skills, and experiences. Designers who are familiar with the same professional content still often have entirely different ways of solving design tasks, and their solutions can be of a very different quality as well. Moreover, the course of reaching solutions can also vary in different design tasks. In other words, it was expected that, beyond the level of expertise, each participant would approach the solution of the textile-design task in their own way. Three prototypical design orientations were found. The first orientation emphasized composition designing (participant 1 and 4), the second orientation focused on composition and construction design (participants 2, 5 and 6), whereas the third orientation (participant 3, 7 and 8) emphasized design constraints equally with the two other design spaces in their designing. However, more empirical study on the individual design orientations and their relation to the visual representations and problem structuring phases may be needed, in order to explain satisfactorily individual differences in the design process.

There are multiple ways of expressing one’s own design ideas but the choice of medium, such as materials or techniques, constrains one’s way through the multitude of possibilities. All design elements are needed for producing a woven textile and, in this sense, equally important (although the relative importance may vary from one to another design). Further, the analysis indicated that the type of production did not completely control how design elements are used; rather, individual characteristics of the designer appeared to have effects, as well as his or her design orientation and expertise. However, the analysis does not indicate that design orientations would represent a permanent propensity to approach design tasks in any particular way: the present study focused on only one design task, thus the results cannot be generalized to other tasks. It is possible that the design orientations emerged from situation-specific or task-related factors, and that the participants would follow different orientations in different kinds of situations. Therefore, the design orientations may be regarded as descriptive categorizations that, in the context of the present study, would help to understand the differences and similarities of the participants. Nonetheless, the skills of the experts in weaving design evidently involved interactive and parallel processing between domain-specific knowledge and domain-general knowledge. The dual-space model of weaving design developed in this study appears to have implications over or above the present study.
References


Contributions made by the authors

This study is based on professor Pirita Seitamaa-Hakkarainen’s doctoral thesis. She designed the study, collected the material, and developed methods used in analysis of the data. Dr. Hakkarainen provided theoretical and methodological guidance during the process and participated in writing of the present article. Grants provided by the Academy of Finland for both of the contributors made finishing of this manuscript possible.
Designing philosophy

D. Sless Coventry University, UK and Communication Research Institute of Australia, Australia

Abstract

I start from two assertions: philosophy is our highest form of practical reasoning; design is our highest form of practical adaptation to our environment. I ask a question. What necessary conditions must exist for us to do both philosophising and designing?

The method of argument I use is based on the philosophical methods of Wittgenstein’s Philosophical Investigations and the principle of parsimony or Occam’s razor: what is the simplest set of ideas necessary to answer the question.

The area of design on which I draw most heavily is the area in which I have done most of my designing and researching: information design.

The argument leads to seeing designing and philosophising as either panaceas or prostheses. If we ‘change the aspect’ in a Wittgensteinian sense, we can move between these two.

The practical and social implications of this conclusion suggest that ‘designing philosophy’ (in the full ambiguity that the phrase implies) may well be one of the most important aspects of intellectual life in the 21st Century.
Designing philosophy

Starting assertions
I start from two assertions: philosophy is our highest form of practical reasoning; design is our highest form of practical adaptation to our environment.

Necessarily (in a logical sense) arguments have starting points that are not themselves dealt with within the argument itself. These starting points are the assumptions, articulated or unarticulated, on which the argument is grounded.

No argument about design or philosophy takes place without being grounded in a whole web of experience, a form of life. I can no more exclude this experience than the air I breathe. However, if I were to try and elaborate the starting points in all their wealth of detail, there would be no end to it. Indeed, as each one of us experiences the web from different positions, there are many different starting points, leading us into many arguments over what we share and do not share by way of understanding our forms of life. In my view, this is not a productive way to spend one’s intellectual life, though I grant that many do, and derive great pleasure from the endless elaboration.

I am starting, then, from two assertions that I do not intend to either explain, defend, or define in this paper. Rather, I am going to rely on what I hope is a shared understanding of what it might mean to do philosophy or design, and see where the argument takes us. I have adopted this somewhat austere approach so that instead of endless justification the argument itself can be the most visible part of the paper.

Note what I am not doing. I am not behaving as a scholar, treating philosophy or design as objects of study; nor am I behaving as a journalist, giving you an account of what I have discovered ‘about’ these things. Rather, I am concerned with them as practical activities, things to do. I am interested in doing philosophy, doing design.

A question
What necessary conditions must exist for me to engage in both philosophising and designing? I stress necessary, but not sufficient, conditions for doing philosophy and design. Doubtless, the list of sufficient conditions would be large and would vary with different philosophical and design activities. My question is about foundations, not assumptions; and it is a question about practice, not essences.

The traditional way of approaching the question of foundations is to dig deep, to look for essences, underlying true propositions on which an intellectual edifice can be built. Russell and Whitehead’s project to ‘discover’ the foundations of mathematics in logic was such a project, and it is the one that Wittgenstein, from whom I take inspiration in this paper, so vehemently disagreed with. He argued that logic was no more ‘basic’ than mathematics; logic and mathematics are just different language games.

So I am not asking a foundational question using the digging deeper approach. I am not creating a new language game (in Wittgenstein’s sense). I am, however, approaching the question of foundations from a novel perspective, inspired, as I said, by Wittgenstein’s Philosophical Investigations. I am also inspired by the principle of parsimony, or Occam’s Razor: what is the simplest set of ideas necessary to answer the question.
With these inspirations in mind, I ask again: what necessary conditions must exist for me to engage in both philosophising and designing? To use the building metaphor implicated in the term ‘foundations’, I am asking what must always be there for the building to be useful as a building. However, because I am dealing with something that we do, rather than with an object, it is more appropriate to ask: what must I be able to do in order to do philosophical or design work?

I will deal first with doing philosophical work. I want to suggest to you that communicating is the foundational basis of philosophy.

I have already developed the arguments for this conclusion in detail (Sless 1986, 1990). In this paper I will summarise the main points of the argument.

If I want to do philosophy I must engage in communicating. I have to argue, articulate, write and so on. Without these communicative activities, philosophy is not only impossible to do but also impossible to even conceive of. For this reason, communication is foundational. I must be able to communicate to do philosophy. However, it could be argued that communication is only trivially foundational; that the ideas which philosophy engages with are more important than the process which carries them. But this argument is only sustainable within a conception of communication as a transmission process. There are good reasons to suggest that a transmission view of communication is unacceptable for all but the most limited technical and instrumental view of communication (see, for example Reddy 1979; Shepherd 1993; Sless 1986; Shrensky 1998). The alternative, a dialogical view of communicating makes communicating central to all forms of intellectual activity: communicating is the process that leads to the creation of ideas rather than being simply their conduit.

From a dialogical point of view communicating is foundational in a non-trivial sense, and is a necessary condition for engaging in philosophy.

Foundations and certainty

I now take this argument further to show that communicating is foundational in the sense of providing us with truths, but not the truths sought by classical philosophy.

I begin with an observation that must necessarily be true of all communicative phenomena: communication depends on signs. To communicate is to assume the logical pre-existence of signs. Therefore we need to have some notions of signs in order to carry the argument further.

My understanding of what a sign is (Sless passim) has in part derived from Peirce (1958). A sign can only be a sign if it is one of the elements in a tripartite relationship consisting of the sign itself, a user of the sign, and what the sign stands for. These three elements are inseparable; it is meaningless to talk about the properties of a sign in isolation from the other two elements, since a sign, qua sign, has its properties only by virtue of the tripartite relation it is in.

In principle anything can be a sign. A sign can be a material object, an imaginary object, an idea, another sign. It derives its sign properties by virtue of its relation to users and referents, not because of anything intrinsic to it. The only partially intrinsic property of a sign is that it should be distinguishable by the user from its referent. This distinction is necessary because a sign cannot stand for itself. Similarly, a referent can be a material object, imaginary object, an idea, even another sign, and it enjoys its properties by virtue of the relation it is in with a user and a sign.

The process of linking signs and referents through the stand-for relation is called semiosis. It is an action, something we do. Semiosis the stand-for relation is invoked by the user and acts as the link...
between the sign and its referent. The stand-for relation accounts for communicating, and crucially locates agency (people doing things) within the process.

**Creating new signs: letness**

Here is another important question: how do we create new signs, new stand-for relations? Answering this question is critical to doing philosophy, and, as you may have anticipated already, critical to doing design.

I will develop the argument in relation to the origins of axioms in mathematics.

Mathematics depends on axioms but has nothing to say on the origins of axioms - where they come from, how they come into being. Yet every mathematical system depends on statements which take the form "let x stand for y". Once x is given its new status, the operations performed on it are as if it were y. .... However, "let x stand for y" is not part of any rule inside a mathematical system. It is the method by which the system comes into existence. The axioms of mathematics come from such humble primary propositions. This is not to be confused with a picture theory of meaning, where terms in the language correspond to facts in the world, the theory of language that Wittgenstein adopted in his earlier Tractatus but repudiated and abandoned in his later investigations. Wittgenstein in both his earlier and later work was concerned with how language worked, or rather how we work language. I have suggested the principle of letness (Sless 1986) to explain how language is possible in a protological sense.

"Let x stand for y", is the simplest expression of the nature of semiosis. The core operation which links the x and the y is contained in the term “let”. ‘Letness’ is at the heart of semiosis, communicating and hence doing philosophy.

Letness is characterised by a fundamental anarchy. It is subject to no logic, no rules of inference, no causal relations or moral imperatives. We may of course attach these things to letness retrospectively or even at the time when a new stand-for relation is created but there is no necessary requirement for letness to be subject to any imperative. Further, letness is not reducible to some other state, condition or explanation. When a mathematician says “let x stand for y”, we cannot reduce this statement down to some more basic construction - untie its logical knots or reveal its inner workings. It stands alone. Letness we may take to be the central metaphysical necessity of the semiotic point of view (Sless 1986).

Two things emerge from these arguments. First, there is a kind of certainty in letness about how we make communication work, though not the kind of certainty sought in classical philosophy. Secondly, and perhaps perversely, there is here a fundamental anarchy: in principle we can make anything stand for anything. In practice we exercise a degree of control over what can stand for what through our cultures, our ways of life. Consistency of usage occurs because it is practical; it works.

Yet the fundamental anarchy of letness is always present. It erupts in tropes, humour, science, the arts, design and madness.

Letness is an incredibly simple principle on which to build the entire edifice of communicating and hence our highest form of practical reasoning, philosophy. How can such richness and complexity arise from so simple an act? I am indebted to people working in the area of complexity theory for a suggestion. Using computer modelling, researchers have found that a remarkably simple set of starting rules can lead to highly complex patterns and structures which can remain stable on the edge of chaos, as it were. These researchers were looking at highly determinate systems, ones in
which numerical computations and simple laws of cause and effect applied. Letness, however, suggests something outside computation or cause and effect. Letness does not imply indeterminacy so much as non-determinacy, not unpredictability so much as non-predicability - something outside a systems view of the world, even a very fuzzy open-ended system.

**Creating new things: design**
If you have been following the threads of this argument and you are familiar with some of the recent history of design theory then you may sense the general direction in which I am heading.

First I need to move from language, communicating and philosophy to design. This may seem like a large leap, but it is quite a small step.

Taking Wittgenstein’s view that language is something we use, it is just a step to realise that language is something we create, albeit slowly and over many generations. Language, we might say, is one the prime examples of collaborative design at work, and it is always a work in progress; new product features are developed all the time, old ones are modified or discarded. At some point in time each feature that we now take for granted was new. And features we now use routinely will almost certainly be changed by future conversations. Iterative testing and development is not a late 20th century invention, not as far as language is concerned.

Some of us, I think, assume that design is primarily concerned with material objects. I am suggesting to you that doing design is a much more generalised activity, indeed may well be the most generalisable of human activities.

Second I want to draw attention to something in Wittgenstein’s philosophical methods and suggest that these are as relevant to philosophical language (or at least the current prototype version that we are testing) as they are to designed objects. One of the most difficult things to discern in Wittgenstein’s philosophical methods, in the way he did philosophy, is the repeated pattern of questioning or interrogation that he uses. He describes it at times as a kind of therapy, a therapy applied to the philosophers’ patterns of language use. Through his methods he demonstrates that if we attend to the way in which we use language, many of the traditional problems of philosophy dissolve. Is this a kind of usability testing? Well yes, but much more. It is also to do with changing the problem definition so that a modified or new usage can occur. How like a designer! And how unlike a philosopher bound by propositions and arguments.

And what is at the core of Wittgenstein’s method of analysis? He often used the term ‘changing the aspect’, and he was intrigued by the distinction between, as he put it, ‘seeing’ and ‘seeing as” looking at something anew from a different point of view. Once again, how like a designer. Let us make x stand for y and see what happens. Letness.

This then brings the two activities, doing philosophy and doing design, together. Hence the title of this paper: Designing philosophy. This is, I believe, an original conclusion.

**Doing both**
Where does this take us? It is relatively easy to see how creating, using, and changing language is a non-determined, non-predictable activity. This is not to suggest that using language is not orderly, far from it. Without the order and regularity of a common shared usage, there can be no language. It is for this reason that Wittgenstein in the Philosophical Investigations spends so much of his effort arguing against the idea of a ‘private language’. It is also for this reason that Wittgenstein continually returns to the idea of language games usage governed by sets of rules. But these are not the immutable rules of nature, the basis of cause and effect, predictability. These are humanly made
rules, like the rules of a game, rules that can be made, changed, broken, and subverted, but not as a result of blind cause and effect or their nemesis randomness, uncertainty, indeterminacy, or chaos, but rather through human action and human interest.

I would like to suggest that much of our design of material things is similarly non-predictable, non-determined. This takes us to the so-called ‘wicked problems’ view of design. However, I come to wicked problems from outside a systems view of design methods and design problem solving. This is not to suggest that designers subvert the laws of physics. But there is an aspect of doing design occurring in a realm in which choosing or creating an appropriate metaphor, for example, is as essential as choosing the right material to fabricate an object. Our highest forms of practical thinking and our highest forms of practical adaptation to our environment come together in designing philosophy

Unfinished business
Yet there is a residual and necessary (in a logical sense) incompleteness to designing. Rules were made to be broken. Going back to letness, nothing ever does nor can completely stand for something else. Gödel demonstrated this through a mathematical proof (Gödel 1931), though I think it is much more easily demonstrated by going directly to the nature of stand-for relations. This incompleteness is at odds with many of the design manifestos that we have inherited from the last century and earlier, ideas that inform both design education, research, and practice. ‘Problem solving’, ‘creating order’, ‘harmonious balance’, ‘synthesis’ are the terms in which the vision of design is cast. These visions recur, even when they claim to be new:

We are faced with the task of building a new approach to design, which yields useful, useable, and desirable products for people (The Nantucket Manifesto, October 1998).

Here is a vision of resolution, closure, achievable ends, complete solutions. In a word, a panacea. Yet, as I hope I have shown, such a vision is a chimera, forever, necessarily and logically beyond reach. Indeed if we change the aspect, that is, look at any design from a different point of view, it is a minor transitory thing, a brief adaptation to a changing environment, a prosthetic device.

How then do we reconcile our historical trajectory with our lived experience?

Working at the boundary
In a recent paper (Sless 2002) I gave some examples of how design ‘problems’ get redefined in the scoping stage of a design project. For example, I talked about the special instructions that had to be designed for a medicine in order to help patients deal with some of its possible side effects. In the scoping stage it became apparent that redesigning the medicine was a better option than redesigning the instructions. This type of boundary shifting is common in design practice: the nature of the brief is changed, the problem is redefined.

One of the ways of dealing with the boundary problem is to extend the boundaries ever outward. Indeed, one way of telling the story of design in the last century is to see it as a series of transitions in which design progressively extends the boundary of its problem solving domain, beginning with designing individual objects, moving through designing for mass production, then designing entire systems, societies, biological ecosystems, forms of life. This story is predicated on the vision of design as offering ever more comprehensive panaceas, boundaries extending ever outwards.

But the visions of a panacea are, as I suggested above, a chimaera. Consider the ‘problem’ of ‘terrorism’. Consider the ‘problem’ of ‘global warming’. How would you design a ‘solution’ to
these ‘problems’? Where is the boundary of the ‘problem’? Is there a ‘therapy’ in Wittgenstein’s sense. Is a ‘solution’ possible?

To even engage in a debate about these issues is, through language, to be involved in designing philosophy. I would like to suggest that what we do at these boundaries is critical to designing philosophy and the emerging challenges of our time.
References


A comparative programme for design research

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Abstract

As ‘designing’ is a diverse phenomenon, but design processes have many important features in common with some other design processes, we can gain insights into how and why designers do what they do by making cross-domain comparisons. In this paper we propose a research programme for design studies: systematising these insights by using comparisons between design processes to compile a catalogue of patterns of designing – sets of features of design processes linked by causal mechanisms, that in combination with each other give a wide range of design processes their distinctive forms. The catalogue of patterns should include patterns describing features at different levels, linked by different sorts of causal mechanisms, so that different theoretical views and scales of description should be integrated in a richer unified understanding of designing.
A comparative programme for design research

Design research: mapping a diverse phenomenon

Designing is a diverse, extremely complex and enormously variable phenomenon, so diverse that it is not obvious whether it makes any sense to regard ‘it’ as one thing, distinguished from non-designing by more than superficial characteristics. What scope do universal theories of design really have? Perhaps the crucial determinants of the nature of design are neither universal nor peculiar to individual episodes, but are shared by types of designing. What types of designing? And what are the crucial determinants of the nature of design?

We have no definitive answers to these questions to offer. What we propose in this paper is a research programme for developing a richer and broader understanding of designing, by examining and mapping the similarities and differences between design processes. The goal of this research programme is to develop a progressively more coherent body of theoretical understanding of design, by working upwards from individual case studies.

This includes both comparisons between apparently-similar processes within one industry and between apparently-dissimilar processes producing radically different products, for instance helicopters and sweaters. We find similarity and difference relationships that cut across conventional industry boundaries – understanding them gives insights that are beyond the scope of universal theories of design and unreachable through single-industry process models.

While design is the focus of our interest, our local and incremental approach to developing theoretical understanding of complex human activities means that we are not fundamentally concerned with the boundaries between design and non-design; our project can and should encompass the similarities and differences between types of designing and other complex human activities such as the practice of science. In contrast top-down universal theory approaches to design necessarily make the difference between design and non-design a central issue (see Love, 2002); this may be a fundamental mistake.

Design as a function of technology and culture

The nature of an artefact – both its physical structure and operating principles, and its intended purposes (see Kroes, 2002) – exerts a powerful causal influence on the process through which it is designed. And design processes are constrained by human cognitive capabilities; although some designers have exceptional abilities, the findings of cognitive psychology give us universal constraints on what is possible for designers. Between these poles, a variety of cultural factors influence how designing happens: At the social level, the business models of the companies involved in the process (see for instance Eckert and Demaid, 2001), and their structures and social organisation. At the individual level, the knowledge, skills and values participants get from their professional training and experiences. Only some of these factors are unique; important elements are shared by the members of particular groups (see Bucciarelli, 1994; Henderson, 1999). Among the very wide range of factors that influence what happens in a design process, some serve to increase diversity, others serve to increase uniformity.

This richness creates a methodological problem for design research: the sheer scale and complexity of comprehensive descriptions or explanatory theories of how complex artefacts are designed. Design researchers are forced to focus on limited subsets of the phenomena in front of them (for an illustration of this, see the twenty analyses of the same data reported in Cross, Christiaans and Dorst, 1996). Even rich case studies of individual processes or working environments are necessarily partial; ethnographers deal with this by adopting as a methodological axiom the view
that different ethnographic accounts of the same culture can be equally valid. Universal theories of designing focus only on some aspects of a few significant parts of the design creation process. And descriptions of design differ radically in the scale of the phenomena they describe, as well as in the coverage they claim and the theoretical and methodological assumptions they embody. For instance Smithers (1998) presented a theory of the types of knowledge designers use; Papamichael and Protzen (1993) and Gero and Kannengiesser (2002) offered theories of the types and sequences of description creation in design; many engineering methodologists have based their views of designing on the theory of technical systems, for instance Andreasen’s (1980) theory of domains. Many other researchers have presented views of design to highlight particular aspects of designing, for instance Taylor (1993) stressed the inherent complexity and parallel nature of designing; we (Eckert, Stacey and Clarkson, 2000) highlighted the role of sources of inspiration in idea generation.

In order to make comparisons between design processes, we need to reduce the complexity of the problem by focusing on a limited subset of the phenomenon of design, as well as a limited set of design processes. Thus the research we do and the results we produce will necessarily be piecemeal, but they should be cumulative. In order to integrate our findings both with other comparative studies and the insights generated by the wide range of approaches to the study to design, we need a way to formulate our results that facilitates combination, both to create richer composite analyses and to reveal conflicts. In the rest of this paper we discuss our experiences of transferring insights between design processes, and the meta-theoretical view our experiences suggest, of how to do this systematically to build a structured mosaic of theoretical understanding of design.

**Comparative analysis: useful in practice**

This paper draws on empirical studies undertaken by the authors in a variety of different domains and industries. The first author undertook a broad and detailed study of design in the knitwear industry, focusing on communication (Eckert, 1997, 2001; Eckert and Stacey, 2000) and the role of inspiration (Eckert and Stacey, 2001), interviewing and observing over 80 designers and technicians in 25 companies in Britain, Germany and Italy (see Stacey and Eckert, 1999 for a methodological discussion of our approach). The broad range of companies studied make it possible to compare patterns of activities across both similar and dissimilar companies, to assess the causes of observed behaviour. In the knitwear industry everyone followed the same steps, so that the design process as described in a detailed flowchart model (Eckert, 1997) proved remarkably universal; however there were very large differences between companies in the effort put into the different stages and the amount of backtracking to earlier stages. Eckert and Demaid (2001) compared design processes in a variety of industries characterised by needing to meet very rigid delivery deadlines. They identified consistent patterns across industries determined by the business models of the companies. How they sold their products had a huge effect on patterns of communication in the design process as well as on risk taking. Some companies design their own ranges and sell them through shows. They do market research, but have no direct interaction with the buyers who make purchasing decisions for retailers. They are free in their design, but take a high risk. At the other extreme some companies work very closely with buyers for retailers, who give them briefs for designs and guarantee the purchase of a certain number of designs. These companies communicate with their buyers, but have no direct contact with the market. They undertake a large amount of rework to satisfy their buyers, but carry little risk until the relationship with their buyers becomes tenuous.

More recently the first author has been studying the design of complex engineering products, focusing on change processes in helicopters (Eckert, Clarkson and Zanker, in press) and diesel engines; and on process planning and communication in the automotive industry (Eckert and Clarkson, 2002; Eckert, Clarkson and Stacey, 2001), interviewing between 12 and 25 engineers and engineering managers in each company. She has gained interesting insights into engineering
processes from her understanding of knitwear design. A stark example is the similarity in communication behaviour between artistic knitwear designers and technical knitwear technicians, and conceptual designers and analytical designers of diesel engines. Knitwear designers’ greatest skill lies in gaining a tacit understanding of the space of contemporary fashion and placing their own designs within this context (Eckert and Stacey, 2001). They communicate their ideas highly efficiently amongst themselves by specifying changes to known examples of designs that are interpreted within the shared context of contemporary fashion (Eckert and Stacey, 2000). Arguing with verbal explanations referring to rational criteria from within a tacit context represented largely in visuospatial terms is extremely difficult; therefore the strength of subjective belief often replaces rational arguments. This mode of communication does not work well with people who do not share the context; it often appears handwavy (quite literally) and unspecific. The designers come across as inarticulate and less knowledgeable then they really are. Several years after observing the discourse of knitwear designers, we studied change processes in diesel engines, and interviewed several designers who were involved in the conceptual design of a new four-cylinder engine. The head designer had to make fundamental design decisions weighing up trade-offs, and defining the fundamental design that would later be realised and tested in several thousand person-years of design effort. This individual has a tremendous tacit knowledge of the properties of diesel engine designs. He uses the company’s old engines as well as competitor engines both as inspiration – for reassurance rather than copying – and as communication aids. When he has different design options, he might decide to follow a similar path to his competitors trusting them to have gone through a careful analysis process. Although design decisions are backed up with analysis, he follows his subjective instincts. In a discussion of degree titles it emerged that the diesel engine conceptual designers often don’t have a degree and if so feel strongly that they should be bachelors of art rather than science, because they see themselves as artists. They describe their work as an art rather than an exact science. Their mannerisms are remarkably similar to the knitwear designers including the gestures they make and the subjective beliefs with which they argue. In consequence their more analytical colleagues experienced them as vague and found it difficult to question their design decisions. When the author pointed out the similarity to knitwear design and explained the difficulty of rational explanation in communication about objects with emergent spatial or behavioural properties, designers from both groups found this very enlightening and requested that this issue be included in a formal feedback presentation. The conceptual designers had never realised that their way of talking was perceived as unscientific and therefore had not provided the rational arguments that they could have constructed; and the analytical engineers had never realised that this way of talking resulted from the task the conceptual designers were doing rather than their personalities (the two are of course not unconnected).

So we have found that cross-process comparisons, focusing on a few locally-relevant aspects of designing, have enabled us to identify and explicate important causal influences on what happens in design processes. However what we have not yet done is formulate the results of such comparisons in a form that facilitates the development of a systematic body of understanding about design.

**Similarity between instances of designing**

Our understanding of the diverse range of human activities we label ‘designing’ is influenced by the similarities we perceive both between pairs of design activities and across large categories. Similarity between domains arises from common features of designs or processes. Different categories of features correspond to a spectrum of layers of design descriptions (Eckert and Earl, 2002). At one end of this spectrum lie the designers’ domain knowledge and the organisation of the process whilst at the other end lie the details of components and the production processes that produce them. In a central layer, the features of products, which include solution principles, function and layout, link 'upwards' to the knowledge and process layers and 'down' to production and component layers. Common features between domains can be examined in each of the layers...
separately. However, in identifying similarities between domains it will be necessary to look across layers. Just as common features (and distinguishing features) can be used to compare domains, so can common relationships between features. Not all shared features will have the same significance, either in our perceptions or in theoretically grounded reasoning. Moreover distinguishing features may overwhelm the similarity due to shared features. One purpose of the research programme we propose here is to change people’s perceptions of similarities and differences by raising awareness of factors other than superficial product characteristics and conventional divisions between industries.

People commonly perceive ‘design’ as having a unity beyond being the activity of creating a plan for an artefact to meet a practical need; and many commentators have argued that it is fundamentally characterised by a cycle of proposing a partial solution, evaluating the solution, reformulating the problem and proposing another solution to the revised problem (Asimow, 1962; see Cross, 2000). But we suspect that much of the perceived unity comes from design activities sharing many characteristics with some others; in order to make sense of the relationships between individual processes and the range of design activities, we need to consider other kinds of similarity relationships.

Most intuitively, similarity classes can be defined where all elements in the class share a set of common features. In mathematical analyses of similarity, closures arising when no more elements can be added to a class without reducing the numbers of features they all share are the critical similarity classes. These similarity classes are related in a lattice structure (Ganter & Wille, 1999) which provides a 'map' of potential similarity relationships. Similarity can also be based on tolerance relations defined by shared features. Tolerance classes are maximal sets of mutually similar elements, that is each pair of elements shares at least one feature (Schreider, 1975; Zadeh, 1971). This tolerance similarity is not transitive so that if domain A is similar to B which is in turn similar to C then A may not be similar to C. Similarity classes themselves are the subject of a tolerance relation based on sharing a common domain. A weaker definition of similarity classes relaxes the condition for common features to exist between each pair of domains in a class, allowing a chain of connection. Two domains A and C can be similar through a domain B which shares features with A and (not necessarily the same features) with C. A stronger specification takes into account the number of shared features. An m-connection arises from m shared features and corresponding similarity requires that domains share at least m features. Classes defined by chains of m-connections correspond to the multidimensional structures of complex systems (Johnson, 1995).

In measuring the strength of similarity it is necessary to consider both shared and distinguishing features as well as their significance (Tversky, 1977). The 'diagnostic’ or classificatory value of features is dependent on the domains being compared. The strength of similarity between domains can reinforce itself in this classificatory role. Similarity is then perceived as greater within the group. The significance of features is also dependent on the range of domains being compared. Features common to all domains in a range have little or no significance. However, adding more domains, which do not share these common features, can increase the significance of the original features.

**Patterns of designing**

The characteristics that some instances of designing share with some others come in clusters – different instances of designing can have a lot in common because what they share includes powerful determinants of the form of the designing process. Clusters of consistently shared characteristics form patterns. If we observe such a cluster, we can hypothesise that the shared characteristics are linked by causal relationships, or are all symptoms of some as yet unrecognised
underlying cause. We can test such a hypothesis in two ways: by looking at other design processes to see if the presence of some of these attributes predicts the presence of other attributes; and by trying to construct and test theories of how the attributes are causally related.

In our view, recognising and making sense of patterns of designing is crucial to developing a rich, multi-level understanding of design. [Note that we avoid the term design pattern; this refers to an abstractly-formulated solution to a recurring problem, together with a description of the type of problem it fits and the consequences of using it, an idea introduced into architecture by Christopher Alexander (Alexander et al., 1977) and widely adopted in software engineering (notably, Gamma et al., 1995). This notion has long been implicit in much engineering practice.]

Patterns of designing can be detected at all the scales at which designing can be analysed and described – of time, number of participants, the portion of the whole artefact being considered, and the activities that are the units of analysis. Moreover, given sufficiently rich observations of design processes we can look for patterns comprising features at different levels of description. But identifying similarities that can be represented as patterns of designing is not trivial: it involves finding the right abstractions of observable phenomena; this requires imagination and reframing the design situations in different conceptual terms.

Causal stories: elements of theories of designing

Even if the elements of a group of characteristics appear to be consistently present or consistently absent in a range of design processes, the group will be unpersuasive as a pattern of designing until we have a causal explanation for why these features are related. Thus the next step given a putative pattern is hypothesising one or more plausible causal stories for how the features share common causes, or are linked by a chain of cause and effect. The instances of designing under study can then be scrutinised for supporting or disconfirming evidence. Hypothesising causal relationships enables the generation of more focused questions about what is really going on in an episode of designing.

But the processes of designing complex artefacts are immensely complex and variable, and the causal mechanisms that influence the form of designing may operate with different strength. Causal influences on some aspect of designing may collide, chains of causality may be blocked or modified by other influences. So we should ordinarily formulate our causal stories in terms of causal pressures rather than rigid determination. We may observe only part of a previously defined pattern in another design process, so that some characteristic of the process is predicted by the pattern but is absent. We should look for reasons why the causal mechanisms that according to the pattern should produce it are blocked, as well as for evidence that they are not operating. Either finding should enable us to refine our formulation of the pattern or suggest a new one.

We retain an open mind on the question of whether a science of design is possible, or whether the study of design is necessarily a humanistic discipline (see Darke, 1979, for an articulation of this view). But the collection of patterns of designing has the form of scientific research – what we are after is understanding regularities and causal processes, by hypothesising and testing covering laws relating observable variables in the form of clusters of characteristics of design processes, and partial theories in the form of causal stories for why the elements of the pattern are related. Such covering laws and pieces of causal explanation formulated as patterns of designing are local and fragmentary – pieces of a fuller theory subsuming all valid universal theories and accurate process models, that it may be impossible ever to complete.

A research programme in comparative design studies

Because designing any complex artefact involves an extremely complex process, and design processes are influenced by a wide variety of phenomena at several levels, complete causal
explanations of why everything happens and the way it happens are infeasible. But design processes are neither completely dissimilar from each other nor completely unpredictable. We can aim to develop an understanding of design that explains the nature and effect of major causal influences on design processes; and that predicts to a useful degree the form of design activities and the problems they will meet. The immensity of the task of developing a complete theory should not worry us, provided that our theory fragments not only function as free-standing explanations of interesting phenomena, but can also be combined to understand what happens when different interesting phenomena occur together.

We propose that cataloguing patterns of designing should be a significant part of future empirical design research. Researchers should take opportunities to use previously documented patterns to gain insight into new design processes. At the same time they should take opportunities to test, corroborate, falsify and refine previously documented patterns as well as add new ones. In each case they should explicitly raise the question of how general are the phenomena they see in individual cases. Through an incremental process of critical evaluation by a diverse body of researchers – everyone who wishes to participate – we can incrementally develop a progressively greater understanding of similarities and differences between design situations, and the causal influences that give design processes their form.

The view of design processes as varying in similarity to each other along different dimensions, and the research programme we outline here, is independent of the theoretical assumptions and foundations that underlie any particular approach to understanding what is going on in design. The comparative programme should encompass and orient a variety of different theoretical and methodological approaches to design studies. It should provide a basis for examining the scope of particular analyses and their relationships to similar analyses of other design processes; and for relating different theoretical perspectives on the same phenomena.

We welcome the participation of researchers with different concerns and theoretical viewpoints. Patterns of causal influence can spring from technical, organisational, social and cognitive causes, and can act at many different scales, and a key part of the programme we propose is looking to see how different patterns describing different types of phenomena interact. Researchers tend to interpret phenomena that they see on one specific layer and attribute problems to the cause they are most familiar with. Sociologists tend to attribute problems to the interpersonal nature of design, psychologists to cognitive factors, business researchers to organisational processes. For instance Eckert (2001) described a variety of causes for breakdowns in the communication of design ideas between commercial knitwear designers and knitting machine technicians (and argued that the primary causes were the inherent difficulties of describing knitted structures in the available representations and the participants’ lack of understanding of the nature of their communication problems, while several secondary causes made resolving the problems harder). The two groups are socially as different as possible: young university trained women versus older men trained on the job with little formal education. Sociologists repeatedly commented that only when they heard this fact, they understood why the two groups don’t communicate. However we have also observed communication difficulties between socially homogeneous engineers with different areas of expertise and mental representations – what Bucciarelli (1994) termed different *object worlds* (Eckert, Clarkson and Zanker, in press). Comparative studies that allow us to test causal hypotheses should enable us to assess the validity of different explanations.

**Comparative analysis through observational studies**
While theoretical analyses and experimental studies of designing in more or less realistic scenarios can yield important insights, particularly into the cognitive processes involved in particular kinds of
problem solving, the primary source of information in the comparative design research programme will be studies of actual commercial design processes through interviews and observations.

Sociology offers many different methodological approaches for studying cultures. Ethnography (see for instance Agar, 1980; Hammersley and Atkinson, 1995) has been widely adopted as a way to understand work cultures to assess the real requirements for software systems (for instance Suchman, 1987; Viller and Sommerville, 2000; see Anderson, 1994; Button, 2000), and has been taken up by many design researchers (notably Bucciarelli, 1988, 1994) including ourselves (Eckert, 1997, 2001). Ethnographic methodology can be applied to developing analyses of design in terms of cognitive analyses of expertise (Ball and Ormerod, 2000) and knowledge-level analyses of the information used and transmitted by the participants in a design process (Stacey and Eckert, 1999), as well as sociologically-oriented analyses of the types of statement that members of design teams make to each other (Minneman, 1991) and the role of visual representations in structuring design processes (Henderson, 1999).

In an ethnographic study the researchers join in the daily life of the groups they are studying and attempt to learn the skills and perspectives of the actors, while remaining conscious of their role as an outsider. This dual perspective enables the ethnographer to make sense of how the participants in the culture themselves see what they do and why they do it. Ethnographic studies are traditionally very detailed studies of one culture, which do not make any claims to generality. The criterion for validity is that assertions ring true to the participants in the culture; some researchers have attempted formal validation exercises with their participants, this is not unproblematic (Hammersley and Atkinson, 1995). However the rich data and insights gained by ethnographers can allow us to interpret behaviour we see in other situations. For example Anderson (1994) pointed up the analogy between Levi-Strauss’s (1969) study of marriage and gift-giving among Amazonian Indians and the social processes involved in experts helping their less knowledgeable colleagues customise software (Mackay, 1990). While some ethnographers argue that researchers should enter a culture without prior hypotheses, in practice hypothetico-deductive reasoning and explicit hypothesis testing is an important part of ethnographic fieldwork (Hammersley and Atkinson, 1995); we have argued that this is an essential part of understanding how cultural factors and the nature of the artefact interact to determine the form of the design process (Stacey and Eckert, 1999). Comparisons between design domains can provide a rich source of hypotheses to test and refine in observational studies; their use should be enhanced by making testable hypotheses available in a systematic catalogue of patterns of designing.

In most of our own empirical studies of engineering, applying ethnographic methods is infeasible; we are largely reliant on interviews (Eckert, 2002). The information gathered is less rich, and suffers if the interviews are away from the engineers’ normal workplaces. Nor can we always take statements in interviews at face value, as ethnographers well know. However we find interview studies to be effective given appropriately selected informants, especially if assertions can be discussed with several people with different viewpoints. We are able to actively test hypotheses derived from cross-industry comparisons. We employ aspects of the ethnographic mindset: we recognise the importance of understanding the participants’ own perceptions of tasks, situations and cultures; and that interpretations are selective and partial, so that different accounts may be equally valid. However, central to our approach is generating and testing more general and abstract causal processes, and using comparisons between situations to test hypotheses and rival explanations.

The return journey: practical applications of comparative design studies

Our approach is pragmatic. It aims to provide useful insights into particular situations from the richness of the immense variety of other design processes. While we are intellectually interested in understanding the nature of design, our ultimate goal is to find ways to support and enhance the
work of practising designers. In the development of computer support tools, methodologies and management procedures, it is crucial to know the scope of phenomena the techniques are designed to address. It is necessary to identify the root causes of problems. The catalogue of patterns we envisage should provide designers, managers and software developers facing local practical problems with a toolkit of concepts with which to make sense of design processes they want to improve. Our comparative design research programme is intended to enable the transmission of best practice between companies and between industries by enabling the recognition of which design processes share needs and problems, instead of relying merely on the similarities between products.

We also believe that our comparative approach can yield benefits for design education in a variety of design disciplines, which try to develop their own models and teaching methods without benefiting from each other’s experiences. Many working designers we have met in knitwear design as well as engineering fail to understand the nature of their colleagues’ work – for instance knitwear designers typically fail to comprehend that knitting machine technicians do designing (Eckert, 2001) – with visible adverse consequences for design processes. We find that designers in ‘subjective’ fields like knitwear design lack understanding and respect for the technical, problem solving aspects of their own work, while designers in ‘technical’ fields like engineering lack understanding and respect for the holistic, perceptual or subjective thinking involved in design. All these designers would benefit from a greater understanding of the similarities and differences between different kinds of ‘artistic’ and ‘technical’ design. In the long term, this more sophisticated view among designers may influence public understanding of design. The recruitment into different design professions is influenced by the public’s perception of the different fields, for example many believe that textile design would be more creative than engineering. Stereotypes perpetuate old gender divisions and attract certain personalities to certain fields.

Acknowledgements
Claudia Eckert’s contribution to this research has been supported by the EPSRC block grants to the Cambridge University Engineering Design Centre. This paper was written while Louis Bucciarelli was a visiting professor at the Delft University of Technology. Several members of the Cambridge EDC have participated in our empirical studies of engineering design processes, particularly Tim Jarratt and Brendan O’Donovan. We are very grateful to all our informants in many companies who have given their time to interviews and observations.
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Information and cognitive process: a communication theory for design

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Abstract

Design lacks a direct language for discussing meaning as it is experienced and constructed by receivers, and it lacks operational methods for measuring meaning and relating it to the design decisions that determine the spatial and temporal composition of communications. Thus, at the heart of the design process itself is a lacuna.

This paper describes a theoretical approach to bridge the gap by examining how users construct meaning. The proposed cognitive process model is based on the processes of perception, thought, and memory: species wide competencies that underlie the manifold social and cultural code systems of communicative forms. A method is derived to make inferences about that user constructed meaning on the basis of observable outcomes. The research protocol provides a robust, repeatable, in situ method that can be used in different communications situations for exploring highly varied communication questions, and for extending empirically substantiated theory. The research method can support the development of a larger analytic base for communication design. The research provides methods in which communication outcomes can be clearly demonstrated, with the potential for replacing survey and focus group analysis in those situations where they are dubious or ambiguous with a tool that is simpler to use, more direct in its measures, easier to interpret, and which can be unobtrusively embedded into pre-existing communications.

The theory and research demonstrate that it is possible to use empirical methods in non-positivist ways to creatively explore subtle and meaningful ideas about communication and design. The results of such explorations can be used to create new ways of designing communications.
Information and cognitive process: a communication theory for design

Let us begin with two simple premises. First, what distinguishes much designed communication from art and other forms of expression is accountability, i.e. that it is required to communicate something specific: either a set of data or facts, or a specific frame for looking at data or facts. Second, the communication of data and facts relies on frames for interpreting them. Without frames of reference, facts are meaningless. The dependence of communication on the frames it must communicate is the conundrum. Often communicators can presume that competent receivers already possess the appropriate frames. Let us take financial communications as an example. For professional readers, the presentation of a company’s history of earnings growth and its current price earnings ratio will cue a frame of reference within which to look at the stock price. But, we can quickly imagine three scenarios in which the strict information display model is not adequate. Scenario 1: the frame of reference is unknown or problematical. The information is an enigma that cannot be placed into the reader’s known frames. It needs a new frame of reference to make it intelligible. Scenario 2: the reader is not a professional, but a consumer who needs to be educated as well as informed. Scenario 3: the reader’s arena of action is substantially separated from the domains of the information. For example, the reader is presented information about a specific stock or sector, but he or she must use the information to make decisions about personal spending, and retirement goals and strategies.

Designers are currently confronting these scenarios, reflected in new information requirements of changing markets, customization of information for consumers who are increasingly acting as their own fiduciaries, and particularly in terms of delivering information and providing information interfaces that are directly actionable by end users. New approaches range from consolidated information statements, to smart agents, to qualitative (low-resolution) displays. These considerations bring us to an aspect of communication design that complements the notion of communication as information display or message: a cognitive process model of communication.

Basic tenets of the cognitive process model can be summarized as follows. The content of a communication is comprised by the receiver’s formation of a concept: an interpretive frame or frames of reference, which make the communication intelligible. The communicative content is not expressed information or subject matter. The content is what is not expressed: what is created by the receiver using his or her cognitive faculties. Thus, most importantly, communication is the guiding of cognition, a rational, human, species wide competence. This competence is a constant, which underlies varied cultural and social beliefs. It is also implicit in communications, as artifacts, which are created and received not as objects in themselves, but as vehicles of communication.

The cognitive process model of communication proposed here sees the communication not as the transmission of information, but as a series of challenges, rewards, and resources that provoke and guide the receiver’s perception, thought, inference, recognition, and memory. This model complements information presentation or message approaches by concentrating on the receiver as the one who constructs the interpretive frame. It recognizes the receiver as an active participant. It balances this by recognizing the communication as an active participant as well. The communication is not merely a tool, but an interactive partner: indicating the situation, modeling roles by displaying comportment that is appropriate to the situation, and steering the receiver toward the frames it wishes the receiver to invoke.

When we speak in terms of the document, we speak of its meaning, while when we speak of the reader’s participation, we speak of interpretation. The focus on receiver participation stresses
interpretation. The term “interpretation” can be taken in three ways: identification, meaning or implication, and evaluation. Of the three, identification is primary and objective: it is who or what we are seeing or what is happening. Comprehension grows out of the inner consideration of external objects and events, and evaluation is one’s sense of the objects as related to one’s goals and desires. Identification is a highly objective, non-idiosyncratic, and rational process. It is out orientation to the outside world. We count on its objectivity to keep us from walking into doors and falling down stairs. Communicators count on the rationality and consistency of this process among receivers and thus on the ability to anticipate, encourage, and accommodate it with appropriate affordances.

Theory orientation

This paper presents the cognitive process model through research conducted at the Institute of Design, Illinois Institute of Technology [Storkerson, 2001]. At the heart of this model is the notion that a receiver must, select or create a frame of reference to make a communication intelligible. That frame defines the communication’s meaning or content, as distinct from its subject matter, and it is the primary communication goal or prerequisite. Again, the subject matter may be the price of a car, while the content may be “Should I buy this car if I want to retire in comfort in fifteen years?”

Increasingly, communications are combining symbolic modes such as language, with sensory modes: visualizations including charts and diagrams, sounds, motion, navigation, etc. In doing so, they mix two different human cognitive systems. The distinction can be demonstrated directly. Take the sentence “The house fell on my head,” and ask how we make sense of it. In terms of word meanings, it is difficult to find linkages between “house” to “head” that specify their semantic relations, but it is very easy to make up a little imagined visualization, and watch the house lift up, rotate, turn upside down and fall on my head [Waltz, 1981]. On the other hand, it is hard to imagine visualizing symbolic calculation like the old chestnut “All men are mortal. If A. is a man. Then, A. is mortal.”

Sensory and symbolic cognitive systems are complementary and distinct (Figure 1). Sensory systems tell us about experience and operate according to experiential dimensions of time and space. They function narratively, like the house visualization, and are tied to specific events and locations. Sensory systems organize the flow of experience spontaneously, into the discrete events and entities of perception, and resolve them by coherence. Symbol systems are category driven. They require the naming of events and entities: their construal in terms of general categories that are not tied to any such specific places and events. Symbol systems concentrate on a finite number of items, calculating and inferring answers on the basis of reasons rather than some overall coherence. Finally, sensory modes give us experiential knowledge, which is incommensurable with symbolic knowledge. The house visualization does not just give us more information about the sentence, it tells us what the sentence might “mean” in terms of experience.
In graphic and multimedia communications, the symbolic and sensory modes must be integrated to give a single experiential-conceptual amalgam. This cognitive integration gives graphic communication its power. Cognitive processes combine perception and thought to form concepts or inferences, which are projected or imagined and compared with direct perception (Figure 2). When projected inferences and direct perceptions match, the result is recognition, which is a combination of sensory and conceptual elements resulting in a phenomenology or sense of knowing or grasping (Figure 3).
Figure 2: Cognitive process

Figure 3: Cognitive phenomenology
For example, I see someone new who looks vaguely familiar. I don’t remember her, so I try to think of whom she looks like. I think of someone, visualize the person as of when I last saw her, and compare that image with the person in front of me. I recognize and isolate the resemblance, e.g., eyes or hair. Now, recollections and feelings about an old acquaintance also enter my mind in a flood.

Graphic and multimedia communications harness the knowledge built into sensory cognition and apply it to other domains. A stock price graph relies on symbol systems to refer to days and to indices, but it is sensory cognition - the ability to run movies in the head - that is behind the implied motion of diagonal lines and that enables viewers to intuit that prices are “rising” and “falling”. Thus, graphic communications leverage sensory knowledge and use it to teach about other things, and to imply narratives.

Image-text composites are even more fascinating. Consider the photograph of Figure 4, left. By itself, this image has little discernible meaning. Now, forget the image and consider the sentence: “Joanne used the press as the press used Joanne.” By itself, this sentence is enigmatic. When, however, the text is placed next to or over the image, the two are combined. Now, we have a new interpretive frame. It’s a picture of Joanne. We are looking through a picture taken by a press photographer whom Joanne is fending-off by shielding her face. She is a celebrity and the press are “using” her by invading her privacy. But, if she is using the press, her pose is also ironic. She is, perhaps, both fending-off and attracting the press. She is negotiating her celebrity. We cannot “know” these things in the veridical sense of warranted proof—the picture could be staged and the caption was certainly added—but the combined image and text convey the meaning by supporting new interpretive frames and afford us the phenomenology or sense of knowing what we are seeing. Phenomenological knowing is a primary goal of information design. That intuitive sense of grasping makes information actionable. Such composite presentations are all the more persuasive because as receivers, we think we are making our own interpretations.

Once defined, cognitive processes and outputs can be measured as memory. Psychologists have demonstrated that memory is not a record of stimuli, but of cognitive activity: work and successful results. We remember the things that we make sense of and we see them as significant in terms of some set of events or discourse. We remember them as we interpret them: in the forms of meaning they have for us. We do not, for example, remember details in noise and clutter; we do remember configurations with form and structure. Memory can be seen in three aspects: retention,
comprehension which is the depth of processing that is reflected in the entities remembered, and
interpretation which is the structure or organization of what is remembered.

Given that memory tracks cognitive work and its results, the primary cognitive act is integration, the organization of the perceptual field into distinct events and entities. Successful integration results in phenomenological knowing which can be measured as confidence. The cognitive work involved can be measured as processing time or latency. The primary record of cognitive process is long-term retention: recall (Who was the president during the civil war?), or recognition (Who is in this picture?). Comprehension can be measured by the conceptual level of memory. Ericsson and Simon have demonstrated that verbalizations are limited by the sophistication of comprehension (Ericsson and Simon, 1996). Finally, interpretation can be measured as the selectivity and structure of memory cues (what part reminds a receiver of what other part).

**Figure 5: Cognition and memory**

**Experiments**
This model makes an ambitious claim that bridges from cognitive processes to interpretive content: “If I know what you remember of a communication, I know how you can think about it, and by knowing how you can think about it, I know what you think.” Experiments can help determine whether this claim can be sustained. Two experiments were devised for this purpose. Both used a computer program to show movies and ask questions about them. Each movie was eight to twelve seconds long with a single event on video and a spoken text with a single statement or proposition (Figure 6).

In the first experiment, 40 movies were shown individually to 120 subjects, both male and female, from 18 to 60 years of age and with varying levels of education. The relations between the modes (video and spoken text) varied according to whether the video and words explicitly presented
common subject matter, or concepts, if they implicitly presented common concepts, or if there were no credible common concepts or subject matter presented. Interpretation was operationalized as the integration of video and words into a whole. Processing, or cognitive effort was measured by latency: the length of time required to either make the integration or decide that it was not possible to do so. Phenomenological knowing was operationalized as reported confidence. Thus, after each movie, subjects were asked whether the video and words made sense together (yes or no). Then, subjects were asked how confident they were of the response. Records were made of responses and response times.

**Figure 6: Experimental movies and questions**

From the data, movie scores were constructed for each movie. A movie’s integration score could range from 0% if all subjects reported segregation, to 100% if all subjects reported integration. Its confidence score could range from 1 if all responses reported low confidence to 3 if all responses reported high confidence. Both responses and response times or latencies were collected as data.

Movie scores showed normal distributions with rates of integration varying from approximately 10% to 90%, confidence scores ranging from approximately 1.8 (low-medium confidence) to 2.8 (high confidence) and latencies ranging from .2 sec. to 10 sec (the maximum allowed by the program). The mean score for integration of movies was 44%, which means that on the whole movies were integrated 44% of the time. On average, it took almost 2 seconds to respond to the integration question, about 1 second of which was keying and reaction time. The mean score for confidence was about 2.4, indicating that most responses were in the moderate to high confidence range. The confidence latencies averaged near one second, indicating that confidence was not a considered judgment but a feeling that could be quickly reported.

Integration latency showed a significant U-shaped relationship to integration score (Figure 7), indicating that the movies that were most often either integrated or segregated were processed most quickly. Those with scores near 50% took substantially longer to process, indicating that they were more difficult and required more thinking. Movies with integration scores near 50% were movies on which subjects split as to whether they could be integrated. In itself, this could be a matter of cultural or individual differences in interpretation, but other measures indicate that individual interpretations were not so idiosyncratic. The relationship between integration score and latency indicates that behind the apparent differences in interpretation for movies with scores near 50%,
there was greater difficulty in interpretation. This was a strong relationship with an Rsq greater than 40%, significant at the .000 level.

The movies that were difficult to process were also reported as ambiguous. Subjects were most confident of their judgment with movies scoring high and low on rates of integration (figure 7). Their confidence dropped as the integration scores approached 50%. This was a very strong relationship with an Rsq of 61%, significant at the .000 level.

Finally, background information was collected including age, gender and educational attainment. There were some differences between groups: greater tendencies to integrate, slightly different mean reported confidence levels, etc. but the relations were the same for all groups.

**Second experiment**

Experiment 2 focused on the effects of perceptual disturbances on interpretation and memory. This experiment used 20 of the movies which were used in experiment one, but here, the temporal relations between video and spoken words were altered yielding nine Delay States including synchronized presentation (identical to experiment one), and with either video or spoken words delayed: by one second, with one second overlap, with no overlap, or with a one second gap between whichever mode was first and the mode presented second (Figure 8).
As in the first experiment, immediately after each movie was shown, subjects were asked if video and words made sense together, and to report their confidence in their judgment (low, medium, or high). Also, as in experiment 1, latencies were measured (Figure 6).

The Integration and Confidence results of experiment 2 showed the inhibiting effect of Delay State on Integration (Figure 8). Integration was highest in the synchronous 0 Delay State, with a score of 52%. It dropped to as low as 35% for Delay States 2 and 3. It dropped significantly, to 43%, with only a 1 second delay. Figure 8 also shows that it made little or no difference which mode was delayed, indicating that neither mode carried a predominance of meaning.

Since there was no one-to-one correspondence between videos and words, a delay of one mode merely altered already arbitrary adjacencies of words and video. It appears that subjects were attempting to integrate modes based on perceived onset as a cue: trying to realign video and words using sensory or working memory. The temporal “misalignment” of modes was perceived as such because it violated the expectation that things that belong together start together. The lesser effect of a 1 second delay was consistent with compromised cognitive function as delays approach the limits of perceptual memory.

**Integration and memory**

In the second part of experiment 2, subjects were tested on their memory via recognition. The strategy was to re-run each of the movies, presenting one of its two modes—either the video or the spoken words—while presenting the other mode from four movies including the correct match.
(figure 9). Subjects were asked to correctly match video and words that belong together in the same movie. In this way, either video or spoken words could serve as a cue for the recollection for the other, and it might be possible to detect which movies were remembered.

Figure 9: Recognition test; matching video and text

The overall rate of correct identification (Memory) was high: 86% of movies were correctly identified, compared to a chance 25% correct response rate. The overall Memory Latency, i.e. the time it took to match video and words was 8.1 seconds. This reflected the difficult job of matching video and words, which involved memory and discrimination between memories while presentations were being shown. The mean confidence was 2.55, indicating that subjects were moderately to very confident of their recollection. Given the high level of correct answers, most of the calls were probably easy.

The major single finding with respect to memory was that the movies that subjects had integrated when they first saw them were substantially better remembered than movies that they had not integrated (Figure 10). Only 7% of integrated movies were not remembered while 13% of not integrated movies were not remembered. For integrated movies, the variable Delay (regardless of which mode has precedence) had no significant relationship to memory, but for segregated movies, delay improved memory from 72% scores for synchronized presentations to as high as 85% for delay states of one second. As figure 10 shows, memory was highest for overlapping or gaps between modes.
This finding points toward a second factor beyond integration affecting memory: i.e., cognitive effort itself. Research on “cognitive interference”, challenges like the one presented by temporal shifts, indicates that such interference may inhibit initial learning, like integration, but may also actually “facilitate” longer cognitive effects like memory. (Battig, 1966, 1972) Interference and facilitation effects are generally beyond the scope of this paper.

**Conclusion**

This paper has proposed a cognitive processing model of communication in order to bridge the gap between the physical configuration of communications and received meaning. The goal of this model was to make a path by which meaning can be operationalized, and tested against physical variables. It accomplished the goal by relating meaning to cognitive processes with measurable indicators.

The experiments cited are formative, but they present a strong case for the validity, researchability and potential usefulness of the cognitive process model. They demonstrate that cognitive processes are measurable and consistent across a broad population, and that they are related to primary interpretation (integration), phenomenological knowing (confidence) and memory (recognition). The use of time delays indicates the potential importance of sensory manipulations in the inhibition or facilitation of integration and memory as well as the organization of memory (interpretation).

These are formative experiments initiating a larger research program which can include many other hypotheses and variables. The experimental method has demonstrated the validity of the theoretical approach based on cognitive function can be resolved into specific predictions and those predictions can be tested. It has the potential for application as a method for gaining access to a broad range of variables through cognitive processes. The method can be refined and extended in many ways:
• Refinement of variables: Specific parameters like the lengths of movies, and specifications like the use of videos and spoken texts as distinct from images and written texts could be altered for comparison and for refinement.

• New Variables: This method could be used to examine a wide variety of variables including the use of still photographs, superimposition of text, video montage and quality, the speaker’s age, race, sex, manner of speaking and tone of voice.

• Sequence Testing: Experiments could be extended to include associations between different movies and sequences of movies. It could be used to study the effects of photographic variables, sound, or music, and it could be used to access a broad variety of socio-cultural attitudes as they affect interpretation, comprehension and memory.

• Human-Computer Interaction: Methods could be extended to the domain of human-computer activities: eliciting and steering human motivation.

• In situ testing: The experimental methods used here could be applied unobtrusively outside of the laboratory, in real-world situations and integrated into design processes.

The approach and the research presented in this paper has direct implications to communication design on 3 levels: findings, theory, and meta-theory: i.e., a theoretical base that can be used to produce hypotheses regarding design practice.

• Findings: It generates findings in the domain of communication design: practical advice for communication designers. Some findings may be surprising, such as the facilitating effects of interference. These findings can be used to predict and measure results, and to creatively explore new design possibilities.

• Modeling: It presents a theoretical model of communications that is testable: it can be used to make hypotheses that can be affirmed or refuted.

• Empirical methods: It builds an experimental method that can be used to generate and test new hypotheses and in that way to refine, extend and produce new models.

• Using this simple procedure, it is possible to incorporate assessment into communications as they are being used.

This approach demonstrates that it is possible to build models that are both theoretically sophisticated and empirically researchable. It takes a step toward communication design as a theoretically informed, research-based enterprise that can specify and design communicative outcomes and assess performance.
References


A field study methodology using self-photography of workplace activities

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Abstract

The design of a new tool or technology for a workplace should take into account the broad range of activities that go on in a given work environment. This paper describes an observation methodology in which the users - those who actually work in a given environment - photograph their own activities, acting as their own investigators. In this methodology, some visual tools are used to enhance communication in the design process. During follow-up interviews of the workplace activities between designers and workplace users, the self-photographs serve an important role as a medium to help designers understand how users function in the workplace. An interaction map, which visualizes the structure of the work practice, promotes and mediates interaction between the user community and the design team. In addition, the self-photography helps to give users a sense of participation in the investigation process. This helps users become involved in the design process thoroughly and smoothly. By applying this observation technique to three design projects, it is confirmed that the self-photo methodology is effective not only as an observation tool but also as a mediating tool among the various communities across the entire design process.
A field study methodology using self-photography of workplace activities

Introduction

The development and deployment of a new tool or technology affects a broad range of work activities and people, necessitating changes in various kinds of activities. A new tool or technology does not stand alone; rather its use depends on people, organizations, and other tools and technologies (Suchman 1987). In other words, a new tool or technology is embedded into a socio-technological network. From this point of view, the design of a new tool or technology must be based on a proper understanding of practical user activities in an actual workplace.

Our main research interest is to develop a methodology for observing the work practices of users in order to design a new tool or technology. How to reflect the field study data into the design is also a significant research issue. Another interest is the collaborative design process. Various kinds of people, such as designers, researchers, planners, and developers, are involved in the design process. Close communication among these participants is necessary (Bodker 1996, Kensing 1998). We focus especially on how to share information about users’ work activities during the design process.

In this paper, we describe a methodology, called “self-photo study”, to understand users' work practices from an ethnographic approach. Our research focus is to develop a photographic field study methodology, and self-photo study is one such methodology. Based on three experiments we conducted using self-photo study, our research confirms the effectiveness of self-photography for data gathering and shared understanding among users and the design team. Furthermore, we discuss how this methodology helps the interaction between the user community and design community in the design process.

Self-photo study

In order to understand the work practices of users (or workers) we are developing a simple fieldwork method, in which the users themselves serve as investigators; each user photographs his or her own work practices (Bly 1999: Mountford 1991: Gaver 1999). This method is called "self-photo study”. In our trials of this method, each subject was given a disposable camera and was asked to take photographs during the course of a typical workday. They were instructed to record, through the photos, their activities related to work, communication, and relaxation. Each photo of an activity contained places, people, artifacts, and so on. After the film was developed, the subjects were interviewed about the photos. Some of the questions were as follows.

- What place is this?
- What kind of activity are you performing here?
- What kinds of tools and documents are you using in this photo, and how are you using them?
- With whom are you working or communicating here? What kind of technology is mediating such communication?

Photographs and interview data are arranged on a workplace data sheet, which consists of several fields, such as photograph, place, time, activity, people, artifact, communication, and so on (Figure 1). Then an interaction map is created from the workplace data sheet (Figure 2). This map visualizes the relationships between or among workplaces, workers, artifacts and activities. After the interviews, subjects and members of a design team hold a workshop to discuss their activities through the workplace data sheet and the interaction map.
**Figure 1. Example of a description of a workplace data sheet**

<table>
<thead>
<tr>
<th>tz0033</th>
<th>tz0034</th>
<th>tz0035</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Explanation**
- At home
- tz0033: setting PC on the table
- tz0034: power unit
- tz0035: ISDN
- tz0036: a screen of PC (infoseek)
- tz0037: a screen of PC

**Activity**
- Checking mails
- Netsurfing

<table>
<thead>
<tr>
<th>tz0036</th>
<th>tz0037</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Place**
- home

**Time**
- 9/1 24:00

**Frequency**
- alone

**With Whom**
- alone

**Artifacts**
- Notebook & Network Modem & Web Browser
- Almost for E-mail, slightly for netsurfing.
- At home, I don’t work very much without checking mails.
- My notebook is left on the desk of the living room.
- A E-mail to read troublesome in the company is read closely in the house.
- (CC for myself)

**Communication/Connection**
- Connecting provider by a network modem.
Three experiences in self-photo study

The self-photo study method was applied to three different kinds of design projects. Here we present overviews of three case studies and characterize the results.

Case 1: Design of the next-generation mobile technology for salespeople

Objectives
The design objective was to design and develop a new mobile technology for salespeople. We surveyed a sample of the Tokyo sales force. These salespeople in Tokyo were already working with the current mobile technologies, such as the portable PC and the cellular phone. Our survey objectives focused on understanding a sales representative’s work practices in a real field, interactions among salespeople and issues in current mobile technologies. We also sought to obtain perspectives on the design of new mobile technologies to support sales forces. The subjects were nine sales representatives from the general Tokyo sales force, including several sales managers.

Features of their work practices
The mode by which a sales representative works is inherently mobile. Among the nine salespeople participating in this study, the typical activity pattern in the daytime is to visit a customer, introduce the products that the salesperson represents, ask the customer about his or her needs and issues, make a proposal to solve those needs and issues, and make a contract. Each morning and evening,
in preparation for visits with customers, the salesperson works at his or her primary office. Such
deskwork includes creating proposals and writing up contract documents.

From the self-photo study, it turned out that despite the use of mobile technology, the salespeople
did not elect to work anytime and anywhere. Because the documentation and related work takes a
lot of time, even if the salesperson had come to rely heavily on mobile technology, he still created
documents at his office, not in impromptu settings such as cafeterias, libraries, or customers’
offices.

The most radical change brought about by mobile technology is the shortening of turnaround time.
Sales representatives access their company's Intranet to download the documents needed to service
customers or access the Internet to get the information for answering the customer's question from
the customer’s work site. Sometimes customers ask their sales representatives some questions
which they can’t answer quickly. To answer such difficult questions, the sales representative
collaborates with support staff. The Tokyo sales force has back-office support staff who investigate
various kinds of queries. The sales representative sends an e-mail to a member of the support staff,
delegating the investigation from an impromptu setting (e.g., a cafeteria) as soon as he or she leaves
the customer’s work site. This employee investigates via the Internet and e-mails an answer back to
the sales representative. As soon as the sales representative receives the e-mail, he or she can then
give the customer an answer. The remarkable change brought about by the use of current mobile
technology is this sort of improvised correspondence between sales representatives and their
customers.

**Characteristics of photos**

Many of the sales representatives’ activities proceed through communication. The chief
characteristic of the photographs they took is the large number of people with whom they
communicate. Moreover, many of the locations or settings in which these photos were taken are not
fixed and monotonous places (e.g., the home office), but rather are varied spaces outside the office
(e.g., customer sites or restaurants). The representative’s workplace changes to a great degree.
When photographs are arranged in sequence, we can see the dynamics of these changes.
Furthermore, each photograph contains many visual cues, such as communication partners and
artifacts. These cues help us understand the activities that are going on at that moment. It can be
said that these features make the self-photo study technique very suitable for this application
(Figure 3).
Case 2: Design of a casual-communication space of a research institute

Objectives
A research institute consists of researchers with various specialties. The design objective was to design a space for free and active discussion in a relaxed atmosphere by fostering impromptu encounters between the researchers. The objective of this investigation focused on a) understanding the typical activities of researchers, b) understanding how to link the new communication space and the existing flow of activities, c) what kind of resources are conducive to positive communication. The subjects were ten researchers including several research managers. Most of them are IT-related researchers.

Features of their work practices
The work styles differed in many ways between the general researchers and the research managers. The fundamental work style of a general researcher is that all activity is independent and proceeds according solely to the researcher’s own work. In other words, these researchers work all day at the PCs on their desks. In the few moments when they’re not at their desks, they are either talking with their colleagues or they taking a tea break for relaxation. Such poor communication and discussion among the researchers is the essential issue of the current workplace. On the other hand, research managers spend much of their time communicating, such as attending formal meetings, having informal discussions, or coordinating activities. It is far from easy to reserve enough time for their own research.
Characteristics of photos

We can find out the characteristics of a typical researcher’s work style by studying the photographs these general researchers have taken. A remarkable feature of these photos is how little the dynamics of their workplace change, because they spend the whole day sitting at their desks, getting up for tea breaks, and returning to their desks. In this routine, the photos taken before the tea breaks look just the same as the photos taken after such breaks (Figure 4). Since these researchers work independently, another characteristic of these photos is that they contain very few people. Moreover, an IT researcher’s main tools are his PC and his software, and most of his activities occur in a virtual workplace. Physical objects are very few; indeed most of the researcher’s objects are virtual and therefore can’t be seen in the photos. This explains the photos’ lack of variation. In this application, we were able to some extent supplement the lack of data by interviewing the researchers, but the photos themselves provided little information.

Case 3: Layout design of a head office based on a new concept

Objectives

The design objective was to promote the strategic nature of the head office and to incorporate this nature into the facility and the layout design. Changing the layout affects the work style, the document management method and the technology deployment. Therefore, at the beginning of this project we surveyed the work practices of the head office staff by using self-photo study. Our study objectives were, a) to obtain the perspective necessary to support a new work style, a new document...
management methodology and a new technology design for the strategic staff and b) to incorporate the work practice into a layout design that reflects the strategic role of the head office. The subjects were nine members of the head office staff of a combined general affairs and personnel department.

Features of their work practices
The head office staff combines the work style of the mobile sales force and that of the researchers’ self-containment. Although the head office staff members do not work outside the office the way sales representatives do, they do move around inside their home office's building. It can be said that they are mobile workers inside a single building. On the other hand, prolonged activity at a desk is also essential for this staff. Unlike the case at the research institute, the head office workers use a lot of paper documents and physical tools to process physical objects. These two types of work style are intermingled, it is hard to say which is predominant. Such seemingly contradictory characteristics are inherent in their work.

Characteristics of photos
Although the work style of the head office staff resembles that of the researchers in some aspects, their photos are very different. The photos taken by the head office staff contain a rich variety of visual cues (Figure 5). Because these employees handle a lot of paper documents, their photos show various physical tools, such as seal impressions and filing folders. In addition, because the head office staff members are also mobile workers inside their office building, the dynamics of a sequence of photos resemble those of the sales force’s mobile work, and changes in the settings of the photos are clearly seen. Moreover, their photos show various people with whom the staff members are communicating. Based on these features, it can be concluded that, even though these photos were taken by a worker inside an office building, this methodology proved to be suitable for application to this type of semi-mobile workforce.

Figure 5. The characteristics of self-photos by the head office staffs
Data gathering by photos
The important features of self-photo study related to data collection are as follows.

- The subject takes his or her own work photos, thus acting as the investigator.
- The interviewer and interviewee study the photographs together during the interview.

The first point contributes to the user's feeling of participation in the study, while the second point contributes to the sharing of a common context between the users and participants of the design project (designers, planners, developers, and so on). From these two viewpoints, we examined the data collection capability of self-photo study.

1) Sharing a common context during an interview
The primary reason to use photographs is to share the context of the workplace between users and participants of a design project. Because the participant has not actually been in the workplace about which the user is talking, the photographs provide the participants with a shared context and various cues that trigger questions. Compared with conducting an interview without the benefit of photographs, interviewing with the aid of photos makes it easier to ask the proper questions and to gather a lot of interview data. Photographs are a tool for remembering and reproducing the contexts of work activities and for mediating the interaction between users and participants.

Of course, conducting an interview at the actual workplace, such as Contextual Inquiry (Beyer 1997), can create a richer context than a photograph can. But as we see from these three experiments in self-photo study, work activities now tend to take place in a variety of settings, not in limited or fixed workplaces. Therefore, methodologies that rely on workers having a real or fixed workplace face new limitations. On the other hand, this methodology, in which the user takes snapshots of his or her work activities, puts these contexts into photos, which aid the interviewing process. This methodology is suitable for investigating the latest modes of working.

Furthermore, thanks to the decision-making process that underlies actually setting up and snapping a photo, users’ awareness of their workplaces increases, and the situations depicted in the photos become strongly embedded in their minds. This helps users easily recall these situations even if the interview occurs a few days after the snapshots were taken.

2) The worker's feeling of participation
Compared with observation techniques such as shadowing, the greatest difference with the self-photo study technique is that the subject, who is usually observed by others, photographs himself or herself. The most important effect of this is the user's feeling of participation in the investigation or design activities. It is important, not only in the design stage but also in the investigation stage, that users participate deeply in all of the design processes, especially from the early stage of investigation onward.

Because this method gives users control over the photography, the users are less self-conscious (e.g., they don’t feel chased), than when they are shadowed. Several users in our experiments echoed this sentiment:

User A: "I like taking photos personally, so this experience was very enjoyable."
With shadowing, it would be impossible to obtain such a positive comment. So self-photo methodology increases the feeling of participation, benefiting both the investigation stage and the design stage.

In some cases, subjects didn’t take the photographs that the investigators had instructed them to take, because they controlled the timing of the photos. Instead, the subjects snapped scenes that they themselves wanted to take, sometimes to show themselves in the best light. But the merits, such as the increased feeling of control, the diminished self-consciousness or feeling of resistance, and the strong sense of participation, outweigh this drawback.

**Interactions among communities in the design process**
The design process proceeds through interaction among various design communities. As we described above, the photographs mediate communication between the user and the design team communities during the interview. Here we discuss various interactions between these two types of communities and the mediating tools in some stages of the design process (Figure 6).

![Diagram showing various interactions among the communities](image)

**1) Sharing work practice data among the design project team**
During interviews, only a few interviewers are present, since the more interviewers there are the more pressure the interviewee feels. Therefore, design project team members must share their interview data and work practice data with each other after the interviews. A design project team
usually consists of various specialists, such as a designer, a planner, an engineer, and so on. Here we discuss what kind of methodology is efficient for sharing data, referring to our layout design experience.

The design team assembled for Head Office Layout consisted of one staff member in charge of layout, four researchers, two office designers, and one sales representative. A self-photo interview took an hour for each subject. Two or three interviews were conducted each day. Only two members of the design team participated in the interviews as interviewers. After the day’s interviews were completed, all of the design team members gathered in the interview room to share their experiences and discuss the data they had collected.

Figure 7 shows a scene of data sharing among the design project team members. In this scene, several photographs are arranged in sequence on a table, so that the design team can visualize the flow of workplaces and activities. While the members who attended the interview explained each photo to the other members, they all were studying the photos together, often pointing to various photos or to items in them. Each individual’s input and opinions reflected his distinct specialty, resulting in a balanced and integrated discussion. In this way the interviewers could share the interview data and discuss the users’ work practices in a way that involved all of the design project team members.

In this data-sharing and discussion process, the role of the photograph is very critical. One designer made the following comment.

Designer A: "We can see the activities going on in the photos. We designers often take photos of a facility itself before and after changing the layout. But these photos contain not only the hardware of the office but also the behavior."
Another designer pointed to one photo, a snapshot of a meeting that the user regarded as critical to his activities.

**Designer B:** "This one shows the knowledge community for Mr. Tanaka."

A knowledge community cannot be seen, of course, but this designer realized that a meeting (or those attending it), as depicted in one of the photos, stands for the user’s most important knowledge community. Indeed, the designer referred to the photo as “This one”, as if the knowledge community had become a tangible, visible object.

We consider the self-photo a mediating tool for sharing interview data among design team members. In this case, it is critical to capture the activities on film. In our experiments, some photos focused on an individual physical object such as a document or a tool (Figure 8). Although such photos provide some information, it is not enough to understand the work activities. The lack of information about relations among objects and workers in such photos will make it impossible to fully convey the activities that are actually going on in that workplace.

![Activities in the photographs](image)

**Figure 8. Activities in the photographs**

On the other hand, even photos that show only an array of tools or other objects can inform our understanding of such activities. For example, the way tools are arrayed may reveal how they are used. Photos including people are also very informative. They show how users interact with tools and any other artifacts or how they interact with their colleagues. We can capture the rich information about users’ work activities from such photographs.

However, it isn’t always easy for a self-photography to capture human interactions or human-artifact interactions. Certainly the sales force and the head office staff found it relatively easy to snap situations in which people in the field were communicating with each other. Such communication is frequent, and often the users asked their colleagues to photograph them (the users) during such communication. But this is not the case in fields such as that represented by the research institute, in which we saw barely any photos that included people. Thus it can be hard to
understand the work activity going on from such self-photos. For shared understanding and promoting communication among the design team members, the lack of interaction on the photos is an essential issue.

2) Communication between design team and user community
As described above, self-photo study is thought of as a methodology to involve users more fully in design projects. The visual material of self-photo study is useful as a mediating tool that provides opportunities to promote and organize interaction between a design team community and a user community, in the early stage of the design process; it is especially useful as an aid during and after interviews and for discussing and coordinating a rough design direction.

In the head office layout design project, we organized a workshop for communicating between these two communities. The objectives of this workshop were as follows.

a) Following the self-photo interviews: Describe to the user community the results of the self-photo interviews and how the design team understands the users’ activities.

b) Sharing rough design direction: Introduce the initial idea of the rough direction of the design policy, and discuss whether or not it would be proper for their work practices, and whether or not this design policy is acceptable.

In our workshop, the user’s community consists only of those who participated in the self-photo study, not all users.

a) Following the self-photo interviews:
The design community members create an interaction map from self-photo interview data. In other words, this map visualizes the design team’s conception of the users' work practices. In the workshop, users are shown this interaction map and are asked for their feelings about whether the design team’s understanding of their work practices is adequate or not. The users are also asked whether any other important workplace activities or communications have not been uncovered by the self-photo and/or interview process. The primary objective of this activity is to understand more fully the work practices through supplementary information and to complete the interaction map. In our workshop session, users watched the interaction map for a while, and then several users expressed an opinion like this one:

User B: "I think this map is close to my idea of what my work activities entail."

Very few workplaces and activities were added to the map, as most of these had already been included on the interaction map. This means that interview with self-photos can fully collect the work practice data and the interaction map represents and visualizes the overall structure of the user's work practices quite accurately. Although the formal description format of the interaction map is under development, our experiments confirmed that a visual tool such as an interaction map is able to mediate communication, and to help a shared understanding of work practices between both communities.

b) Sharing rough design direction:
The objective of this activity is to share and discuss an initial design direction. We prepared two mediating materials, the design policy and scenario. To foster an energetic discussion, we proposed an extreme idea. For example, one design policy is that "workplaces must go wherever the work actually takes place." The consequent direction is twofold: a) Reduce the space allotted to fixed desks, and b) then deploy mobile technology to realize the mobile work style. Such a proposal
serves as a kind of platform for communication between the design team community and the user community. In our workshop, some users offered opinions like this one:

User C: "If I accept that design policy, your individual proposals are acceptable. But I don’t necessarily accept your premise."

This comment promoted an active discussion about the direction of the workplace design among the participants. In addition, one user read the scenario and said,

User D: "It's me. I want to work like this."

It is essential to hold the workshop with such visual materials and to discuss and achieve a consensus for the design policy and direction in the early stage of the design process involving the user community. The users participating the self-photo study experiments attended the meeting positively, arguing the issues and offering their opinions actively. In this way, the self-photo methodology shifts the user's participation from the investigation stage to the design stage smoothly.

3) Reorganizing a community to include two or more design teams
Another type of communication is the interaction between one design project team’s community and another’s. This means some design projects will utilize the work practice data collected by another design project. Here we discuss how to describe and share work practice data to facilitate communication between different design project communities.

In this discussion, we refer to the case of an electronic-paper design project. This device can display and handle any information like the paper, and it would replace the physical paper in the future. The project utilized the work practice data of sales representatives (Hasuike 2002). In this project, the designers created a scenario based on the sales force’s mobile work data, and simulated the scene using an electronic-paper for mobile use. They conducted an interaction analysis experiment using this scenario. In the experiment, a subject acted as a mobile worker who was required to interact with a mock-up of an electronic-paper in a pseudo-practical work environment. The design team observed the subject's behavior and interaction with this mock-up. In this project, the electronic-paper was designed for general-purpose use, so the designers had to consider various kinds of scenarios, and the mobile work scene was one of them.

In this way, self-photo data stored into the work practice database mediates the interaction between different design project teams. Self-photo database consists of workplace datasheets and interaction maps. The workplace datasheet format, which shows both the photos and text at once, provides the work practice data and its context simultaneously. Members of this design project team did not share the context of these work practice data. For this situation, visual tools such as the interaction map and self-photos itself and workplace datasheet format may be meaningful for interpreting the work practice data. If written text data with no visual material are stored into the database, it is very hard to reproduce their work practices vividly. Hence, these visual tools promote the reproduction of the context and interpretation of work practice data by another design project team, and accelerate the interaction between different design communities.

Conclusion
Because a tool or technology is embedded into the socio-technological network in which it will be used, the development and deployment of a new tool and technology requires an understanding of users’ work practices and the participation of users into the design process. Some methodologies
already exist for this purpose. As a method for understanding a user's actual activities, there is a simple ethnographic method, which is represented by Contextual Inquiry (Beyer 1997). User Participatory Design (Schuler 1993) is a key methodology to involve users in the design process.

In this paper, we have proposed self-photo study as a photographic field study methodology, and we have confirmed this method’s effectiveness and applicability through three case studies. From these experiences, we have confirmed that self-photo technique is useful not only as a simple observation method, but also as a mediating tool for promoting the interaction in the design process. From the viewpoint of an observation technique, the self-photos provide a shared understanding of what is happening in the workplace, and help the design team to gather the rich data of workplaces. From the viewpoint of the interactions, it is confirmed that the tools of self-photo study, such as the self-photo itself, the workplace datasheet that shows the data and context at once, and the interaction map that visualizes the structure of a user’s work practices, can effectively mediate the interactions between the user’s and designer’s communities.

The self-photo study methodology still has room for improvement as an observation method, especially for the aim of investigating a virtual workplace. In addition to such current issues, our further work focuses on a) how to formalize the visual tools and create the pattern languages to promote the communication between user’s community and designer’s community, b) how to create the scenario by utilizing the work practice database, c) how to organize design communities involving users and provide opportunities for communication in the whole design process through enhancements to the self-photo methodology.

Acknowledgements
Sala Bly and Elin Pedersen originally had researched self-photo study for a sales force at FX Palo Alto Laboratory. We had collaborated with them in Tokyo sales force's survey using self-photo study.
References


Inter-linkages in the design process: a holistic view towards design knowledge and sketches

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Abstract

This paper reveals the close connection between design knowledge and sketches in an attempt to propose a holistic view of design studies. Two sets of experimental protocol data were analyzed. We first observed the interaction between meaning-based design knowledge and sketches in our residential house design project. The protocol collected in a museum design was analyzed using design content-oriented coding scheme to show detailed linkages between perception-based and meaning-based knowledge and sketches. The results demonstrate a close link between design knowledge and sketches. The dichotomy of design knowledge was proposed to pinpoint the importance of design media, such as sketches in this study. As a result, the design process should be studied from the combination of design knowledge and sketches.
Inter-linkages in the design process: a holistic view towards design knowledge and sketches

Design sketches and design knowledge are amongst the most important issues of design research. There have been significant findings regarding these two aspects (Gero & Rosenman 1990; Goldschmidt 1991; Suwa and Tversky 1997; Purcell and Gero 1998; Heylighen, et al. 1999; Uluoglu 2000; Varejão, et al. 2000; Goldschmidt 2001). The emerging problem of design research is failing to connect these results to form a holistic view of the roles of sketches and knowledge in design. Design knowledge includes the perceptual recognition and discovery of interesting visuo-spatial features and consolidation of ideas presented on paper. Similarly, design sketches require design knowledge to form an understandable presentation and to read the conceptual meanings revealed by drawings. This study intends to explore the inter-linkages between design knowledge and design sketches through cognitive behaviors of designers.

Design knowledge and sketches

The knowledge used in designing can be distinguished using various types of categorizations. The recent researches tend to include every aspect of the design process into the framework of design knowledge. For example, the recent computational model of design knowledge (Varejão, et al. 2000) proposed an ontological framework for knowledge-based design systems. This structure included design requirements and artifact descriptions. This structure also included five major design activities that are applied to manipulate knowledge and to generate end products. A similar structure of design prototypes has been proposed in design studies to identify the different aspects of design knowledge in terms of function-behavior-structure (Gero 1990).

There seem to be two distinct kinds of design knowledge. One is the normative description of a knowledge body and its attributes describing the content of a design unit, for example, the components of a living room. The consensus of the content of a design unit among designers and clients establishes the foundation of communication. The extra personal interpretation of a design unit, however, differentiates a designer from the others. The other kind of design knowledge is the relationship between these design units and their attributes describing the knowledge designers use to reason the design problems, to realize the solutions, and to progress the design process. For example, how to establish a proper circulation connecting a garage and a living room may both produce and resolve the problem of a pathway in a house.

This concept of dichotomy has been defined as declarative and procedure knowledge of meaning-based representations in cognitive psychology. The former includes all explicit knowledge of various facts of the world, while the latter includes how to perform various tasks based on declarative knowledge. Anderson (2000) proposed detailed structures of them as propositional networks and schemas.

The sketches studied in this paper refer to depictions made by pens on papers. The content of our exploration includes the cognitive activities that are related to sketches. They are drawing sketches, looking/revising sketches, and perceiving visuo-spatial relationships in sketches. In a sense, we try to explore the interactions between design knowledge and “sketching” that includes physical depictions and cognitive events of designers.

Two sets of data were analyzed from our research project and from Suwa’s (Suwa and Tversky 1997; Tang 2002). The data of Suwa’s project contained encoded protocols of one expert and one novice architects participating in a museum design. The details of this have been published (Tang and Gero 2001a; Tang and Gero 2001b; Tang and Gero 2001c; Tang and Gero 2001d). The data of
our research project contained a collection of protocol and videotapes of 5 experts and 5 novices participating in a residential house design (Tang 2002). The 5 experts had more than 25 years of experience in residential house design. We observed the general features of design knowledge and sketches in these 12 data sets, and analyzed further the detailed relationship between design knowledge and sketches using encoded protocol.

**Observing design knowledge**

We first observe the design knowledge and sketches following the dichotomy of declarative and procedural knowledge. In terms of declarative knowledge, our observation found that the experts produced more complete lists of requirements in regards to the same design brief than the novices did. Although both briefs in the residential house and the museum design provided detailed functional requirements, these experts still produced their own checklists regarding different aspects of the design. The issues concerning the experts in the experiments were much richer than those outlined in the design brief and those concerning the novice designers. For example, the concern about building materials and council restrictions were important in the experts’ design processes of museum, but not so in the novices’ processes. This implies that the knowledge body of a design unit, a residential house or a museum, in architectural experts consists of more detailed attributes and these then enable experts to produce more thorough solutions regarding different aspects.

In the residential house design setting, we inadvertently omitted the specific requirement for a second toilet. During the experiments, none of the novice designers detected this problem in their designing processes. All experts however detected the lack of the toilet in the requirements and expressed concern about it within the experimental duration. It is possible that novices would have found out this missing requirement if given more time. This situation demonstrates one of the well-known differences between novice and experts. The efficiency of experts implies that they are more familiar with the attributes of the knowledge body than novices.

Design sketches play a role as detection aids in these situations. These experts detected the missing requirement when scanning through their sketches. Sketches serve not only as an external memory aid, but we speculate that the spatial configuration of the residential house reveal the missing features. The mismatch between spatial configuration and the attributes of a residential house enables them to discover the missing requirements.

In terms of procedural knowledge, we found that the experts had more organized and longer scripts to advance the design process. In residential design, experts took care of different aspects of the design in clear order, while in museum design the experts explored the unknown issue of the museum in a systematic way.

All of the experts controlled the design process more effectively than the novices did. In the experiments of residential houses, all the experts finished the design with scaled details within 45 minutes. These results imply that the procedural knowledge experts possessed enabled them to cope with design problems more effectively and efficiently. One very experienced designer in residential design appeared to simply describe the design on the papers without ostensive thinking. We could speculate that he utilized his declarative and procedural knowledge without hindrance in solving this problem, which he had been doing for the past 25 years. The design quality however was obviously better than the novices.

Different experts however had different ways to approach design. For instance, some preferred to draw bubble diagrams and reason about the requirements, alternatively following the design methods, while one expert, being also a senior lecturer of design, preferred to list all the requirements on the right side of the papers first, Figure 1. After reasoning the requirements, he
started to draw corresponding drawings on left side of the papers next to the requirements. These could be regarded as personalized aspects of procedural knowledge, which were established corresponding to their personal capacities and experience.

Figure 1: A sketch of the expert architect who wrote requirements first on the right side and then drew ideas on the left side.

The efficiency of procedural knowledge of experts includes their utilization of sketches. The experts in residential house design tended to draw firmly and carry on the progress without trial and error in sketches. In the novices’ sketches, modifications and even erasure could be observed frequently. The very experienced designer in residential design who appeared to simply put his design on papers produce the final design in 20 minutes, Figure 2. The quality was however satisfactory. We speculate that his rich procedural knowledge of utilizing sketches enables him to map the conceptual requirements and visual configuration on papers precisely. The interaction between requirements and visuo-spatial properties then further shape his knowledge. The expert in the museum design did not possess such rich knowledge of museum design, so his design was not as precise as the sketches we saw in the residential house design, Figure 3. If given 10 years experiences in museum design, his sketches might look as precious as these in residential design with the aid of his knowledge in mapping functions and forms in terms of museum design.
Figure 2: The design produced by the very experienced designer in residential design who appeared to simply put his design on papers.
These observations reveal a close interactive connection between design sketches and knowledge. To explore the details further, we investigated the linkages between knowledge and sketches using protocol analysis. The relationship among sketches and design activities in different cognitive levels are examined in our encoded protocol. In the following, we first describe our method and then present the analytical results.

**Observing the interlink between design knowledge and sketches**

This study applied retrospective protocol analysis in the following study (Ericsson and Simon 1993). The subjects were an expert and a novice architect participating in a museum without interference. After design sessions, they gave protocols with the aid of videotapes documenting their design processes. The protocols data were segmented and analyzed by design content-oriented coding scheme (DCOCS) devised by Suwa and his colleagues (Suwa and Tversky 1997; Suwa, Purcell et al. 1998; Suwa, Gero et al. 2000). Each segment in the design process was categorized through four cognitive levels, physical, perceptual, functional, and conceptual. There were dependencies hidden in these levels, for example, a perceptual seeing instance depended on a physical drawing instance. These dependencies established the perpendicular linkages in specific time duration, a segment. The foci of our exploration are these linkages. They reveal the relationship between design knowledge and sketches. In the encoding process, two coders participated. Details of these encoded data have been published (Tang and Gero 2000; Tang and Gero 2001). To clarify the terminology, the instance in DCOCS refers to an observed occurrence of a specific activity in a level; for example, depicting a line is a drawing instance (D-instance) in the...
physical level. An instance describes an occurrence of an event. It could be drawing, looking, perceiving, and functional referencing, in short L-instance, P-instance, and F-instance.

In the previous discussion, we focus on knowledge of meaning-based representation according to Anderson (2000). Meaning-based representations attempt to conceptualize some significant aspects of an experience. Another comparable kind of knowledge Anderson proposed is knowledge of perception-based representation that attempts to preserve much of the structure of a perceptual experience. In the design research community, perception-based representation has not received much attention as one kind of knowledge. We however suspect that the perception-based knowledge makes the design process different from pure scientific rational activities. Designers have to reflectively interact with media that could be sketches, short-term memory, or computer-mediated material. Perception-based knowledge is the channel for the communication between designers and media.

The concept of different representations proposed by Anderson (2000) therefore was applied to analyze our encoded protocol. They consist of perception-associated instances and function-bounded instances. The perception-association instances could be the bases for perception-based representation, with the function-bounded being the bases for meaning-based representation. For example, the connection between a depiction and its corresponding visuo-spatial relationship could be stored as knowledge of perception-based representation. Similarly, the semantic connection between a depiction and its corresponding functional reference could be preserved as knowledge of meaning-based representation.

Knowledge of perception-based representation
These perception-associated instances referred to making different kinds of depictions, looking at existing depictions that are drawn in previous segments, and attending to visual features and visuo-spatial relationship through existing depictions.

The identification of perception-associated instances was done by checking whether an instance had either direct or indirect associations with a visuo-spatial relationship. A direct perception-associated instance meant that this instance was perceived as part of a visuo-spatial relationship. We identified the relationship from video images and protocols. For example, the designer reported “Then I try to see the symmetry within the site along this line, here is one, here is another..”, and, at the same time we saw that he drew a line in the middle of the site. We recounted consequently that the site and the line were perceived as parts of the symmetry, and thus these D-instances were perception-associated. An indirect perception-associated instance was a source instance perceived by a P-instance, the first, which was included within another P-instance, the second. This source instance therefore had one direct perception-association from the first P-instance, and at the same time had one indirect perception-association from the second P-instance.

The numbers of perception-associated and non-perception-associated instances of both participating designers were calculated. The results indicated that more than 60% of the D-instances were perception-associated, while 80% of L-instances were perception-associated, Table 1. There were about 15% of P-instances being perception-associated. These experts had more perception-associated instances than the novices in terms of D-, L-, and P-instances.
Table 1: The percentages of perception-associated and non-perception-associated instances of the novice and the expert architects.

The linkages between sketches and different cognitive actions, including drawing, looking, and perceiving, are the structure of a perceptual experience in Anderson’s definition of perception-associated representation. They are design knowledge applied in the design process if these linkages are retrieved from designers’ mind, or they are design knowledge learnt during the design process if these linkages are created in the new situation. The non-perception-associated D- and L-instances represent the doodles and revising that are pure external representation without reflection to the designers’ attentions yet.

The results indicate that this expert had better abilities in utilizing the sketches because more than 70% of drawing and looking actions were utilized in this perception. This implies that this expert had better knowledge to master the media and to provoke more opportunity in sketches. These linkages are knowledge of perception-based representation, and this connection in the design process is evident. Designers learn perception-based knowledge to use media in design processes, and in turn apply it to facilitate the progress of design.

Knowledge of meaning-based representation
We examined further the relationship amongst D-, L-, P-, F- instances to explore knowledge of meaning-based representation. D-, L-, P-instances are related to the media that designers use to reflect their thoughts and ideas. Some of them were arbitrary without conceptual intentions and meanings, such as purposeless doodling on papers, but some were given meaning through designers’ intentions. One square might represent a garage in a residential house, and an emergent space between two circles could represent the tension between two buildings. In our analytical structure, the linkage between D-instance and F-instance and the linkage between P-instance and F-instance respectively represents these two situations.

The method to identify a function-bounded instance was checking whether an instance had either direct or indirect functional references in a segment. A direct function-bounded D-instance meant that a designer knew the functional reference of a depiction when it was created. For example, in a segment a designer reported “First, I tried to place the building over here, so you enter here, you see all the things and finally come to the building.”, and, concurrently in the video, we saw that he drew a square inside a big circle. We consequently recounted that he has attached a functional reference to the square, and thus this D-instance of drawing a square was function-bounded.

In contrast, an indirect functional reference was one in which a designer attaches meanings to a D-instance through L-instances or P-instances. In the first case, the L-instance had a direct functional reference and the D-instance has an indirect functional reference. In the second case, the P-instance had a direct functional reference and the D-instance had an indirect functional reference and a direct perception-association.
The results indicated that more than 55% of the instances were function-bounded, Table 2. The only exception was the P-instance of the novice designer. On average, the expert had more linkages than the novice. It is noteworthy that 77% of the expert’s depictions were function-bounded. This means his drawings were meaningful and close connected to his conceptual reasoning.

<table>
<thead>
<tr>
<th>Percentage (%)</th>
<th>Novice (SM01)</th>
<th>Expert (EM01)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Function-bounded</td>
<td>Non-function-bounded</td>
</tr>
<tr>
<td>Drawing instance</td>
<td>63.9</td>
<td>36.1</td>
</tr>
<tr>
<td>Looking instance</td>
<td>73.7</td>
<td>26.3</td>
</tr>
<tr>
<td>Perceptual instance</td>
<td>38.5</td>
<td>61.5</td>
</tr>
</tbody>
</table>

Table 2: The percentages of function-bounded and non-function-bounded instances of the novice and the expert.

These findings describe the connections between sketches and the functional references that designers used to conceptually reason the design problem. Sketches are utilized as part of the conceptualization of some significant aspects of an experience. They are part of design knowledge of meaning-based representation. The concepts and meanings of a design are stored in its representation so that we can see it is important in design education and practice to learn knowledge through reading drawings and plans of famous architecture. Design research has speculated that sketches do not only present the perceptual features of design but also the functional aspects of design (Goldschmidt 2001). Here, we examined the detailed linkages between depictions and abstract ideas. They formed design knowledge of meaning-based representation. As for those non-function-bounded instances, they were unfruitful attempts in design. They had not been utilized by the designers to visually reason the design issues, but being pure external representations without connections to the content of design.

**Nature of the main findings**

This study attempts to elicit a holistic concept in studying design activities through the interactions between design knowledge and sketches. There are three main findings in response to it. First, there is a strong connection between design sketches and design knowledge. The details of this relationship were observed in the design process. The complex networks amongst physical actions, visuo-spatial perceptions, and functional attachments were revealed. Our empirical data showed statistically significant relationships between them. Second, there is perception-based and meaning-based design knowledge, which are concordant with human knowledge representation (Anderson 2000). The former is applied to understand sketches and discover interesting visuo-spatial relationships, while the latter is applied to visual reasoning and functional attachments. Third, design sketches are perception-related and function-associated. Drawing and looking sketches require both perception-based and meaning-based design knowledge to effectively and efficiently utilize, or the design sketches are just meaningless doodles and graffiti of designers.

In conclusion, the strong relationship between design sketches and design knowledge is established by the inter-linkages amongst physical actions, visuo-spatial perception, and function-associated conception. It is this network which constitutes the essence of design knowledge, and its complexity makes design activities interesting and arduous to understand. The concept of close connections between design knowledge and sketches has impact in design thinking, methodology, and
education. Design knowledge could not be learnt purely verbally, and sketches have to be part of design expertise. However, this concept should be extended to design media and design knowledge. The media are any kind of material designers apply to externalize ideas, to internalize visuo-spatial relationship, and more importantly to communicate reflectively with themselves and others. Hopefully, this paper could establish part of common ground for studying design activities holistically.
References


Understanding designing and design management through constituent market orientation and constituent orientation

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Abstract

The paper builds on research undertaken in Norway and Australia in constituent market orientation and models of affective design cognition to develop a more coherent and integrated theory frame for modeling designing in organisations, particularly the increasing number of design organisations undertaking virtual multidisciplinary teamwork.

Attempts to develop an integrated theory of the interactions between stakeholders have focused mainly on the properties of designed artifacts, the characteristics of the design problems and brief, or on the technical, social and communication processes. This has been less than fully satisfactory and resulted in a lack of adequate theoretical integration with underlying individual human processes, human values, motivations, feelings, eccentric proclivities, and the political foundations of human social behaviour.

This paper combines constituent market orientation with recent findings from brain research to develop theory to provide guidance for designers and design managers wishing to improve their effectiveness and efficiency in commercial contexts.
Understanding designing and design management through constituent market orientation and constituent orientation

Introduction

This paper focuses on improving the performance and management of design activities through findings from constituent market orientation and affective cognition.

Improving the performance and management of design activities is important because of their key roles in innovation and social and economic development. Innovation is the process of transforming new scientific knowledge into products, systems and services that bring economic and social benefits and is strongly shaped by design activities (Commonwealth of Australia, 2001; Dept of Industry Science and Resources, 1999, pp. 3, 9-10; Innovation Summit Implementation Group, 2000; Love, 2002; Love, 2000; Love, 2000; Love, 1998; The British Council, 2001).

Designers and design teams undertake the transformation of new human knowledge into designs for real-world products, systems and services, and thus play a key role in innovation processes on which social and economic development depends. Improving design teams’ performances increases commercial and social benefits by improving efficiency and effectiveness of design processes: offers immediate and direct improvements in innovation (Baird, Moore, & Jagodzinski, 2000; Sarsfield, 1998). Successful design teams offer competitive advantage. They shorten time to market, reduce life cycle costs, improve designed outcomes, minimise risk of adverse economic consequences of design failures, and reduce the intrinsic costs of the design process.

Achieving the full potential and efficiency of design teams has been elusive (CIPD, 1999; D'Hertefelt, 2000; Macmillan, Steele, Austin, Kirby, & Spence, 2001). Research has not resulted in well-developed strategies for the optimal management of multidisciplinary design teams. This is due to: conceptual difficulties; poor theoretical foundations; the direction of research efforts; and poor integration between theories, findings and theoretical perspectives, especially between human and technical issues (see, for example, Dixon, 1987; Love, 2000, 1998; Lovins, 1993; O’Doherty, 1964; Pugh, 1990). We need a unifying theoretical framework that spans across: the individual subconscious cognito-affective basis of design activities, team interactions, technical issues associated with complex design problems, communications between stakeholders, and the interactions between design activities and other organisational, business and commercial processes.

This requires pragmatically useful definitions of core concepts. The following definitions by Love (2002; 2001; 2000; 1998) align with other disciplines and with major dictionaries:

- ‘Design’ - a noun referring to a specification for making a particular artifact or for undertaking a particular activity. A distinction is drawn here between a design and the manufactured outcome.
- ‘Designing’ - non-routine human internal activity leading to the production of a design.
- ‘Designer’ - someone who is, has been, or will be designing. Someone who creates designs
- ‘Design process’ - any process or activity that includes at least one act of ‘designing’ alongside other activities such as, calculating, drawing, information collection, many of which can be routine or automated.

This paper brings together business and organisational issues associated with design teams in commercial contexts and individuals’ behaviours and internal functioning. It points to a coherent
theory stream that includes individual activities, construction of knowledge, and commercial organisations’ dynamics that offers two practical benefits:

1. Improvements to how designing is undertaken at individual and team levels to better support the vision, mission and strategic organisational outcomes of planned organisational processes.

2. Improved understanding in management as to how expertise and other resources used in designing can be better used to gain competitive advantage and organisational security.

The underlying problematic has three parts:

- The lack of a comprehensive model of designing spanning the large number of disciplines and theoretical domains that are involved, which would provide a sound basis for analyses to support improvements to designed outcomes. For a multidisciplinary field such as design research, it would be expected that theories have identifiable and theoretical support for their relationships to all of Friedman’s six sectors (Friedman, 1999). They must form at least one continuous pathway through all nine levels of Love’s (2000) meta-theoretical hierarchy.

- Epistemologically and conceptually, the body of literature of research into designing and designs is marked by confusion, conflation and confabulation of ideas and analyses (Love, 2000).


In combination, theories of constituent orientation and physiologically based theories of design cognition offer the means to address these problems and provide epistemologically sound bridges between the different classes of theories.

The theories and research findings of Constituent Market Orientation (CMO) are supported by research findings about the physiological processes underpinning human cognition, motivation, attention, and agency. This is an important issue. Most theories about business, management, organisations, planning, design, group and individual behaviour and motivation have inadequate causally based epistemological foundations. Their justification is tenuously, and epistemologically inadequately, based on correlations between information about external properties more appropriate to theory making about simple passive physical objects. The combination of CMO and physiologically based theories of human cognition explain how the orientations of stakeholders can positively shape design processes and designed outcomes, and improve design management.

This paper consists of five sections. The second section provides an overview of constituent orientation and constituent market orientation. The third section describes the contribution new brain research findings make to providing a sound causal foundation for constituent market orientation to improve designing, design management and business outcomes. Section four demonstrates how constituent market orientation and affective cognition theories provide insight into improving design outcomes and managing design processes successfully. Section five provides a summary and a short list of improvement heuristics for designers and design management.
Overview of Constituent Market Orientation (CMO)

This section draws on Tellefsen’s (1999; 1995) extensive research into top-management led programmatic and natural learning based on feedback from the constituents (‘market-back’) theory of Constituent Market Orientation (information from 235 CEOs, 244 market managers, 188 purchasing managers, 163 personnel managers, 179 union representatives, 154 PR managers, and 175 lobbying managers). His findings indicate that these theories are broadly applicable to a wide range of organisations, including design organisations.

Like all living creatures, organisations can only be understood and defined in their environmental context. When constructing a business solution, many constituencies and stakeholders determine the business idea’s market value, effectiveness, and efficiency. These include: labour markets; downstream markets; collaborative markets; upstream markets including suppliers, market regulators such as industry associations; governments; and general influencers like the media and the public. Market-oriented leaders direct their attention and efforts towards these constituent markets to maximise a business unit's competitiveness. The above distribution of attention and the associated learning patterns forms the ‘constituent market orientation’ of an organisation.

Market orientation is a theory of environment-driven organizational learning and innovation. Individuals learn through interacting with their environment. The closer the interaction with a particular part of the environment, the more the individual learns about that part. If an individual has no direct interaction with a part of the environment, that part will become unknown and invisible. Commonly, the constituent market orientation of an individual becomes unbalanced and results in increased focus on some constituents and partial ignorance of other constituents.

The individual’s group membership configuration is the most important factor of their orientation. Intense learning occurs primarily in face-to-face groups. Groups with frequent contacts and internal double and triple-loop learning establish a strong culture with common beliefs, values, goals, priorities, language, habits and recognition patterns. In larger group contexts, they form a sub-culture. The number, type and heterogeneity of an individual’s cultural traits (often referred to as the individual’s personality) depend on the number and type of social groups he or she belongs to. Each individual’s consciousness is limited, tending to routinise behavior, and result in focusing on a limited set of social relations. When an individual is preoccupied with something — due to habits or previous learning of beliefs, values, priorities and goals — other things are unattended, invisible or not comprehended.

Crossan et al (1999) say the same limitations apply to groups sharing mental frames, paradigms, observations and experiences. These limitations combined with in-group double-loop learning; result in many groups developing distinct, homogenous, and stable sub-cultures. These factors interact with other organisational, management and leadership factors in significant ways. An organization institutionalizes what tasks are to be carried out by whom, who works with whom, and the rules and intensity of interactions. The nature and structure of the institutionalization has profound impact on the emergence of distinct sub-cultures within industrial clusters, networks of cooperating firms, single firms, and inter- and intra-organizational work-groups. The tighter group-internal relations are, and the looser the group-external relations are, the stronger the sub-cultures of individual groups become.

The market orientation of many firms is primarily downstream. Most businesses also have other constituents (stakeholders) such as suppliers, staff, regulators, government agencies, the media and customers. The complex interconnected markets or networks in which most organisations operate dictate that a constituent orientation is required to fully realise value inherent in these markets and associated stakeholder relationships. The value of the product, systems or services is defined and
created through identified interactions between the organisation and upstream and downstream constituents.

Consciousness is limited and the agents of the organisation (typically leaders or managers) become preoccupied because of previous learning, beliefs and values, leaving other parts of reality to become incomprehensible, invisible or unattended. CMO provides a means to map, define, and prioritise these alternative realities and relationships. The cognito-affective research findings provide causal explanations that support these high-level CMO models.

CMO based organisations succeed by focusing on market behaviour optimisation through managed interaction with their constituents and the development of systems and architecture which allow them to respond quickly and correctly to signals from across their network. Specific business units or work groups may demonstrate orientations that differ from the organisation and other groups. Leaders need to support integration through programs designed to generate double loop learning across work groups and business units.

Business success depends on being oriented toward the needs of multiple constituents. Members of the organisation must know the constituencies, how they are affected by and how they value solutions. Members of the organisation must develop a common purpose and a common set of solutions. These solutions must also satisfy diverse wants, goals, and agendas of each constituent. If not, people will exit the network, whose social legitimacy is reduced (Tellefsen, 1999, 1995).

In designing, as in other forms of business, there are two main organisational traditions: organisations focused on individuals, and team-based organisations (Tellefsen, 2000). In organisations built on the individual, the overall task is divided into subsets of functionally defined sequential tasks until each sub-task is small enough to be handled by one individual. Authority is delegated down a hierarchy from individual to individual. When an overall task is split up, two organisational challenges arise:

- Hierarchic integration of expertise to manage the total task.
- Horizontal co-ordination among experts to link activities along value producing chains and networks.

Integration and co-ordination are the domains of individual managers. The line of command is the vertical integration axis and can be very efficient in stable environments. The individual focus tends to overload the hierarchy, and extensive control of lower levels, bureaucratisation, and inflexibility follows. Limited span of control produces many vertical layers. Since the hierarchy is top-down, experts at lower levels are not expected to take part in co-ordination and integration and lack the motivation and insight to do so. This tends to create adversary political groups, since only one truth can be used to legitimise the use of power and selection of means and solutions. The idea fight becomes a war of organisational dominance and personal position in the hierarchy, and directing resources to own causes.

Team-based organisation originated in the group-oriented Japanese society. The team defines purpose, goals, values, strategies, products, and the means and methods to be employed. Every team member contributes to integration and co-ordination. The organisation is driven and directed bottom-up. Instead of leaving the problem detection and solution to individuals who dictate to others, team members all listen to the environment and share information in horizontal systems. The team works on the problem definition and solutions until it has reached a common understanding and consensus on what to do. Creating solutions often requires more time and effort in teams. Implementation is normally faster and less prone to sub-optimisation, conflict, misunderstandings,
and mistakes, but compromises may eliminate optimal solutions. When a team works optimally, leaders emerge. Leaders at one level become members of the next level team until accumulation is reached to take care of the total task. Rewards are group based (Manz & Sims Jr., 1995). Team proponents believe that individual expertise only has value when combined with the expertise of others. Focus is on totality, integration, synergy and co-ordinated change. This allows flat structures with decisions close to the point of value creation.

Team socialisation processes can make teams self-centered, reducing their effectiveness, creativity and quality of outcomes. The lack of room for distance, alternative thoughts, and divergent and competing power structures may reduce the production of new tacit knowledge that the group solution is so adept at turning into tacit knowledge. By including members from other cultures, institutions, teams and constituencies on a rotating basis, this problem of lack of heterogeneity and inward focus can be eliminated.

Team-based organising is easily extended to creating flexible, cooperative networks within industrial clusters. These networks can be anything from strategic to taking care of one-shot innovation and design tasks where expertise from many vocations and institutions need to be combined. Often the networks consist of several hierarchy levels, from governance groups to permanent and ad hoc administrative, developmental, implementing and production teams.

**Physiological basis of human affective cognition in designing**

Designing involves many internal and external phenomena relating to: designers’ internal creative processes involving partially completed design solutions, underlying semiconscious ‘design worlds’, ‘feeling-based’ valuing and decision making structures; and the communication of these between designers and other stakeholders. In organisational terms, it includes: the internal processes of individuals; the group processes of multidisciplinary design teams; and interactions between design teams, other parts of their organisation, and other social and economic stakeholders. Communication between these stakeholders requires common explicit knowledge, the codification of tacit knowledge, and situations for shared experience that multiply tacit knowledge (Johannessen, Olsen, & Olaisen, 2000).

Human somato-sensory processes play a significant role in design-related activities and their management. Recent brain research indicates that all of the internal and external aspects of designing are more determined by the physiology of body processes than previously realised (see, for example, Bastick, 1982; Damasio, 1994; Miller, 2000; Reilly, 1997).

The significant roles of physiologically-based somato-sensory processes in human cognition is widely supported by the neurological literature. Studies indicate that the affective brain and body systems associated with feelings, emotions, values and subjective perception provide the initiation and regulation of conscious thoughts, including the creative ideas essential to designing (see, for example, Badgaiyan, 2000; Bastick, 1982; Damasio, 1994; Davis, 2000; Fabri, Polonara, Quattrini, & Salvolini, 2002; Fleckenstein, 1992; Franklin, 1999; Love, 2000; Macaluso, Frith, & Driver, 2002; Miller, 2000; Mogi & Tamori, 1997; Paller, 2000; Sloman, 2001). Important to designing is the way that the areas of brain central to gathering experience for use in later circumstances, is comprehensively linked with sensory and motor systems in both top down and bottom up arrangements (Miller, 2000). Reilly (1997) concluded that processes from the sensory motor-domain form the neurological foundations for computation in higher-level human cognition and creative cognition.
The emerging physiological picture is that designing is based on highly interdependent cognitive, affective and motor processes consisting of multiple parallel neurological and hormonal processes operating together in both brain and body (Damasio, 1994).

Damasio (1994) has drawn attention to the way human development has occurred through a layering of new physiological systems on top of, or alongside, existing systems. This results in older systems being reused in new ways, or in collaboration with new systems. Early in evolution, the simplest ‘brain’ neurological/hormonal processes of an organism were concerned with managing the organism by sensing its environment through its boundary and modifying (using its motor and other physiological systems) its boundaries’ responses to its environment. These primitive proto ‘brain’ processes are distributed through the organisms’ structure and essentially concerned with ‘feeling’ an organisms environment and drawing on past experience to produce relatively automatic responses that maximise the organism’s survival possibilities.

The strong interdependence of feeling, motor and cognitive processes in humans are a consequence of the evolution of elementary proto-‘brain’ systems distributed throughout early organisms. Through human evolution, the layering of new physiological systems onto, and alongside, old systems has resulted in the foundations of human design cognition being actualised through many alternative parallel processes. These underpin much of the complexity and differences that mark human responses to their environments. One of the most significant to human behaviour, and especially designing, are the separate parallel neurological pathways associated with ‘direct response’ and ‘as if’ responses. A practical example, the experience of a personal insult produces direct responses in terms of thoughts (cognitive responses), feelings and emotions (affective responses), and gross and subtle bodily behavioural and physiological changes such as heart rate (motor responses). Thinking about the same experience, results in similar, but not identical, ‘as if’ responses. These responses are a result of the ‘as if’ experience being processed by slightly different neurological and hormonal pathways some of which are more open to conscious management and manipulation.

Although actualised through multiple parallel biological systems, human cognito-affective-motor processes are limited. It is impossible for a human to think of or process everything at the same time. The internal flow of events is strongly shaped by neurological and hormonally based dispositional mechanisms grounded in each individual’s prior and current experiences, mental models, habituation and the conscious direction of their attention (Badgaiyan, 2000; Damasio, 1994; Miller, 2000).

The ability of an individual to refocus their attention does more than bring a different situation to their ‘mind’s eye’. It results in dispositional changes to their neurological, hormonal and memory systems that influence their ability to learn, act, and make decisions. This extended physiological understanding of the basis of cognition, decision making and action provide causal explanations and epistemological foundations for the observed consequences of CMO.

If brain areas associated with the affective aspects of cognition (feelings and emotions) are damaged then the result is usually the appearance of dysfunctions such as schizophrenia, manic-depressive disorders and a profound failure to make sensible and successful judgements. Miller (2000) and Dimasio (1994) have described patients with pre-frontal cortex being strikingly normal upon superficial examination, able to carry on a conversation, with normal IQ scores and performing familiar routines without difficulty. Their ability to organise their lives is, however, profoundly impaired.
One might expect that equivalent organisational malaises might ensue where organisation models of interaction and learning do not appropriately include equivalent ‘affective’ processes. It indicates that models of human designing and organisational processes are likely to benefit from a broader picture of human psycho-neuro-physiological functioning. It also implies that many aspects of organisational models of designing are more easily conceptualized and addressed if account is taken of the reality that human thought processes, decision-making, precognitive processes, and actions depend on physiologically based somato-sensory and somato-motor states and processes. 

Physiological somato-sensory and somato-motor aspects of human thinking are particularly relevant in understanding closure of cognitive activities that determines human behaviour in designing and in organisations. Closure refers to the usually subconscious stopping, starting, continuation or redirection of human internal or external processes. For example, the connections of axons in a developing baby’s brain involve closure processes shaped by a wide variety of environmental and intrinsic forces. All human development and functioning, including design cognition is dependent on closure processes. In the case of cognition, and especially creative design cognition, physiologically based somato-sensory and somato-motor issues are important because they enable closure in cognition (Bastick, 1982).

Closure processes are implicit in Rosen’s (1980) conclusion that all forms of analysis depend on ‘intuition’ processes that shape an individual’s logic (see, also Walton, 1997). They are a core part of primary cognitive processes such as those that underpin the ‘human information coordinating behaviour’ that Spink (2000) identified as an important element of human information management (as in designing).

These factors point to the human activity of designing being run through with closure-based activities. Simplified models of relationships between physiologically based feeling states; closure, design cognition, and individual’s internal design optimization processes are described in Love (2000).

Rosen (1980) has shown that intuitive closure processes are often faultily described in terms of object attributes (a category confusion between activity and property). For example, whether a human is correct to say that 5 is the correct answer to 2+3 usually focuses on the properties of the numbers 2, 3 and 5 and the closure process is assumed to be similar. In physiological terms, according to Bastick (1982), this involves physiological self-perception processes that lead to an individual feeling confident that the answer (5) is correct. Closure happens where people’s internal state moves from them feeling uncomfortable, that ‘the process is not complete and fully checked’; to feeling comfortable, that it is complete, and that they can proceed.

Increased understanding of the neurological/hormonal mechanisms underpinning closure provide further physiological explanation of the causal phenomena that underpin the findings of Constituent Market Orientation research, and the benefits that accrue from moving to team and constituent orientation-based organisational models.

The implications of both these findings have not yet emerged in design theories. 

**Constituent Relations in Designing and Design Management**

Designing involves many disciplines (Friedman, 1999; Margolin, 2000) and is conceptually and epistemologically complex, especially collaborative designing involving multiple quantitatively and qualitatively based disciplines.

Throughout history people have worked together to accomplish tasks, make decisions and solve problems too big or complex for one individual. An organisation requires a common purpose,
accepted by the group performing the overall task (French, Bell, & Zawacki, 1994). The task is best defined, organised and executed if the group has a shared understanding and accepts a common purpose. The group participates ideally in developing a goal hierarchy, a strategy and solutions; activities and knowledge that helps the group achieve the purpose (Aranda, Aranda, & Colon, 1998). In addition to internal management factors, the history, culture and competitive climate influence outcomes. The organisational challenge is threefold:

- Creating open, inclusive systems for transferring explicit knowledge and storing shared memory (single-loop learning (Argyris, 1977)).

- Establishing meetings for shared development of learning and transfer of tacit knowledge (double loop learning (Argyris, 1977), or generative learning (Senge, 1995).

- Creating a learning environment (Fifth discipline (Senge, 1995) and triple-loop learning (Argyris, 1993; Senge, 1995)).

Tellefsen & Love, (2001) indicate that leadership of an organisation has to construct and manage four parallel systems in addition to the system for current operations. To establish and maintain a holistic business idea the leadership group needs to use:

1. **The power system:** Ownershhip that establishes who ‘we’ are, social legitimacy, authority to make decisions, risk-taking, the distribution of values gained and consumed (including financing of investments, distribution of revenues and costs, liquidity and profits)

2. **Internal driving forces:** Common beliefs, purpose, values and objectives of the organization

3. **Strategy making processes:** The processes and systems for developing organization-wide agreement on who ‘we’ are, our image, who we want to relate to and exchange values with (the stakeholders), who the ‘others’ are (competition and other constituents), how to compete (defining moral and wanted behavior) and with what (technology and know-how).

4. **Operative management and systems:** Management processes and procedures, including methods for task delegation, solving disputes, accountability, value production, value distribution, delegated risk-taking, Development and integration of real-world and virtual systems of operations.

The Constituent Market Orientation analysis of an organisation is represented in Figure 1 below (Tellefsen, 1999).
In Figure 1 above, the antecedents determine the extent of constituency based market-oriented learning that takes place within the organisation. This learning provides the human competitive edge that makes an organisation more effective and efficient than similar organisations. The focus of CMO here is the consequences of the direction of attention of members of an organisation towards different important constituents of the market within which the organisation operates. Important findings that emerged from Tellefsen’s research and from the ensuing theory model are as follows.
1. The higher the conflict level within an organisation, the lower the external driven learning.

2. The better the nerves among top leaders, the more market oriented learning occurs.

3. The more the leader is preoccupied with proper market orientation, the more market oriented learning occurs in the organisation.

4. Increased focus on constituents performing prime activities in the value chain (Porter, 1985) increases market oriented learning, whereas focus on others (government, media, industry organisations, etc) lowers the aggregate externally driven market oriented learning.

5. Top manager signals related to the content of market orientation increases market oriented learning in the organisation. Other signals weaken the market-oriented learning.

6. Higher environmental and internal turbulence, more intense competition, and higher degree of differentiation (from competitors) all strengthened the significance of CMO for outcomes. The opposite states of course weakened the effect derived from the learning.

7. A higher CMO led to getting more of whatever consequences are listed at the bottom of the model. The exception is the costs where higher CMO led to lower total per unit costs in an organisation.

Perhaps of most interest in terms of exploring a common ground of practice amongst stakeholders in design processes is:

8. The most important factor for a high constituent orientation is varied personal backgrounds within the leadership team. One-sided backgrounds, regardless of which it is, reduces the organisational CMO learning intensity, though it may improve learning with constituencies with same background as the leadership group.

Taken together these factors reinforce a single point for the integration of design activities into larger organisational purposes:

**Simultaneous learning in many dimensions and directions is beneficial for the organisation. This learning has to be integrated through interdisciplinary and inter-organisational teams.**

The obvious explanation for this is that innovations are complex and involve a series of groups that have to act together regardless of ownership and other institutional arrangements.

Organizations that consist of heterogeneous groups with strong sub-cultures become difficult to govern and lead. Common language, perceptions, values, experiences, goals and habits are weak. Performance and behavior become unpredictable for the organization as a whole, and the organization will not be able to develop a common identity and image. The challenge to the leadership is to establish programmatic learning loops led from the center of power. The purpose of programmatic learning loops, is to establish common purpose, values, and objectives. They must also result in, a common understanding of language, facts, and the environment, with its internal processes and structure, constituents and stakeholders. From a strategic point of view, it is essential
to establish definition between ‘us’ and ‘others’: the limits and borders of the organization and its competition. To establish a strong common culture in the organization, the common elements established by the leadership must be communicated to all members of the organization, and be implemented in all decisions regarding leadership style, organizational architecture, structures and processes, strategies, operations, services and products, and be reflected in all external communication with the constituents. An alternative, to this organizational approach to producing and exchanging values in the sub-groups of an organisation, is the market solution of distance and freedom of choice among the actors. Resource-based and agent-based theories of networks have explored the feasibility and economics of these alternatives: administrative versus market solutions of exchange (Conner, 1991; Dahlstrom & Nygaard, 1999; Heide, 1994).

Knowledge management is a key factor in the above issues (see, for example, Prusak, 1997). Learning theory distinguishes between tacit and explicit knowledge. Explicit knowledge can be communicated through a common language, which includes the meaning and feelings attached to body language, pictures, sound, and any form of symbols including written language. Knowledge can also be tacit, and can occur at several levels: individual, work group, networks, firm, industry, language group, etc.

**Summary and conclusions**

The paper has given an overview of the contributions and impacts of Constituent Market Orientation and new brain research findings for improving designing, design management, designed outcomes and business outcomes. It has sketched out an alternative theory framework aimed at improving the effectiveness and efficiency of organisations that include design activities that seamlessly stretches from the physiological underpinnings of human functioning in designing to theories of management and organisational learning.

The current lack of integrated theory impacts adversely on design management, leaving design managers managing complex design team situations on the basis of partial, contradicting, sub-optimal and, sometimes irrelevant knowledge. The lack of theory also impacts adversely on software development for supporting complex innovation processes. Research in this area requires an integrated theory framework that draws on new knowledge from brain and neurology research, and is coherent with theories from management and organisational learning, and which pragmatically bridges across issues of structure and agency in human individual and group behaviours.

There are significant benefits for stakeholders:

- Large organisations with in-house multidisciplinary design teams: Improved economic efficiency, increased potential through innovation, minimization of cost and risks of failure.

- Organisations providing design teams services: Increased competitiveness, profitability and capacity for additional work, minimization of risk.

- Government: a direct, positive and immediate impact on the rate of innovation. Shortening of time to gaining social and economic benefits.

- Research Councils: benefits to research viability because efficient and effective multidisciplinary design activities improve the conversion of new scientific knowledge into real products, systems and services with economic and social benefits.
• Design Research field: New coherent and comprehensive theory foundations and radical extension of theory in fields of participative design, collaborative design, computer supported cooperative work, group decision support services, and virtual teamwork.

• Small businesses involved in designing: A theory model and strategies to support participation by individuals and small organisations in collaborative design teams.

• Lessens the need for ownership control of collaborative arrangements: CMO across institutions and disciplines will increase the benefits of network solutions.
References


Design, words and history

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Abstract

Every dominant movement in art has depended upon the development of an accompanying critical discourse. Using the writings of design critics and design journalists, this paper suggests that there are similar, albeit under-developed, discursive dimensions to the reception of innovative design. Critics, advertisers and commentators offer vocabularies of appreciation analogous to the critical discourses of artistic avant-gardes. These suggest the manner in which a design should be used or experienced, the nature of experiences that should follow and the discontents with earlier forms that inspired it.

A major implication is that the lukewarm enthusiasm of the UK public for good design is unlikely to be overcome simply by exposure to it. Good design, of some kinds at least, can no more be expected to speak for itself than good art. It needs to be approached with some understanding of what it sets out to do, what is to be gained by engaging with it, motivated, where appropriate, by a new sensitivity to the shortcomings of what went before. Except amongst those already inclined to value design innovation, such frames of mind are unlikely to arise spontaneously. They depend on the promulgation of appropriate vocabularies of appreciation from within the relevant design communities, and these, like the discourses of modern art, will need to possess a critical and historical dimension.
Design, words and history

Art Critics: what do they do?
“*You cannot explain Mondrian’s painting to people who don’t know anything about Vermeer.*” Rosenberg (1952)

It is 1967 in the Art World of North America. Jules Olitski’s painting Feast is on show. For most people outside the art world, it is simply a tall rectangular canvas sprayed with red paint locally smudged with vague darker patches. But that is not how matters stand inside it. For the initiate, this work stands in relation to others, in a dense field of critical commentary, visual sensibility and the social currency deriving from them. It makes sense, that is, in relation to particular conceptions of the nature of art and of art history. Not unconnected with this, it also stands in relation to a lucrative and rapidly expanding art market.

The critic Clement Greenberg, once the isolated champion of abstract expressionists such as Jackson Pollock, William De Kooning, and Robert Motherwell has become the sought-after adviser of both painters and gallery owners. He has also been adopted as a guru by a group of postgraduate students of art history at Harvard University. For the students, Greenberg possesses the charisma of a once-isolated prophet who has been proved right in the important case of the first generation Abstract Expressionists. For the critic, the young academics provide theoretical and historical backing for his judgements. The consequence is an ossification of both, a dogmatism of judgement backed up by a doctrinaire version of art history. This insists that the defining feature and touchstone of authenticity in each of the arts is truth to its medium – in painting, the flatness of the canvas and the boundedness of the frame. In Greenberg’s view, each genuine avant-garde is a reaction to the exploration of these properties by previous avant gardes, with ‘painterly’ and ‘flat’ styles in dialectic alternation. Painting which falls outside this schema is to be regarded as mere fashion, not an authentic forward move in the evolution of modern art. According to Greenberg, the current direction of evolution is through ‘Post-Painterly Abstraction’, a cool flat-toned reaction to the explicit working of the paint in Abstract Expressionism. It is an intellectually tidy version of art history which has no place for such prominent movements as Dada, Surrealism and Pop Art (Reise 1992). Partly for this reason it generates intense controversy.

In his 1965 introduction to The Artist in America, Greenberg has already identified Jules Olitski with the coming of Post-Painterly Abstraction, seeing him as an artist who seeks to continue and expand Abstract Expressionism rather than break with it entirely (Greenberg 1993: 215). In his introduction to Olitski’s work at the Venice Biennale of 1966, Greenberg comments specifically on the spray paintings:

“In the first sprayed paintings linear drawing is displaced completely from the inside of the picture to its outside, that is, to its inclosing shape, the shape of the stretched piece of canvas. Olitski’s art begins to call attention at this point, as no art before it has, to how very much this shape is a matter of linear drawing and, as such, an integral determinant of the picture’s effect rather than an imposed and external limit. The degree to which the success of Olitski’s paintings depends on the proportion of height to width in their inclosing shapes is, I feel, unprecedented. Because they attract too little notice as shapes, and therefore tend to get taken too much for granted, he has had more and more to avoid picture formats that are square or approach squareness. He has had also to avoid picture formats that are long and narrow, simply because these tend to stamp themselves out as shapes less emphatically than formats that are tall and narrow do . .
The grainy surface Olitski creates with his way of spraying is a new kind of paint surface. It offers tactile associations hitherto foreign, more or less, to picture-making; and it does new things with color. Together with color, it contrives an illusion of depth that somehow extrudes all suggestions of depth back to the picture's surface; it is as if that surface, in all its literalness, were enlarged to contain a world of color and light differentiations impossible to flatness but which yet manages not to violate flatness. This in itself constitutes no artistic virtue; what makes it that - what makes Olitiski’s paint surface a factor in the creation of major art – is the way in which one of the profoundest imaginations of this time speaks through it.”

Several features of these passages speak to the argument we will make in this paper. Firstly, they situate Olitski as a motive force in the new phase of art history, with implications for how his work should be viewed. As Lucie-Smith (1969:111) put it, we are to see Olitski’s work as experiments with a critique of abstract expressionism . Secondly, the work is described in terms of Greenberg’s conception of truth-to-medium in painting. Namely, the description concentrates on what the artist does with the rectangular frame and the flat surface. Thirdly, the reader is offered instruction on how to look at the work so as to pick up on these aspects - and on the experiences which are supposed to follow from that looking. The absence of lines, for example, is to be seen as a displacement of drawing from the picture to its frame. This, in turn, should be seen as ‘calling attention to’ the role of the frame in determining the overall effect of a picture, and thus as a comment on painting as such. Fourthly, there is an authoritative assertion that the work is major art, perhaps with the unspoken implication that the sensitive viewer ought to be able to experience it as such. In sum, Greenberg’s writings on Olitski, and probably most critical writings on most art, offer a ‘vocabulary of appreciation’ through which the critic believes the work ought to be experienced.

**Vocabularies of appreciation**

Since the work of White and White (1966), we have become accustomed to the idea that new movements in art do not succeed through the unaided persuasion of the work itself, nor do they do so through spontaneous movements in taste. Rather they are actively promoted through a ‘dealer-critic system’. Dealers of the kind Boime (1976) called ‘ideological’ support young artists who appear to have prospects, acquiring in return a stock of their work whilst prices are still low. They then work to create a public for the new art, with the dual aim of publicising a form of art in which they believe and drawing a profit when its prices appreciate. The balance between these two aims, of course, varies with individual dealers.

Whilst much has been written about the ‘dealer’, or entrepreneurial, component of the dealer-critic couplet, the way in which critical writings work to create a public for new art has received little attention. We will use the term ‘vocabulary of appreciation’ to refer to the medium through which this is achieved. As the term implies, it includes ways of talking and writing about the new art which highlight and valorise the intentions behind it and the experiences it is supposed to produce. Typically in avant-garde movements, the intentions, the values, and the talk about them, derive from a particular critique of the artistic modes against which they are a reaction. Because of this, the vocabulary of appreciation associated with an avant garde is simultaneously a vocabulary of deprecation towards its predecessor form, one which articulates and emphasises its limitations. Here Clement Greenberg, in a characteristic move of avant-garde criticism makes his case for post-painterly abstraction by showing his readers how to see cliché and degeneration in the diffusion of abstract expressionism which preceded it:

“Having produced art of major importance [abstract expressionism] turned into a school, then into a manner, and finally into a set of mannerisms . . . The most conspicuous of the mannerisms into which Painterly Abstraction has degenerated is what I call the “Tenth Street touch” which spread through abstract painting like a blight during the 1950’s. The stroke left by a loaded brush or knife
frays out, when the stroke is long enough, into streaks, ripples, and specks of paint. These create variations of light and dark by means of which juxtaposed strokes can be graded into one another without abrupt contrasts. . . In all this there was nothing bad in itself, nothing necessarily bad as art. What turned this constellation of stylistic features into something bad as art was its standardisation, its reduction to a set of mannerisms, as a dozen, and then a thousand, artists proceeded to maul the same viscosities of paint, in more or less the same ranges of color, and with the same “gestures” into the same kind of picture.”
(Greenberg 1993: 193)

As this passage demonstrates, vocabularies of appreciation are more pro-active than mere description. Greenberg is showing his readers how to pick out the technical similarities in different painting so that they can be seen as cliché. As with paradigm shifts in Kuhn’s picture of scientific revolutions (Kuhn, 1962), those involved in new artistic movements actually see the world in different terms, both the new art to which they are committed and the old against which it is a reaction. For this reason vocabularies of appreciation include ways of looking as well as ways of describing, sensitivities to the intentions behind new forms which are simultaneously sensitivities to the limitations of what went before.

It is the mission of critics to share their experience of the work with a wider public, writing of it in language which assumes the values it pursues and the validity of the technical means by which it does so. The same language, as we have pointed out, also stresses the limitations of what has gone before. To the extent that writing of this kind succeeds, it does so not simply by getting people to try the new art for themselves, but by persuading them to look at it as the critics do, to see what they see and to feel as they do. In the process the new audience comes to assimilate some of the aesthetic culture within which the new art originated, its discontents with previous forms and the version of art history in which its solutions are the main direction of artistic development.

**Vocabularies of appreciation in design**

**Adolf Loos**

Thus far we have seen that the artwork itself reveals its full meaning only through the vocabulary of appreciation which comes into being alongside it, a vocabulary which it is the business of the critic to publicise. The result, when it works, is a public which looks in new ways at much else besides the new art. Importantly, it is likely to share the avant garde artists’ impatience with the forms against which they are in reaction, thereby seeing art in the context of a new version of art history. Those convinced by Greenberg’s interpretation of the role of the frame in abstract art, for example, would likely see continuities with its role in representational art. Each form of art, then, is apprehended through a vocabulary of appreciation which is both critical and historical.

We will now argue that much of this is true of the way we apprehend the designed artefact. In this field, there are obvious counterparts to the innovative art critic. A prominent example is the pioneer architect and polemicist of modernism, Adolf Loos (1870-1933). A practitioner rather than a systematic theorist, Loos’ writings were less concerned to advance a coherent position than to persuade people to see things differently. To this end, they were ‘exaggerated, full of hyperbole, untenable contradictions and paradoxes’ (Maciuika 2000). Our concern here, however, is less with the mechanics of Loos’ rhetoric than with the intentions behind it.

His well-known essay, ‘Ornament and Crime’ (1908, reprinted in Loos, 1997), is a convenient starting-point. As the title states explicitly, Loos’ aim was to undermine the appeal of decoration, not by reasoned argument from hard evidence (indeed, how could he?), but by creating a series of disreputable associations between a love of ornamentation and various forms of immature and anti-
social and behaviour. To this end, his essay begins not with his actual target - the then-current Viennese taste for decoration - but with the tattoos of ‘Papuans’ and the doodles of children, forms of decoration which Loos connects in a parody of evolutionary recapitulation:

“When man is born, his sensory impressions are like those of a new-born puppy. His childhood takes him through all the metamorphoses of human history. At two, he sees with the eyes of a Papuan, at four, with those of an ancient Teuton, at six, with those of Socrates, at eight, with those of Voltaire.”

It is only after lodging these connotations in the minds of his readers that Loos moves on to the Viennese taste for ‘wallets and leather goods covered with Rococo ornamentation’, and ‘tin bathtubs that aim to look as if they are marble’ (Maciuika 2000). Having made his point, Loos then wraps it up in an aphorism so that his readers can carry it around with them:

“I have made the following discovery and I pass it on to the world: The evolution of culture is synonymous with the removal of ornament from utilitarian objects.”

Logically, empirically, scientifically, and even politically, the argument is ridiculous (Banham 1999:18). Loos knew it and so, judging by the essay’s notoriety, did his readers. That, however, was not the point. As a pioneer of modernist architecture, Loos saw decoration as childish and unsophisticated, not in a considered way, but as part of his immediate experience. Whilst his style of writing may not have added up as logic, it made every sense as an attempt to persuade his readers into this way of seeing. The aim was not so much to encourage them to reflect on the meaning of decoration, but to frame their next encounter with it, to superimpose the image of the tattooed Papuan and the childish doodle, as it were, on the ornate object or building. At the time Loos was writing, this new way of seeing also required a new version of design history to justify it, one which saw the Vienna Secession not as the revolt of a vigorous avant garde against academic conservatism but as a regression to a primitive state, a taste for decoration destined to be superseded by a mature and sophisticated functionality.

**Reyner Banham**

Writing almost half a century later than Loos, Reyner Banham’s day job was in academia rather than in practice. Possibly for this reason, the philosophy behind his design journalism was more systematic than Loos', or perhaps just more systematically expressed.

His view of aesthetics as realised in what is now called ‘active consumption’ (de Certeau 1984) set Banham apart from those modernist designers for whom ‘use’ tended to equate with the narrower considerations of ergonomics and functionality from which appropriate form was supposed to follow. This dissent surfaced in articles such as ‘Machine Aesthetes’ (1958) which pointed out that the smooth plain surfaces rendered onto reinforced concrete in the ‘White Architecture’ of the Thirties had little to do with the look of actual machines or with truth to material. Rather they were products of amateurish misunderstandings of both by ‘aesthetic fumbletrumpets’. Banham’s opening up of the supposed fusion of form and function in modernism marked an important moment in its slow leakage of authority. Even amongst those broadly sympathetic to modernism, it was a scepticism which was in the air. Thus Lynes, (1959: 338): ‘Modern architecture, even when it doesn’t work – and it often doesn’t – looks as though it ought to’. Thirty years later, Ewen (1988:210-211) was less sympathetic, ‘The machine look which they produced, however, contained a paradox. In many cases it could only be achieved by painstaking hand-craft methods.’ and ‘There is a greater concern that the building should look rational rather than that rational methods should be employed in its design.’
Banham, then, was an early interrogator of the air of rational inevitability with which modernist design had hitherto been presented. For if its aesthetics did not, after all, follow from function, they must be – just aesthetics. In practice, Banham observed, much of the form justified in the name of functionality was actually that of classical geometry, in which respect ‘modernism’ could fairly be castigated as retrograde and academic. And even when it did express a genuine functionality, it was a legislated functionality, not one derived from the actual practice of users. In this respect modernism could fairly be accused of authoritarianism, an accusation which certainly resonated with the slum-cleared inhabitants of the Brutalist flats of the 1950s.

Once suspicions of this kind are planted in our minds, we begin to look differently at modernism – which brings us back to our main line of argument. An autobiographical example will illustrate. In that quintessential representative of functional ‘White Architecture’, the New York Guggenheim, there are a number of spiral arms which end in blank walls. At the time of a visit by one of us in 1996, one of them bore a notice attributing the slogan ‘form follows function’ to Louis Smith, the mentor of Frank Lloyd Wright. It was Lloyd Wright himself, apparently, who took the ‘next step’, declaring that ‘form and function are one.’ There was not even a chair from which the visitor could reflect on the relevance of these proclamations to his imminent need to retrace his own steps – the point being that the prior existence of a discourse of scepticism towards the modernist project sensitises the spectator to performative contradictions of this kind. Alert to the possibility of hand-crafted unevenness in the supposedly machine-like curvatures of the Guggenheim, sure enough we find it.

Contemporary design journalism

It is in the work of innovative thinkers on design (and major art critics) that vocabularies of appreciation are at their most visible, and this is because they are trying to change them. In order to do so, they need to draw out what is ordinarily taken-for-granted, what we habitually attend to, what meanings we attach and the standards or icons of design against which we make our judgements. In the ordinary way of things, these matters are largely implicit; we apprehend the designed object without reflecting overmuch on how we do so. Following major changes of taste, that is, vocabularies of appreciation sink back into what Bourdieu (1986) called the ‘habitus’, giving rise to the illusion that design (or art) can speak direct to our unsocialised humanity. But this is an illusion: spontaneity is not instinct.

This means that we should not expect to find vocabularies of appreciation systematically set out in the everyday journalism of design. As the ideas of pioneer thinkers slowly filter into the small change of routine description, they become familiar and can be evoked through a repertoire of stock phrases. A kind of shorthand evolves, which comes to stand for a whole ‘look’ and a whole way of appreciating it. Readers of style magazines and newspaper colour supplements are bombarded with articles about interior decorating and home makeovers which are full of these terms and phrases. The objects and room-settings are shown in pictures accompanied by a vocabulary of appreciation now reduced to slogans or adjectives. If, for example, an item is described as ‘clean and functional’, we now know that we are intended to experience it through the lens of a popularised modernist aesthetic, one which looks for and finds virtue in simple geometric form and undecorated surfaces. Even in these truncated forms, however, vocabularies of appreciation still display occasional traces of the tendencies outlined earlier. That is, they also work as vocabularies of deprecation towards rejected styles. In this vein, the journalist Jonathan Margolis (2000) offers his readers a compact reprise of Loos’ fulminations against decoration:

“It is common today to enter a working class home and find amidst the swirly carpets and ornate three piece suite, a couple of stunning modern Scandinavian items....”
If Margolis echoes Loos’ modernist functionalism, Friedman (2002a) urges her readers to look at it with the scepticism of Banham:

“The modern movement dictated that white should be one of the commandments of contemporary design, simple pure and light. . . [but white] . . . is actually a singularly unfunctional and inappropriate colour for furnishing fabric, wall covering or carpet in London in particular, one of the filthiest, greyest cities in the world.”

Notice too the echo of Banham’s charge of authoritarianism against modernism. In the following extract, also from Friedman (2002b), the historical dimension to a vocabulary of appreciation is visible, in this case a version of history which sees the initial excesses of modernism gradually softening as architecture opens to the influence of its users:

“A house has to be eclectic and have a bit of history. You have to bring some meaning to ownership, not just be a tenant in your own home. Modern architecture has always been extreme…..today’s architects are less doctrinaire in their approach”.

Despite these adjustments, continues Friedman, many users have still not assimilated the modernist vocabulary of appreciation, even in its softened version: “inexperienced buyers of the new can still feel overwhelmed by what they see as the expectations of contemporary design”.

Friedman’s mention of personal history points to an important difference between the way we experience art and design. For most of us, most of the time, artworks are viewed in social spaces set apart from everyday life. Even the wall-space over the mantelpiece may be thought of as such a place. In contrast, the designed object is often part of everyday life. Whilst the difference is obviously not a hard and fast one, it means that design is more likely than art to carry associations of the aspect or phase of life into which it fitted. Although most of these associations are private, enough of them are public to create a market for works of design intended to dispel them if they are unpleasant or to tap into them if they are pleasant. Thus Deyan Sudjic (2001) explains the early success of Habitat as a cheap and simple way of covering up decor which by the early 1960s had come to carry associations of scrimp and save:

“the foam sofas, plastic wastepaper buckets, Art Deco wallpaper, brushed aluminium up-lighters and rush matting helped a generation liberate itself from the bleak memories of their parents’ world. Conran showed how the lingering odour of utility furniture, coin-in-the-slot gas fires and bath times limited to three inches of water a day could be dispelled with a coat of orange paint, a floor sander and a scattering of ethnic durries”.

However, the terms in which Sudjic describes the Habitat package hints at a vocabulary of appreciation which now sees through it. It seems now to be seen as a cut-price veneer of fake modernism which could only work so long as it succeeded in staving off its association with the sadness it typically covered up. On a par, perhaps, with the boy racer’s hopeful addition of a rear spoiler to his parents’ cast-off Rover saloon.

The use of design as a way of tapping into (mostly) pleasant associations is signalled by one meaning of that complex adjective ‘retro’. At its simplest level, retro indicates that a piece is to be viewed not as an embarrassing relic of an obsolete style but as a keepsake from a simpler, nobler, and better past. The aluminium-spoked steering wheel is intended, perhaps, to evoke the world of pre-war motoring with its open roads, its absence of speed limits and casualties largely confined to pedestrians, animals and cyclists. But retro may also signal that we are to understand a display of past design as a knowing, ironic and even post-modern framing of kitsch. An example is the revival
of the 1960’s lava lamp by a company called Mathmos, named tongue-in-cheek after the ‘bubbling life force’ in the sci-fi cult film Barbarella (Tyrell 2001). The commercial success of objects of this kind bears witness to the appeal of demonstrating our own sophistication by a suitably framed display of its cheap and tacky antithesis. Need we also add that such a display depends on a vocabulary of appreciation which is also a vocabulary of deprecation and which is historical in its nature?

Design also differs from the fine arts in the matter of functionality. Typically the functional counterpart to the aesthetic vocabulary of appreciation is a combination of the book of instructions and the sales brochure. Though the two overlap, the first concentrates on how to use the product and the results which should follow, whilst the second focusses on the improvements these represent over previous designs. In this respect, the brochure works rather like the historical dimension of avant-gardeist vocabularies of appreciation. As with certain artworks, moreover, it is sometimes possible to build statements of both kinds – of usability and historical movement - into the physical form of the product itself. The transparent barrel of the Dyson vacuum cleaner is an interesting example. This not only declares a technological advance over previous types, but also guides the user on the disposal of the dust. This mention of product semiotics, however, leads away from the main topic of our paper.

Conclusions

There are times when design seems to work with an immediacy which suggests that its appeal is direct to the central nervous system. If all design actually worked like this, the education of the public into the appreciation of good design would require nothing more than exposure to it. And should this direct and simplistic approach fail - as we think it always has - the disillusioned would-be missionary is at least left with the consolations of snobbery. To the extent that good design remains a minority taste, it is one which speaks of a refined sensibility.

We think this whole picture is misleading. Sensibilities are manufactured; in the fine arts through the agency of the dealer-critic system; in design through the writings of pioneer critics as filtered down through style magazines, advertising and other media of design journalism. In the writings examined in this paper, we catch these critics in the act of cajoling their publics into looking at things differently, describing them in different terms. These writings are the verbal component of what we have called vocabularies of appreciation, ways of paying attention and describing which have developed alongside the modes of design or schools of art to which they are attached. It is these specific vocabularies of appreciation, not some more generalised refinement of sensibility, which enable us to read works of art and design more-or-less as they are read and intended within their native aesthetic communities.

Since the arts and designs of the twentieth century were importantly characterised by a succession of avant-garde movements, each defining itself in reaction to what went before, vocabularies of appreciation possess a critical-historical dimension, in which the meaning of a work lies partly in what it rejects. Modernist design, for example, invites the eye to wander over its bland surfaces, luxuriating in relief from the decoration which might once have been applied to them. Thus the eye sees through the lens of a version of design history and vocabularies of appreciation are simultaneously vocabularies of denigration. For the lover of good design, it follows that failure to be up with the game signifies not merely a lack of good taste; it is bad taste. As Poggioli (1968) put it, ‘the typical form of the ugly for the avant garde is “ex-beauty”, the cliché.’

From all this it follows that a wider appreciation of good design depends on the dissemination of its associated vocabularies of appreciation. This would require design criticism and the journalism derived from it to be far more explicit on the matter of what to look for in good design and what
experiences are supposed to follow. That instruction of this kind would strike some of its current public as crass only symptomises the strength of the exclusionary tendency. With the expansion of higher education in art and design, vocabularies of appreciation are now increasingly acquired in the course of professional training, with the fluent and confident mastery of them serving as a sign of initiation. In more traditional social forms the love of art could legitimate inherited privilege by denying the long process of socialisation through which it had been acquired (Bourdieu and Darbel, 1992). By similarly suppressing their educational origin, contemporary vocabularies of appreciation can serve to define a community of ‘spontaneous’ good taste against an excluded philistine majority. With a wider public understanding of what to do with good design, all that would have to go, but that is only to say that design cannot simultaneously be popular and exclusive.
References


Managing architectural analyses in a collaborative context

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Abstract

The study of precedents plays an important role in design and design education. Architecture students prepare analyses of prominent precedents with respect to various criteria. Such design analyses are represented and communicated through abstractions. Collections of these abstractions are stored, related, managed, and presented in digital environments. Such web-based environments can serve as an extensible library of design precedent analyses. The use of an extensive library by a collection of students requires a flexible and extensible information model for relating and integrating the various contributions. We propose a methodology that establishes an information model for digital architectural analysis environments. This model facilitates a rich information structure of abstraction entities and their relationships, both structural and semantic, offering increased value for accessing and browsing this information. Specifically, a rich information structure allows one to access the information from alternative views to those that are expressed by the individual abstractions. In this paper, we start by discussing precedent-based learning, and describe the abstraction model currently used for precedent documentation and analysis. We then present our methodology for achieving a rich information structure. We end the paper with a description of an implementation of this methodology as an architectural analysis construction and presentation environment for a second year design studio.
Managing architectural analyses in a collaborative context

Precedent-based learning
The study of precedents plays an important role in design and design education (Akin, Cumming, Shealey and Tunçer 1997). While practitioners can rely on their own and their colleagues’ experience in the process of a new design, students can only draw upon documented examples of success and failure from known architects. Especially in the early stages of design, it is common practice for architecture students to collect information on prominent buildings relevant to their design task. ‘The rationale for banking on so called precedents is straightforward: it is wrong to wish to reinvent the wheel over and over again. … We should learn from our elders and adopt their successful solutions to problems similar to the ones we cope with’ (Goldschmidt 1995: 70).

Precedents as finished and complete design objects contain knowledge of design. A study of such precedents can yield, among others, heuristics used by the designer, design principles for various purposes and situations, and prototypes from building typologies.

Architecture students often prepare case studies for their design studio projects, gathering information about existing buildings with similar functionality to the subject of their project. They present this in the form of collages on paper, or as hyper-documents. By integrating the respective results into a common library, students can draw upon others’ results for comparisons and relationships between different aspects or buildings. There have been attempts at collecting and organizing these results into computational environments (e.g., Madrazo and Weder 2001; Madrazo 2000) as a collection of categorized and hyperlinked documents. The EDAT example (Akin et al. 1997) additionally offers the students a tool to present their work in the design studio and is extendable in different ways, e.g., for carrying out performance analyses on the stored test cases.

Such environments for precedent-based learning generally use an abstraction model or a document-based model. They use collections of abstractions for representing, storing and presenting design information. A drawing or text specifies a single abstraction; each abstraction expresses a different aspect of the design object, such as form, function, acoustics, structure, process, space, and organizational relationships (Schmitt 1993: 39). Abstractions are expressed as documents of various formats, e.g., drawings, diagrams, 3D models, images, simulations, and texts. Such computational environments treat the individual abstractions as entities or objects that are organized and related according to various categories and attributes. The purpose is to offer a flexible organizational framework and enable easy indexing and retrieval of documents.

There may be many different reasons for retrieving information on precedents in an electronic environment. Given a group of precedents of a specific building type, e.g., theaters, one may be interested in a particular theater hall because the works of that particular architect are of interest. Or, one may want to look at all foyers in order to get an overview of different circulation schemes used in theaters. Alternatively, one may want to deduce rules of thumb about designing theater halls with good acoustics by looking at theater halls that are considered to be examples of good acoustics. Such cases can be enumerated for pages. In general, information retrieval in such environments are based on keyword searches. Documents are indexed such that each document is represented by a set of keywords. This indexing can be done manually or automatically. Information retrieval actions within precedent-based learning environments generally fit one of the following two categories. Firstly, one may want to retrieve a specific known document that resides in the repository. If the retrieval query contains one or more of the document’s keywords, the retrieval will be straightforward. Secondly, one may want to retrieve all documents pertaining to a certain concept or topic, including their links to other related documents. Such an overview of relevant documents may provide the necessary information in order to establish or verify a certain design aspect. The
possibility of interpreting the entire document structure seeking information related to a concept of interest is an important requirement in such an environment.

As a result, the use of an extensive library by a collection of students requires a flexible and extensible model for relating and integrating the various contributions. Specifically, there is a need for an information organization that enables a user to access information independently of the individual viewpoints of the authors of the information space. The approach described in this paper provides a methodology for modeling information in such a way as to provide a rigorous recipe when creating cooperative information environments for creating, managing, and presenting architectural analyses.

**A recipe for digital architectural analysis environments**

**Rich information structures**

Information structures are created, at a minimum, by a collection of information entities, an organization of these entities, and a specification of the relationships between these entities. In the context of an architectural analysis, the individual abstractions and their relationships define the information structure. A dense information structure offers better support for searching and browsing this structure. Searches in a larger structure will offer more results while a denser structure can serve to distinguish entities by their relationships. Browsing a structure is also facilitated by its density as additional relationships offer more ways to move through the space. This density is directly defined by the authors of the information space. Therefore, we aim to support the authors with a methodology for increasing the structure’s cardinality and its interrelatedness towards a richer structure: augmenting the structure’s relatedness with content information, and expanding the structure through the replacement of abstraction entities by detailed component substructures.

In a syntactic manner, an abstraction can be considered as a compositional structure of data entities and relationships. While each abstraction touches upon a different aspect, abstractions relate through commonalities, similarities, and variations in vocabulary and compositional structures. When the abstractions are numerous and diverse, recognizing these relationships creates a tight network in which the individual abstractions no longer stand out. Such a network of abstractions can be said to embody a rich representation.

A rich information structure of abstraction components and their relationships, both structural and semantic, offers new possibilities for accessing, viewing, and interpreting this information. First, it allows one to access specific information directly instead of requiring a traversal of the abstraction component hierarchy. Individual components can be reached and retrieved more quickly when provided with more relationships. Second, components can be considered from a different point of view. The location of a component in the structure is no longer only defined by its place in the abstraction component hierarchy. Instead, components provide direct access to other related components, forming a part of the first component’s context. Third, one can access the information structure from alternative views to those that are expressed by the individual abstractions. New compositions of components and relationships offer new interpretations of the structure and generate views not inherent in the structure as created by the original abstractions. Such interpretations can lead to new abstractions.

**Document decomposition by content**

A document management system commonly provides for an organization of documents with respect to categories or keywords. However, a categorization with keywords offers little
information on the importance of a concept as specified by a document keyword, or on the portion of the document this keyword applies to. Furthermore, users may opt to simply ignore keywords which apply to only part of a document. In this way, these document properties offer only a quantitative rather than a qualitative valuation of the document. Instead, by allowing the user to select portions of a document for assigning keywords, many more keywords that better fit parts of documents can be specified and associated with the appropriate document portions. This will make the documents inherently related by content.

Decomposing documents by content creates a richer information structure. Replacing documents with component structures automatically increases the number of information entities. Decomposition relationships between document components extends the network of relationships. Furthermore, a document decomposition enables the relating of keywords to document components, allowing for the specification of keywords that may otherwise be ill-suited to relate to the document at large. Document components that share the same keyword can be considered additionally related.

**Separation of syntax and semantics**

Document decompositions can be represented in various ways. We choose to consider a structural decomposition of a document as opposed to a semantic one, that is, document components are defined as subsets of the overall document and using the same representation. This approach to decomposing documents provides a uniform structure that is easily adaptable, unlike a semantic decomposition. In this structure, the semantics of the decomposition are separately specified by a categorization of the document components. This semantic keyword structure is derived from an analogy with the semantics of a system of architectural types. A structural document decomposition particularly applies to texts, images, and simple line drawings, as these lack any strong inherent structure. All composed of symbols from a relatively small vocabulary, i.e., characters, pixels, and line segments, in simple one- and two-dimensional patterns, they are represented in a similar structure and can be operated on in a similar way: divided into smaller parts and the parts organized into a hierarchical structure (figure 1).

Figure 1: An exemplar image decomposition hierarchy from the design studio application.
Separating semantics from syntax allows a semantic organization to augment the document structure without imposing a specific representational structure. This semantic organization can be specified as a compositional structure of descriptive keywords, in various ways (figure 2). Such a semantic structure assists in achieving a rich information structure. When keywords are organized in a structure, relationships between keywords define additional relationships between document components.

Figure 2: Schematic diagram of four different semantic structures for descriptive keywords. a) a linear structure, b) a hierarchical structure, c) a network structure, d) a combination of the previous structures.

The separation of syntax and semantics ensures extensibility and flexibility of the overall representation and avoids the imposition of a fixed frame of reference. The semantics can easily be altered at any time without requiring an adaptation of the syntactic structure. Users can alter either the decomposition or the categorization without affecting the other. Furthermore, the user has full control on the effective positioning of any document within the categorical organization, by selecting either or both the number of keywords assigned and the level of decomposition. This flexibility avoids a rigorous and tedious process when using an application of this methodology.

Architectural types as semantic guideline
Within a discipline, members structure shared knowledge through the definition and classification of common concepts. Architects generally classify building designs based on spatial and formal features. This classification introduces the concepts of type and typology. Types in architecture assist, besides the communication of shared knowledge, the analysis of existing buildings, and the design of new buildings (Leupen et al. 1997: 132). The concept of building types plays a central role in architecture, although there is no single definition of type and various approaches to the subject exist. Building types, e.g., museums, offices, and libraries, generally define classes of buildings that have common, often functional, characteristics. However, the functional classification is not the only aspect of building types. Generally a type can be described as the encoding of prominent features of a design object. Such features include function, form, and context. According to Moneo (1978), a type can be ‘defined as a concept which describes a group of objects characterized by some formal structure.’ This implies a grouping of objects by certain inherent structural similarities. These objects are not isolated from a spectrum of concerns from social activity to building construction. Type as a formal structure is defined by the relationships
between all these aspects and the elements that make up the whole. This definition of types as a structure of aspects, elements, and their relationships makes it possible to formalize a building type as a network of components, concepts, and their relationships.

Relationships between types play an important role; a type is related to and dependent on other types. According to Johnson (1994: 347-348), a relationship has first to do with identifying characteristics of elements. These make the elements recognizable as belonging to some family of elements. Second, a relationship relates to the distance between the elements, be it an abstract, conceptual, mathematical, semantic, or physical distance. Relationships between types result in formal and spatial organizations and ordering principles (Ching 1979). Types and their relationships can be represented in a graph system, as nodes and edges. Type as a concept has no notion of representation. Nor does a typology prescribe a particular semantic structure. The structure may be expressed linearly (figure 2a), or hierarchically, offering various levels of detailing (figure 2b). When parts of the hierarchy are reused at various locations within the structure, a network structure results where types can have more than one ‘parent’ type (figure 2c). The structure’s complexity can be extended or reduced according to individual cases. The overall structure may also constitute a combination of various dependency substructures, describing different aspects or parts of a typology (figure 2d). In this case, the individual substructures may be considered as different dimensions within the semantic model.

We can consider types in their most simplistic form as keywords. Keywords are commonly used as a means for the categorization of documents in document management applications. Elements of such a semantic structure do not necessarily need to be considered conceptually as types in the architectural sense. Types in this context are used to denote the dependency between elements. When these elements are related according to a semantic structure, they are more than simple keywords or attributes. As types are associated to documents, in the form of keywords, relationships between types induce additional relationships between document entities that otherwise do not exist. These additional relationships tighten the information structure already defined by the document entities and their relationships.

Visualizations
Imposing a semantic structure on keywords as types also facilitates the assignment of keywords to document entities and components. When keywords are organized in a structure, these are more easily visualized and conceptualized, facilitating a conceptual organization of documents with respect to this semantic structure. In particular, effective visualizations allow efficient and fast access to data, and provide a better overview of data entities (Papanikolaou 2001). Visualizations that facilitate visual exploration and manipulation support the process of relating appropriate keywords to document entities and components. For example, a hierarchical structure of keywords allows for an effective overview of the entire structure in a single view that can be used when assigning keywords to documents and when creating new keywords within this structure. Even without any control mechanism to ensure the consistency of the positioning of new keywords in the hierarchy, the clarity of the structure enables the user to better determine which location may be appropriate for placing a new keyword in the hierarchy.

Automation
Types in architecture usually have various formalizations related to them. Formalizations of types make it possible to search for instances of types within documents of different formats. Since types are conceptual entities, with instances of these associated to design documents, the format of a document defines the respective type’s formalization: as a keyword, an image, a sketch, etc. Formalizations of types in different formats can assist in automating the classification of documents by automatically recognizing instances of types within documents. Recognizing instances of types
in documents provides both qualitative and quantitative information about the importance of these
types for the documents. It also enables a specification of exactly which part of a document a type
applies to. This automation facilitates the process of relating and categorizing documents.

The process of document decomposition may be (semi-)automated using pattern recognition
mechanisms and artificial intelligence techniques. Image recognition mechanisms for images (e.g.,
Koutamanis 1995; Barrow and Tenenbaum 1981), shape recognition mechanisms for simple line
drawings (e.g., Chase 1989; Krishnamurti 1981), and keyword or concept recognition mechanisms
for texts (e.g., Greenberg 1999) will assist in presenting the user with suggestions about document
components corresponding to a given categorization. Other formats require similar, though
different, recognition techniques. While there has been a lot of research into the field of image and
pattern recognition, especially in engineering, remarkably few practical applications of this research
in the field of architecture exist. We do however expect these technologies to mature and be able to
serve this purpose. These technologies will surely provide a considerable benefit in the uptake of a
system utilizing document decomposition.

**Representational structures**

The representation of a document decomposition requires the definition and recognition of the
composing structure and relationships. Components and substructures can be recognized as
instances of types. These may be grouped into more complex structures, creating structure to
structure relationships corresponding to relationships between types. Substructures may also belong
to more than one structure, in reference to the formal structure described by Moneo (1978). Types
do not impose any particular representational decomposition on the document or abstraction
depicting an instance of a type. Instead, different abstractions require different vocabularies that
have their origin in the domains of the respective abstractions. These vocabularies may overlap but,
more often, they will offer alternative descriptions of related types reflecting on the function and
context. A syntactical framework that offers representational flexibility is needed to define the
vocabularies that express these structures. We propose the adoption of XML (eXensible Markup
Language) (W3C 2002) as a common syntax for describing document decompositions and their
integration into a single information structure.

**Design studio application**

We developed a first prototype for the presentation of architectural analyses on the web in order to
illustrate the presented methodology (Tunçer, Stouffs and Sariyildiz 2001). Ottoman Mosques
served as a case study for this work. XML was adopted as a common syntax for the representation
document structures and their integration into a single information structure. Based on its results,
we are currently developing a new system for the construction and presentation of a body of
architectural analyses in the context of a design studio.

This design studio will start in September 2002 as part of a new curriculum to implement a three +
two year bachelor and masters program. The design studio will be offered in the fourth semester to
about 350 students. The central design theme of this studio is a “small public building”, in
particular, a theater. The students will be given a relatively complex functional program and will be
requested to design and work out the materialization of this theater.

The students will begin the studio by analyzing selected precedents (historical and contemporary) of
the relevant building with respect to various criteria (composition, program, construction, context,
type, etc). Documentation of these precedents are presented to the students in the form of drawings,
pictures, and texts. Until now, such documentation was commonly provided in the form of a book.
In this studio, instead, this documentation will be available on the web within the same environment
that the students will use for the presentation of their own analysis results. The result will be a
common library such that students, in later design activities, can draw upon other students’ results for comparisons and relationships between different aspects or buildings.

The students will be provided with a keyword hierarchy corresponding to a system of architectural types as a structure to hook up their contributions. In general, and depending on their knowledge of the domain, students can collaboratively define and extend this structure. Additionally, the students will be offered a tool for the decomposition of images and texts, such that the various components can be more accurately organized in coordination with the keyword hierarchy. These and other tools are integrated within a presentation environment for analyses. The user interface provides views for individual documents and all their related documents at one glance, and visual overviews of the entire document and keyword structures and their links. We are developing tools to create the keyword structure, and view it as a semantic map; to intuitively decompose documents and relate them with keywords; to generate pages to draw sections and views on a plan, relate the respective documents, and then to generate web pages from these, as entry pages to analyses.

**Representation**

The content of the system is provided as a number of abstractions from selected precedents and a type hierarchy. Abstractions may be decomposed into constituent entities, in correspondence to the adopted typology. Abstractions in the form of images can be broken up into smaller images using an image processing application. Abstractions in the form of text are immediately structured in XML. Currently we consider only text and image abstractions. The result is a component hierarchy, with the top-level elements corresponding to the various abstractions. The type hierarchy depicts the semantic structure for this component hierarchy, with each component entity assigned at least one type from the type hierarchy. The type hierarchy itself can be imported from an external source or collaboratively composed by the authors of the analysis. Both the type hierarchy and the collection of abstractions can serve as access points into the analysis.

The structure of both type and component hierarchies is specified by the XML grammar and encoded in the DTD (Document Type Definition). It specifies the kinds of elements, their properties and attributes, and their possible nesting. Both hierarchies are recursively defined. The type hierarchy is defined in XML by using the type name as the tag and by nesting the elements according to the hierarchy. An ID additionally identifies each type and is used for linking types to components. Components are also identified by an ID; the component hierarchy is defined by using this ID as the index, and by nesting the elements.

In this organization of types and components, various kinds of component relationships can be distinguished. Components are initially related by the abstraction hierarchy these belong to. By assigning types to components, components that share the same type are implicitly related. The type hierarchy further relates components, these relationships are derived from the nesting of the respective types in the type hierarchy. Additionally, explicit relationships can be specified between components.

The resulting XML structure forms a flexible source for further manipulation and traversal. Components can be flexibly categorized and grouped according to their relationships and attributes, offering various views of the information structure. Views can be traversed and linked using both explicit and implicit relationships. The documents are transformed and visualized using XML related developments (W3C 2002).

**Interface**

The interface allows the user to view both the type and document hierarchies and their relationships in an intuitive way. These views include both in-world and out-world views (Papanikolaou and
Tunçer 1999). An in-world view presents a component (or type) together with its immediate neighbors within the hierarchy, and displays all other components that share a type with it (figure 3). Such a view allows one to browse the structure, interpret the relationships, and as such lead to interesting out-world views. While the types serve for the most part as binding elements in the structure providing relationships between the components, when traversing the information structure, the content as available in these components is the most important aspect. As such, while the component’s type, and its location in the type hierarchy, may be presented as properties of the component, the relationships are specified primarily as component-to-component relationships. This not only ensures that links are presented as shortly as possible, facilitating a swift traversal, but also shifts the focus onto the content, rather than the structure that surrounds it. Types further serve a role as index to the information structure.

![Figure 3: A snapshot of an in-world view from the prototype application.](image)

In addition to the different in-world views, structural maps provide visual feedback to the users on their traversals and selected views by presenting the location of the currently viewed node within the hierarchy. Such views also give an overview of the scope and depth of the semantic structure guiding the analysis. Figure 4 presents some exemplar out-world views as clickable maps that offer an overview of the entire type hierarchy in relationship to the related documents.
Figure 4: Three snapshots from out-world views of the type hierarchy. The focus of this figure is on the graphical representation of the type structures, not on the types themselves. a) a 2D list view, b) a 2D dynamic tree view, c) a 3D dynamic network view.

Tools
We are developing and implementing a number of tools, using Java and SVG, in order to facilitate the development of keyword structures and the decomposition of images and texts, and to construct image maps that can serve as guides into parts of the information space. A first tool serves to create the keyword structure, and view it as a semantic map (figure 4b). This tool extends on an existing freeware application for building up and viewing network structures. Another tool assists the user in the decomposition of image abstractions. Image abstractions are decomposed by selecting rectangular areas from the images (figure 5), selecting sets of keywords from the type hierarchy (figure 4b), and attaching these to the image components. The same application also offers a tool for adding hotlinks to images, allowing for the development of image maps that can serve as a content map or index to a collection of related documents. The base image may constitute a plan of a building, markers can then be positioned on the image and related to the appropriate documents. From this information, a web page is generated containing the respective image map (figure 6). When one moves the mouse pointer over a marker, a preview image of the related document appears. Markers can be clicked to browse to the respective document. Currently we provide for section markers, indicating where on a plan a section is taken, and in which direction (figure 6a),
and view markers, defining where a picture or an elevation is located in relation to the plan (figure 6b).

Figure 5: A snapshot from the image decomposition tool showing two rectangular areas drawn on the loaded image in order to create two image components.
Figure 6: Generated web pages containing image maps that serve as a content map or index to a collection of related documents. a) image map with section markers, b) image map with view markers.
Conclusion
Analysis plays an important role in design and education. An information structure that integrates the different abstractions or aspects of an analysis, such that the analysis can be interpreted and used in ways other than the original abstractions present, would be particularly useful in an educational setting. As the web gains more importance in all fields, including cooperation in educational projects, providing software that makes it possible for team members scattered over diverse sites to share and manage information while maintaining a comfortable, easy-to-use interface becomes crucial. It seems to us that enriching the information structure both by detailing the components and by tightening the structure through content relationships would provide a more powerful structure in such a system. Especially in analysis, one is not just interested in one or more specific documents to be processed or built upon, but in interpreting the structure seeking information related to a concept of interest. Targeting a largely unfamiliar audience, the indeterminacy of viewpoints provides the possibility to anticipate individual requests from the audience. Unexpected viewpoints derived from the information can also invoke new interpretations of existing information, which in turn can lead to creative discoveries. In such a context, a rich information structure where the views one can derive are not simply defined by the original documents is particularly worthwhile.

Acknowledgement
This paper is based on an earlier paper submitted for presentation and publication at the sixth international conference on Design and Decision Support Systems in Architecture and Urban Planning, 2002.
References


Telling tales: understanding the role of narrative in the design of taxonomic software

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Abstract

This paper draws on concepts from the structuralist analysis of narrative to explore aspects of the role of stories in the small group design process. A brief review of relevant narratological concepts is provided. Their application in a preliminary analysis of case study data from a team designing taxonomic software is then reported. It is concluded that narratology, and in particular the notion of focalisation, has useful descriptive potential in this context, and may help to elucidate some difficulties in design communication and documentation. Suggestions for extension of the work are included.
Telling tales: understanding the role of narrative in the design of taxonomic software

Introduction

In this paper we present a case-study based exploration of the role of stories in the small group design process. Small group design activity has been the subject of much research and theoretical development. Shared space, physical resources and embodied action (e.g. Robertson, 1997; Dourish, 2001; Tang, 1991 and Radcliffe, 1996) have received considerable attention, as have the study of the elements and dynamics of the design process (e.g. Olson et al 1992; Olson et al 1996; Potts and Catledge, 1996, Ball and Ormerod, 2000) while the social constructivists have also made their case (e.g. Bucciarelli, 1994; Lloyd 2000). Again from a social perspective, collaboration styles have been studied by Maher et al (1997) while the pattern, structure and substance of communication within and outside the team has received the attention of a number of researchers (e.g. Cross and Clayburn-Cross, 1996; Cahour and Pemberton, 1998; Perry and Sanderson, 1998; Reid and Reed, 2000). We contribute to this last theme by illustrating how stories steer the design work, act as communication tools and create obstacles to mutual understanding. This last point is explored and illustrated by way of a narratological analysis. The paper shows how such an analysis can help both to describe and understand the process and the communication difficulties which arise. Our analysis (and illustration) is based on a study of a small group of designers developing taxonomic software for botanists in a project known as Prometheus II.

As practitioners and occasional theorists of user-centred design (UCD), this paper forms part of a developing strand of research into the role of narrative in the user design process. In contrast to the more familiar study of narratives in design (i.e. the use of the ubiquitous scenario) we are interested in how the concepts, vocabulary and constructs of narratology can provide us with a means of analysing, describing and illustrating the subject matter and dynamics of design meetings.

Elsewhere we have discussed how the desire to commit to a coherent joint design story submerges many competing narratives, with predictably unfortunate results (Turner, Turner and McCall 2001). We have also shown how a strong narrative structure is an essential component of a successfully engaging collaborative virtual environment (Turner and Turner, 2002) and how the actions of the designer as narrated in many reports of UCD bears a startlingly close resemblance to the stylised story of the hero’s journey found in myth and folktale (Turner and Turner, 2001).

Our focus complements the work of Lloyd (2000), who identifies four main roles for stories in the design context: in giving an account of progress to others; as a convenient index to past events or discussions, as competing rationales for the same object – so a specification may be regarded as a flexible resource for efficient selling in the salesman’s discourse, but a defined starting point for the designers – and as the socially constructed meta-story of the process itself. We are specifically concerned with the role of stories (or story fragments) which are told by designers about actual and potential user behaviour and about the role of the software under development. The analysis draws on structural concepts from narratology to analyse how the design team tell stories which arise from the same set of agreed user requirements, but are different in subtle, often unacknowledged, but insidious details.

A very brief introduction to narratology

Of necessity, this paper can only touch upon the richness of narratological theory, and the reader is referred to publications such as Onega and Landa (1996), Bal (1997) and Herman (1997), for thorough introductions. For our purposes, we use narratology to mean the study of narrative texts, the “…representation of a series of events meaningfully connected in a temporal and causal way”
(Onega and Landa, 1996:3). A ‘text’ may be in any medium, thus encompassing the spoken word, film and pictures and as well as written material. In recent decades narratological analysis has been adopted in many disciplines beyond its original domain of literary theory, most pertinently for us in discussions of the design process (e.g. Lloyd ibid) and organisational theory (e.g. Czarniawska, 1997; Pentland, 2000). Our treatment draws on the structuralist tradition of narratological studies. Post-structural theorists have addressed, inter alia, the central but vexed question of the relationship between author and reader in the construction of a story, but this is beyond the scope of the preliminary analysis presented in this paper.

Some basic concepts
We consider design communication in relation to the three levels of narrative commonly adopted by literary narratologists, at least those of a structuralist persuasion. To paraphrase Bal’s (1997) definition, these are:

- The text itself – the set of linguistic signs which appear on the page, or are spoken or otherwise presented;
- the story which the text conveys;
- the fabula – the underlying events and circumstances of which a given story is only one possible account.

In our case we will consider the taxonomical software project outline as the fabula, and the story level as containing the set of explanations of how taxonomy is currently practised, how the new software will support (or change) this process, how the software will be used, how the software will work and so forth. The text consists of the words spoken by the designers, recorded as the verbal protocol of the meeting, together with the documents authored by project members (not considered further in the current paper. Our discussion very largely concerns an exploration of the story level in the design meetings studied.

The structural analysis of stories in literary narratology has focused on a wide range of story features, including but not limited to: characters, their characteristics and values; different types of narrator and the relationship between narrator and point of view; the actions available to particular types of character; the cross-cultural persistence of a set of story themes; the reflection of cultural norms in what is valued, condemned or left unsaid; the role of the narratee (the reader, viewer or listener) in shaping the story; intertextuality (the way in which all stories necessarily relate to all other stories known to author or reader); and the treatment of temporal perspectives. We focus here on two main aspects: the differing emphases in the stories told by designers, and the manner in which these stories are told from different perspectives. A little more should be said here about the treatment of perspective in narratology.

Focalization, voices and roles
Every story has a narrator. This may be an external voice, whether the author of a novel or an academic paper, the witness taking the stand in the courtroom, or the teller of an anecdote in the coffee room. Equally, the narrator may themselves be a character in the story. However, the story is necessarily told from someone’s (occasionally something’s) perspective, and this is not always that of the narrator. It is the owner of this perspective whom Bal (1997) and other theorists term the focaliser. Sometimes the change of focaliser is explicitly introduced (I asked her to tell me how it all started and she said…), but frequently the adoption of a focalising persona is subtle and unsignposted. Just as for the characters in the story, each focaliser has their own set of characteristics and values. Events are thus seen and told through the filter of perceptions and conceptions belonging to the focaliser (Lodge, 1980), as well as the narratological lens.
Focalisation can be regarded as a variant on Bakhtin’s work on the role of ‘voice’ and related concepts. (Bakhtin, 1981, 1986 – note that these dates are misleading, since Bakhtin was active in the first half of the twentieth century.) For Bakhtin, language is a cultural tool and speech is a form of mediated action. Speech comprises utterances which are always oriented towards a particular addressee. Thus in the context of user centred design, language mediates the interplay between designers and designers assuming the role of users with the utterance being the appropriate unit of analysis. An utterance is speech terminated by a change of speaker, and reflects a point-of-view or ‘voice’ in Bakhtin’s terminology. Our current analysis is accordingly at the utterance level. (A further key element of Bakhtin’s argument is that both speaker and listener are active in the process of constructing meaning – c.f. post-modern narratology – this aspect is not taken further in this paper, but will be the focus of further analyses.)

Having equipped the reader with a basic set of narratological concepts and vocabulary we now turn to our case study.

**The Prometheus II case study**

One of the aims of plant taxonomy is the communication of taxon (groups of specimens or other taxa) concepts. This communication allows exchange of ideas and the development of taxonomic knowledge. Part of the communication is based on plant and taxon descriptions. Descriptions provide a textual account of what specimens look like so that the identification of specimens is made easier and the idea behind a taxon can be conveyed to other taxonomists that can in turn use it. However, these descriptions use non-standard words and concepts. It is for example possible to find several definitions of what a “leaf” is depending on the taxonomist that uses it and on the plant group that is described. The word used to talk about these descriptions itself, “character”, is ambiguous and Colless (1985) collected nineteen different definitions. This makes objective communication impossible and as taxonomists usually use their own concepts to understand other taxonomists’ descriptions, it may lead to misunderstanding.

The purpose of the Prometheus II project is the definition of a data model and a database system that would support objective understanding and comparison of plant descriptions. The approach is twofold. Firstly, a standard structure for descriptions is devised, so that manipulation of descriptions by a computer system is made possible. This standard structure is designed to be able to capture all possible descriptions. Secondly, terms are always accompanied by a definition, so that similarities in terminology and concepts can be explicitly recorded. This allows taxonomists to access the definition of a term to make sure they understand it as the author of the description intended. This also allows reasoning about these terms and concepts so that implicit relationships can be discovered, more concepts compared accurately, and checks are possible to ensure that only valid comparisons are performed.

**Dramatis Personae**

At the time of the first meeting in the series studied (see section immediately below) the project was just starting to design the first in a series of three conceptual data models for plant classification. The model was to be used to drive the design of an initial software prototype for testing with users and with a specimen data set. Further iterations would develop two further data models and three prototypes of increasing degrees of complexity and sophistication. The core project members taking part in all the observed meetings were:

- E – the project manager at institution A (a school of computing), a database specialist, although originally a biologist
- F – the project manager at institution B (a botanical institute), a botanist and taxonomical software specialist
• G – a research assistant at institution A, a database specialist
• H – a research assistant at institution B, a biologist

Other personnel contributed to some meetings, specifically another database specialist and a research student investigating data visualisation issues, both members of institution A.

The approach to analysis

We should stress here that this was a preliminary study to explore whether and how narratological concepts could be applied to inter-team communications in the design phase. One of the first two authors attended each of 5 successive meetings between designers in the project. Meeting 1 was audio-taped, and meetings 2 and 3 videotaped. Problems with equipment prevented recording of meetings 4 and 5, but the attending author took detailed written notes, including verbatim records in instances where stories or fragments of stories were voiced. Meetings varied in length, but in total material from around 7 hours of meetings was collected. Informal questioning of the second two authors (members of the design team) by the first two authors, together with project documentation, provided the context for the data obtained from meetings.

The approach to subsequent analysis (by the first two authors) was both bottom-up and top-down. The meeting data (for this study confined to the combined verbal protocol generated by the participants, forming the *text* in narratological terms) was reviewed several times, at first to gain familiarity with the content, and on later passes to make a preliminary identification of aspects of storytelling in the meetings. Once stories or story fragments had been identified, a more fine-grained narratological analysis was applied using the concepts from the literature identified above. The next section summarises the preliminary results of this work, drawing out the varying roles of story in this particular instance of design process.

Analysis

Each of the meetings comprised discussion (or continued discussion) of a series of draft documents prepared by G, the computing research assistant. The documents were intended to capture the current understanding of the conceptual data model for classifying plant specimens. In later months, the project would turn its attention specifically to usage aspects, but even at this stage there was much discussion of the concrete details of current and potential taxonomic practice. Our first step was to interpret and form an understanding of the text we had captured. This process is necessarily and unavoidably subjective and the end result is a series of different stories about the design process. This analysis of the meeting data uncovers evidence of differing stories on several levels. These are now discussed, with verbatim extracts from the meeting protocol (in *italics*) included by way of illustration.

Variations on a theme

The analysis of the text (the collective verbal protocol) reveals there are at least two stories concerning the purpose and direction of the project in terms of the benefits to be gained from the taxonomic software, and to whom these benefits will accrue. These do not conflict fundamentally, and indeed are both present in one of the high level project descriptions (Napier University, 2002), but their differing emphases have consequences when the practical usage implications are considered. These parallel variations distilled from the meeting protocols can be summarised as set out below.

*Variation a – “The taxonomist as expert”*. The taxonomic classification of botanical specimens is a complex task, requiring the exercise of expert judgement. The software will support taxonomists in this task and be as easy to use as possible.
Or as the project description (Napier University, 2002) states “…one of the main challenges in the project will be to create a user-interface that allows the specification and subsequent use of the character framework in an easy way for taxonomists to use. Statements regarding the equivalence of concepts must remain under the control of the taxonomist…”

And in parallel

Variation b – “The need for consistency”. Classification of specimens in current taxonomic data is inconsistent; this makes comparisons and reuse of descriptions difficult. The software will help the taxonomic community by enforcing consistency.

Or again from the project description “..a three year project concerned with increasing the rigour and precision with which taxonomists can store, integrate and disseminate their data…. …taxonomic output is fundamental to all fields of biology that refer to organisms, and taxonomists in turn use data derived from these sources when refining past classifications. However, in taxonomy there is no single way of interpreting data, even though rigorous scientific methods are used to collect them. The result is confusion when using names and ambiguity when reading descriptions…”

The above variations are rarely voiced explicitly during the meetings, but surface in the designers’ discussions of how the software will be used. As we shall see in the next section, they generally belong to different focalisers in stories of current practice and potential software use.

Characterisation and focalisation in usage story fragments

Contributions to discussions about current and future taxonomic practice are frequently expressed as fragments of stories. The fragments concern the interplay between several characters: the taxonomist, both as a practitioner using current tools and as a future user of the software; the software itself; and a shadowy entity which we might characterise as the ‘taxonomic community.

From a close analysis of the story fragments we can see the characteristics ascribed to each character. For example, taxonomists are variously idiosyncratic, trustworthy, rigorous, and require flexibility. Here is an illustrative extract from meeting 1:

F: …so the only sensible way forward is to give the user some credit and hope that they’re going to put appropriate units.

Taking the analysis a stage further, stories of taxonomists and the software can be seen to adopt different focalisers. (As we briefly explained above, a focalisor is the character from whose perspective events are perceived.) All the four designers frequently narrate fragments about how taxonomists currently work, or how they will do so once the software is in place. In the meeting protocol, the designers most frequently focalise their remarks from their own primary perspective, whether this is as taxonomist or database designer. This is H, a biologist, describing the practice of measurement in relation to landmarks in meeting 3. She is placing herself in the role of the taxonomist recording the measurement:

H: Landmarks are used to highlight where you’ve made a measurement …

And E, a database specialist, commenting about taxonomic practice but on the evidence of the terminology used, speaking from her own perspective…

E: So the taxonomists, when they’re describing something, they’re entering structure, property, value…
However, the database specialists sometimes focalise the perspective of the prospective user of the software (extract below), and the biologists in turn speculate about how the software might work from a technical perspective:

G: When you read the description at breast height you don’t have a picture of the person who described it so how do you know how high it is…

And quite frequently the identity of the current focalisor is unclear – who, for example are “we” in the fragment below?:

G: and we have problems for comparisons because we have to understand what breast height means…

The values implicit in different variations of the project story, and the characteristics ascribed to users surface in how users’ actions are described. When the focalisor is a user, flexibility and ease of use tend to be emphasised, even if the speaker is a database designer, as in the second extract. (The extracts are discontinuous):

H: You have to put a unit on, but you are allowed to choose what unit you put on there.

E: …they don’t stop and think am I doing one like this or doing one like this or doing one like this…

Conversely when speaking as a database designer or member of the taxonomic community, expressed values are of consistency and clear structure, while users are characterised as idiosyncratic, as in the statement below from one of the biologists. Note that this is also a very rare instance of “point of view” being mentioned explicitly:

F: I think you see from point of view of reproducibility and consistency then if you just let them use free text then you start to lose meaning and comparability.

Thus we have a situation in which parallel versions of stories of purpose and use, with their attendant values, flow through the meetings side-by-side. In the meeting itself, we suggest that designers are aware of these subtle differences, and although navigation through the eddying streams and currents of story can be a lengthy process incorporating diversions and false starts, there is an impression of consensus. However, this fragile achievement has to be created anew at the beginning of each session. At least two factors can be identified at work here. Firstly, between most meetings discussion is filtered and condensed onto paper, a medium much less forgiving of parallelism, ambiguity and inconsistency than ephemeral speech. Secondly, a further problem hampering the achievement of mutual understanding in the design meetings is the nature of our cognition. As early as 1932, Bartlett demonstrated experimentally that stories are reconstructed rather than recalled. When he asked people to read and remember a story he found that of the original material little was retained except for ‘isolated and striking details’. Moreover these details were only remembered if they fitted into the individual’s pre-conceptions or prior experience. In practice this means that memories are recalled as gist.

**Discussion**

It is noticeable from reviewing the meetings that discussions of apparently quite small points of envisaged usage, and the conceptual model that such usage would entail, are very prolonged. This is confirmed by one of the designers, who noted that the first version of the conceptual data model had taken rather longer to agree than originally envisaged. Any causal relationship between different perspectives adopted by designers, the differing values that belong to those perspectives, and the
different contexts of story fragments, and the elusiveness of clear resolutions cannot of course be
proved. But we suspect at least some obscurity was contributed by these narratological phenomena.
In particular, the concept of focalisation at the level of usage stories has allowed us to suggest some
of the reasons for prolonged discussion. (We should add here that we do not believe that the project
studied was exceptional in its deliberations. Most of the many design projects with which we have
been involved have encountered similar difficulties.)

The subtle and multi-stranded nature of design narrative we have illustrated above adds an
additional explanation for the lack of systems such as gIBIS (Conklin and Burgess-Yakemovic,
1991) and QOC (MacLean et al., 1991) which attempt the capture of formal and unambiguous
design rationale. The central role of the story in the design process also supports the growing
tendency within the human computer interaction community to document designs by scenario.
There would appear to be scope for a suite of parallel scenarios, embodying stories told by different
focalisers and with different emphases, but which nonetheless are satisfied by the eventual design
solution.

As for the next steps in this work, we intend in the short term to extend the preliminary analysis
described in this paper by (i) examining the continuity of stories between meetings and documents
(ii) tracking any systematic change in focalisation of usage stories over time, and (iii) by applying
the concepts of the active listener or narratee to the data. We will then refine the analytical concepts
for application to a more extended and complete series of design meetings. In the longer term, there
are other aspects of story to address. In particular, we suspect that that there may be stereotypical
stories of users and usage which cross different design domains.

Coda: So what do the designers think they are doing?
Within the text of the meetings, there are explicit references to the project story that is to be
presented to the outside world, more specifically the community of fellow researchers. Here the
issue is one of deciding the emphasis of a formal story for publication in academic forums. For
example here are E and F discussing the academic story in meeting 2:

E: As far as I’m concerned the important conceptual idea is that we’re tracking the usage of
defined items, [murmurs of agreement] that’s what we need to make sure is captured in the
conceptual model and published..

F: That’s my view as well.

This is not just a matter of presentation or ‘spin’; the plot of the agreed academic story will partially
determine the focus of the project’s work. Thus, just as in the writing of a novel, the project’s
fabula (or activities) will be arranged to match an agreed story.
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Do we see within-subject change?
Four cases of engineering student design processes

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Abstract

Engineering design is a key facet of engineering practice and engineering education. Our goal in improving engineering education is to understand what contributes to design knowing and learning. Our study focuses on changes in student design processes over time and explores this issue through a within-subject experimental design. Eighteen engineering students solved three engineering problems as freshmen and later as seniors; the students provided a verbal protocol while doing so. We present case studies of four students who represent four distinct patterns of change in design process based on our analysis of these 18 verbal protocols. This work contributes to design research community efforts to understand the nature of design cognition and design expertise.
Do we see within-subject change?
Four cases of engineering student design processes

Introduction
Understanding design cognition represents an important direction for the design research community. Research questions involving design process, knowledge and communication strategies can and have been asked. Such fundamental knowledge of design is critical to those responsible for developing design education, designing tools that support design activity and creating design methodologies that work. Fortunately, much research already exists that sheds light on design cognition.

Frameworks for studying expertise provide a useful means for organizing much of that work. Ericsson and Smith provide one such framework in their 1994 book on expertise (Ericsson and Smith 1994). They identify three important elements critical to research into the nature of expertise (1) identifying tasks that will elicit the expert performance, (2) determining what contributes to expert performance by analyzing performance on the tasks, and (3) focusing on the acquisition of expertise (Ericsson and Smith 1994).

How far has the design research community come relative to this framework? In terms of the first element – identifying tasks that will elicit the expert performance – a variety of tasks have been used to probe design expertise. For example, researchers have asked participants to rate activities on a master list as important and unimportant in overall design activity (Newstetter and McCracken 2001) and identifying factors that they would take into account in solving a design problem (Bogusch, Turns and Atman 2000). In general, the most common task has been to have participants simply design a process or product relative to given requirements (e.g., design a bicycle, design a playground, etc.). Researchers have chosen tasks for their familiarity, their novelty, and/or their complexity. For example, Adelson and Soloway (1985) and Schraggen (1993) have conducted studies using tasks of varying levels of familiarity and complexity.

In terms of the second element, the design research community has also made clear progress in understanding the nature of expert design performance through research using the tasks described above and a wide variety of research design and data collection methods. For example, in a series of expert-novice studies, Atman and her colleagues found that more experienced designers as compared to less experienced designers (1) spent more time engaged in design, (2) had a different distribution of time across design steps (e.g., problem definition, data gathering, evaluation, etc.), (3) progressed farther in the design process (4) transitioned more frequently among design steps, (5) considered a wider variety of design criteria, and (6) created solutions of higher quality (Atman and Bursic 1996; Bursic and Atman 1997; Atman, Chimka, Bursic and Nachtmann 1999; Mullins, Atman and Shuman 1999; Atman and Turns 2001). Concerning progression, these findings suggest that more experienced designers utilize not only the earlier steps of the design process (e.g., defining the problem, analysis) but also those steps that come later in the process, such as making final design decisions and communicating that design (Atman et al. 1999). Moving up a level, Cross has comprehensively reviewed studies in which participants completed design tasks while providing verbal protocols (Cross 2001). In that review, Cross identifies problem formulation, solution generation, creativity, sketching, and opportunism as key areas where researchers have reported on expert design behavior.

The third element of the expertise framework, understanding the acquisition of expert design performance, represents one of the current challenges in research on design cognition. In contrast with the first two elements of the framework, little research has focused on understanding the
acquisition of design expertise. Issues in studying design acquisition include how processes change over time, what range of changes exist, and what types of processing of experiences contributes to growing design expertise. Fortunately, the existing research on design cognition provides a good foundation for understanding the acquisition of design expertise.

In this paper, we present data that contributes to understanding the acquisition of design expertise. Our contribution stems from a within-subject study of student design abilities using a verbal protocol analysis methodology. Specifically, we have analyzed the design behavior of specific engineering students at different points in time (at the beginning and at the end of their course of study). This within-subject approach allows us to gain a deeper understanding of the change in design processes within specific students. Our goal is to explore the general question of how individual student design ability changes over the four-year period of an education in engineering. Our questions include:

- What does change look like for individual students?
- Do all students exhibit a change in design process?
- Is an individual student’s change in design process consistent across different problems?
- Is an individual student’s change in design process consistent across different measures of design performance (i.e., time spent, number of transitions, and progression)?
- Can various patterns of change be identified?

The paper is organized as follows: in the next section, we describe our experimental design, data collection methodology, and analysis approach. In the subsequent results section, we present both summary results concerning the patterns of change that we identified and case studies illustrating each of the change patterns. The discussion is devoted to addressing each of the above questions in light of the results.

Method
Our current study of engineering student design processes uses a within-subjects design. Eighteen subjects participated as freshmen and then later as seniors. We also collected data from an additional 14 freshmen and 43 seniors so that we could address issues such as pre-test effects and the extent to which the within-subject participants represent the entire population of engineering students. This paper focuses only on the within-subject data.

Part one: Problem definition and data collection
Each participant was asked to complete three problems and to provide a concurrent verbal protocol (a “think-aloud” protocol) while completing the problem. In the first two problems, participants were asked to design a solution for a stated set of requirements. The first problem asked the participants to design a ping pong ball launcher that would function as part of a game. This problem, which we refer to as the “Ping Pong Problem”, was stated as follows: “In an attempt to avoid boredom at Benedum Hall, creative engineering students developed a challenging new game. A ping-pong ball is to be launched at a bullseye target, and points are awarded according to the accuracy of the landing. However, the ping-pong ball cannot be thrown at the target. It is up to you to design a device which will lift the ping-pong ball into the air and land it at the target. An accurate landing is desired while also maintaining a long flight time. Given that the center of the landing area is 5 meters away from the launch site, and the entire launching assembly must not be greater than 1m x 1m x 1m in dimension, design a ping-pong ball launcher for this game.”

In problem two, participants were asked to design a method for crossing a busy street at their university. The “Street Crossing Problem” was selected so that the participants would be more familiar with the context of the problem, and thus possibly utilizing a different design process. It read: “College campuses are often overcrowded with pedestrians crossing the streets, since walking
is a popular form of transportation for college students. One busy intersection at Pitt is the crossing of Fifth Ave. in front of the bookstore. Dangers at this intersection include heavy traffic and busses which run against the general traffic flow. The University would like to design a cost effective method to cross Fifth Ave. which would reduce the possibility of accidents at this intersection. Your work should contain a detailed description of your design and should include any relevant diagrams and calculations. Estimate both the costs and the benefits associated with your design. Please clearly state all assumptions which are needed in your analysis and try to keep your design simple yet effective.”

The third problem asked the participants to identify important factors to be addressed in designing a retaining wall for the Mississippi River. The results of this analysis are presented in (Rhone, Atman, Turns, Adams, Chen and Bogusch 2001).

Part Two: Analysis of product and process data for each problem
We analyzed the participants’ products and processes for each problem. To assess the product quality, two scorers evaluated the solutions to each problem using a rubric developed by a team of five engineering professors. The scorers first classified each solution (e.g. bridge, tunnel, crossing guard) and achieved an inter-rater reliability level of 93%. They then applied the appropriate rubric to the solution. For this portion of the scoring they agreed at a 94% inter-rater reliability level. To explore design process, we analyzed the protocols provided by the students as they solved the design problems. To do this, the protocols were transcribed and then segmented into idea units. Two coders then independently coded each segment according to a coding scheme representing steps associated with design activity. The coded design activities were: problem definition (PD), gathering information (GATH), generating ideas (GEN), modeling solutions (MOD), feasibility analysis (FEAS), evaluation of alternative solutions (EVAL), making decisions (DEC) and communicating the design (COM). After coding a transcript the two coders met to compare results, record the initial reliability of the coding and, if an initial 70% reliability level was met, negotiate disagreements to consensus. If the initial inter-rater reliability level for a transcript was below 70%, the transcript was recoded. The coders achieved an average reliability of 81% on the Ping Pong problem protocols and 83% on the Street Crossing protocols.

We entered the codes into a software package called MacSHAPA (Sanderson, Scott, Johnston, Mainzer, Watanabe and James 1994). Using the software we then printed timelines of the coded data for each of the subjects. This enabled us to compare how different subjects spent their time. Example timelines are included in Figure 1 in the results section.

Part Three: Classify subjects in terms of extent of change
By comparing the timeline representing the freshman performance to the timeline representing the senior performance, we investigated changes in participants’ design processes. In a number of the comparisons, we observed a multifaceted pattern of change in that the senior performance differed from the freshman performance on a number of dimensions (e.g., number and frequency of transitions, extent of progression to the later design activities, and amount of time spent solving the problem). We called this pattern simply “change.” In other cases, the process changed but primarily because the amount of time increased dramatically. We labeled this pattern “more of the same.” We also noticed instances where the senior design process looked remarkably similar to the freshman design process. We labeled this pattern “no change.” Finally, for one participant we noticed a pattern of “simplification,” characterized by fewer design activities or fewer and less frequent transitions in the design timelines provided by the participant as a senior. The quality of product score was not used in this classification of change.
Using these four categories of change, we categorized each freshman-senior pair of timelines. Because our data consists of 18 subjects each solving two problems, we ultimately categorized 36 pairs of timelines. The process of categorization began with four coders classifying each pair of timelines. The initial inter-rater reliability was 72%. We arbitrated the cases where only one coder disagreed (three of the four coders had assigned the same category) by negotiating the coding until consensus. For the other cases, two coders reclassified the timelines and then discussed them until an agreement was reached on the classification.

Results

Table 1 shows the distribution of participants in the change categories. In the table, C represents change, M represents more of the same, N represents no change, and S represents simplification. As the data in the table suggest, we found that the design processes of most participants changed from the freshman to the senior year. We also found that some participants displayed change on one problem but did not display change on the other. We identified only one instance of simplification.

In the remainder of this section, we illustrate the patterns of change through case studies. Figure 1 presents results from four participants that illustrate each of the four patterns of change. The freshman results are presented on the left and the senior results are presented on the right. In addition to including the timelines, the figures include actual values for the quality score (maximum score is 3.618), the number of transitions, and the total time engaged in design. All timelines in Figure 1 represent participant performance on the Ping Pong problem.

Case study 1: Change

The timelines in Figure 1a represent a participant whose senior design process differs from the freshman design process on many dimensions. The participant as a senior (a) received a higher quality score, (b) spent more time solving the problem, and (c) had more transitions among design steps. Additionally, this participant as a senior progressed farther into the design process, specifically by spending much more time addressing issues of feasibility and spending some time in the decision and communication steps. While the amounts of time that this participant spent in the final two steps was very small it is still notable that the participant reached these steps. Only 16% of the participants from the full dataset spent time in decision, and only 15% spent time in communication. For these participants who did spend some time in these steps, the average amount of time spent in decision was 11.5 sec and the average amount of time spent in communication was 6.6 sec. Finally, the participant for Case Study 1 also demonstrated explicit “generating” (GEN) behavior, behavior that was absent from the freshman design process.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Ping Pong Problem</th>
<th>Street Crossing Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>D</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>E¹</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>F</td>
<td>M</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>M</td>
<td>C</td>
</tr>
<tr>
<td>H</td>
<td>M</td>
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<tr>
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<tr>
<td>K</td>
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<td>C</td>
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<tr>
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<td>M</td>
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<td>N</td>
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<td>C</td>
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<tr>
<td>O¹</td>
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<tr>
<td>P</td>
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<tr>
<td>Q</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>R¹</td>
<td>S</td>
<td>M</td>
</tr>
<tr>
<td>Change</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>More of the Same</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>No Change</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Simplification</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

¹ Participants E, L, O, and R are the subjects of Case Studies 1, 2, 3, and 4 respectively.

Table 1: Categorization Results
Case study 2: More of the same
The timelines in Figure 1b represent a participant who spent dramatically more time as a senior, but whose design process did not seem qualitatively different from his/her process as a freshman. In looking at the figure, we see that this participant as a senior (a) received a slightly higher quality score, (b) spent more time solving the problem, and (c) had more transitions among design steps. However the frequency of transitions did not change. Additionally, this participant did not progress any farther into the design process. It is as if this participant is simply repeating the same general process used as a freshman, but spending much more time.

Case study 3: No change
The timelines in Figure 1c represent an instance of no change. As a senior this participant (a) received a higher quality score, but (b) spent the same amount of time solving the problem, (c) had the same number of transitions among design steps, and (d) did not progress any farther into the design process. Concerning the progression finding, the participant displayed more feasibility behavior as a freshman than as a senior but displayed more gathering behavior as a senior than as a freshman.

Case study 4: Simplification
The timelines in Figure 1d represent an instance where the design process seems to have simplified over time. We note that the participant as a senior (a) did receive a higher quality score and (b) spent more time solving the problem, but (c) had fewer transitions among design steps, and (d) did not progress any farther into the design process than he/she had as a freshman. While the participant displayed more decision behavior as a senior than as a freshman, the participant also displayed more evaluation as a freshman than as senior. Overall, the participant spent time in more design steps as a freshman than as a senior.

Discussion
Our over-arching goal is to understand what contributes to design knowing and learning in engineering. With our current study we are trying to understand the acquisition of design expertise in engineering students. Earlier we identified several specific questions that interest us. Based on our results, we offer some tentative answers.

What does change look like for individual students? These results suggest that change may look quite different for individual students. In our analysis, we found that five participants’ design processes changed on multiple dimensions on our first problem while eleven participants’ design processes showed this kind of change on the second problem. We were also able to distinguish three other patterns for characterizing freshman to senior change in design processes.
Figure 1: Example Timelines Illustrating Patterns of Change. From top to bottom, the figures illustrate (A) change, (B) more of the same, (C) no change, (D) simplification. In these timelines, the x-axis represents time and the y-axis corresponds to design activities used in the coding scheme. The location and width of each tick mark indicates the starting time and duration of an activity, respectively.
Do all students exhibit change in design process? Twelve of the eighteen participants displayed multi-dimensional change on at least one of the two problems, and most participants had some form of change. We are intrigued by the one instance of simplification. However, we also found that three participants had design processes characterized as “no change” for both problems.

Is individual student change in design process consistent across problems? These results suggest that design performance may be different across design problems, and also that change may differ across problems. As Table 1 shows, half of the participants displayed the same pattern of change for each problem while the other half had different patterns of change across the two problems (for example, participant M displayed a pattern of “more of the same” on both problems whereas participant F displayed two different patterns—“more of the same” on Ping Pong and “change” on Street Crossing). This is consistent with our analysis of the full dataset (all 65 participants). For example, we found that more students engage in evaluation behavior on the second problem than on the first (Cardella, Atman, Adams and Turns 2002).

Is individual student change in design process consistent across different measures of design performance? In our work, we have used a variety of measures to characterize design performance. These measures have included final quality, total time, number of transitions among design steps, and progression to later stages of design. As our coding scheme suggests, student change may not be uniform across these different measures. For example, in the instance of “more of the same” described in case study 2, the participant’s performance changed in terms of quality score and amount of time spent on the problem, but not in terms of complexity of the process. These results suggest that the different measures may provide different insights into change in design ability.

Can various patterns of change be identified? As our coding scheme illustrates, it is clearly possible to identify various patterns of change. Our codes of “change”, “more of the same”, “no change” and “simplification” represent such patterns. In our upcoming work, we will be gaining increasing precision with such efforts to categorize and characterize the change exhibited by these subjects. This work will put us one step closer to understanding what contributes to the acquisition of design expertise.

Concluding remarks
This study attempted to characterize levels of change in engineering design expertise. We see this as a first step in understanding the acquisition of design expertise. We saw that most students acquired some expertise as a result of their engineering education as evidenced by change in their design process behavior. We were able to answer our initial questions regarding change and identified features associated with skill acquisition in design—an increased amount of time devoted to solving the design problem, an increase in number of transitions between design activities, progression into the latter steps of the design process and an increase in product quality. These features are consistent with our findings from previous studies.

The results from this study suggest the need to unpack overall change into compact dimensions for further analysis. We still need to address the question of why some students exhibited change on some measures but not on others. Another question that is raised is how some students were able to invoke a sophisticated design process as part of their freshman performance. How did some students acquire some level of expertise prior to their engineering education?

While the current analysis does not clarify how an engineering education may have contributed to the acquisition of design expertise, we have shown that student design processes do change after that education. As future studies further explore the acquisition of design expertise, we may begin to see the answers to these questions.
Acknowledgements

This work was supported in part by grants from the GE Fund and NSF grants DUE-9254271, RED-9358516, DGE-9714459 and EEC-9872498. We would like to gratefully acknowledge the students who participated in the study, and the students who helped us to code the protocols, specifically Jacob Burghardt, Louise Cheung, Jennifer Chin, Julie Christianson, Cathie Scott, Jennifer Temple, Bettina Vuong, Robert Tai, Eddie Rhone and Alison Schwerzler.
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A critical analysis of John Gero’s function-behaviour-structure model of designing

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Abstract

According to John Gero’s (1990) function-behaviour-structure model of designing, designers transform in three steps desired functions into a design description of an artefact that can perform these functions. Firstly, designers transform the functions into required behaviours of the artefact. Secondly, these required behaviours are transformed into a description of the structure of the artefact. And thirdly, designers transform this description of the structure into the design description that tells how the artefact can be manufactured. In this paper I present and review Gero’s model of designing and show that a precise understanding of this model depends on the precise meanings of the notions function, behaviour and structure. I consider three attempts to characterise functions, behaviours and structure of artefacts and assess how these characterisations affect the model. Also I consider an elaboration of the model by Rosenman and Gero (1998).
A critical analysis of John Gero’s function-behaviour-structure model of designing

Introduction
In this paper I give a critical analysis of John Gero’s (1990) function-behaviour-structure model of designing. An attractive aspect of this model is that it breaks up designing in distinct steps, and that it gives a characterisation of the knowledge used in designing. Gero takes designing as a process in which functions are transformed into a design description of an artefact that can perform these functions. A designer makes this transformation according to Gero in three steps. Firstly, he or she transforms the functions into required behaviours of the artefact. Secondly, these required behaviours are transformed into a description of the structure of the artefact. And thirdly, if this description of the structure is satisfactory, the designer transforms it into the design description that tells how the artefact can be manufactured. The knowledge a designer uses to make these transformations is by Gero characterised as knowledge collected by the designer during earlier (alike) design tasks. This design knowledge is brought together in what Gero calls design prototypes. A less attractive aspect is that a precise understanding of Gero’s model depends on the precise meanings of the notions function, behaviour and structure and that Gero initially did not properly lay down these meanings. It is therefore not that clear what Gero initially meant with the distinct steps of his model.

In this paper I present and review Gero’s model of designing. I consider three attempts to characterise functions, behaviours and structure of artefacts and assess how these characterisations affect the understanding of the model. Also I consider briefly an elaboration of the model by Michael Rosenman and Gero (1998).

I start by sketching Gero’s (1990) model. Then I discuss what Gero initially had in mind when speaking about functions, behaviours and structure of artefacts. Thirdly, I consider two proposals for more precise definitions of functions, behaviours and structure. One is by Robert Cummins (1975), the other by Rosenman and Gero (1998). I argue that these characterisations of functions, behaviours and structure change the understanding of the model considerably: from Gero’s initial characterisation it follows that the knowledge needed to make the different steps of Gero’s model cannot be merely scientific knowledge, whereas Cummins’ definitions and those of Rosenman and Gero seem to allow that scientific knowledge is sufficient for making these steps. Fourthly, I describe Rosenman and Gero’s (1998) elaboration of Gero’s (1990) model. By this elaboration, designing is a process in which human purposes are, via functions and behaviours, transformed into a description of the structure of artefacts that can be employed to achieve the purposes. This elaborated model introduces new steps in designing, namely, transformations between purposes and functions, and decompositions of purposes, functions and behaviours. These new transformations require that design knowledge is again more than just scientific knowledge. I end by analysing the new purposes-functions transformation by means of the description of designing proposed by Houkes, Vermaas, Dorst and De Vries (2002).

Gero’s model of designing
In Gero (1990) designing is characterised as a process in which desired functions $F$ are transformed into a design description $D$ of an artefact that can perform these functions. A design description of an artefact consists here of information needed for manufacturing the artefact. Gero analyses this design process and assumes that there do not exist transformations $F \rightarrow D$ that translate functions directly into a design description. He thus rejects the possibility to model designing as a process in which designers directly arrive at design descriptions on the basis of the desired functions. A model $F \rightarrow S \rightarrow D$ according to which designers firstly transform functions $F$ into a description of the structure
of the artefact and then into a design description, is rejected as well; Gero assumes that direct transformations $S\rightarrow D$ exist in general, but that direct transformations $F\rightarrow S$ are not.[1] Instead, Gero comes up with a model of designing in which $F$ is transformed indirectly to $S$. This indirect transformation makes use of a detour via the behaviours $B$ of artefacts. Spelled out, Gero’s model is as follows. Firstly, designers transform the functions $F$ into required behaviours $B_r$ of the artefact.[2] This step $F\rightarrow B_r$ is called formulation. Secondly, designers transform these required behaviours into a candidate structure $S$ of the artefact. This step $B_r\rightarrow S$ is called synthesis. Thirdly, it is checked what behaviours $B_a$ this candidate structure actually exhibits. This step $S\rightarrow B_a$ is called analysis. Fourthly, designers compare these actual behaviours with the required behaviours, $B_r\rightarrow B_a$, which is called evaluation. Finally, if the comparison is satisfactory, the candidate structure is transformed into a design description of how the artefact can be manufactured. This final step $S\rightarrow D$ is called production of design description. Given that the evaluation step $B_a\rightarrow B_r$ yields a satisfactory result, Gero’s model can thus be taken as consisting of the following sequence of transformations:

$$F\rightarrow B_r, \quad B_r\rightarrow S, \quad S\rightarrow B_a, \quad B_a\leftrightarrow B_r, \quad S\rightarrow D$$

Figure 1: Gero’s model of designing

The evaluation step $B_r\rightarrow B_a$ may also result in the rejection of the candidate structure $S$. This amounts to iteration: after the evaluation the process restarts with a new synthesis step $B_r\rightarrow S'$ yielding a new candidate structure $S'$, or continues with a reformulation step $B_r\rightarrow B_r'$ yielding new required behaviours $B_r'$ and/or new functions $F'$. In the first case, designing continues with the step $S'\rightarrow B_a'$. In the second case, designing may start all over again with the step $F'\rightarrow B_a'$.

Gero’s model simplifies designing by suggesting that designers transpose directly a desired function $F$ into a behaviour $B_r$, and then into one chunk of matter with structure $S$. A more reasonable description is that the desired function is firstly decomposed into a set of subfunctions and that these are transformed into a set of required behaviours. These behaviours may then be decomposed themselves into a set of subbehaviours, and these subbehaviours are transformed into components of an artefact with specific structures. These decomposition steps are part of Rosenman and Gero’s (1998) elaboration of Gero’s model of designing, which is presented in the second half of this paper.

Design knowledge according to Gero

How do designers manage to make the different transformations and derive from desired functions, the behaviours, the structure and the design description of an artefact? Gero’s (1990) general answer to this question is that designers proceed by employing what Gero calls design prototypes. A design prototype associated with a particular design process, brings together all the requisite knowledge appropriate to that particular process. It schematises knowledge from alike design cases about the functions, behaviours and structure of artefacts (relevant to the design process) and their relations in terms of, for instance, the dependencies between variables of functions, behaviours and structure. The design prototypes available to a designer originate from his or her own experiences with earlier design tasks. But despite this personal nature of prototypes, Gero suggests that ‘like-minded’ designers will tend to agree on their general content.

Designing using these prototypes goes then as follows: A designer begins with the functions desired by a client. These functional requirements (plus other behavioural or structural requirements the client may have) are used to retrieve potentially useful design prototypes, that is, prototypes that schematise knowledge about designs that have those functions (and satisfy those possible other requirements). These prototypes represent what the designer remembers when he or she examines the client’s requirements. In this way the designer acquires information about the directions the
design process can lead. It facilitates the formulation step $F_B$, by providing behaviours consistent with the desired functions. And it introduces candidate structure of the artefact needed for making the synthesis step $B_rS$. Also it helps guiding the analysis step $S_B$, because prototypes indexed by a given structure $S$ indicate the more regular behaviours $B_r$ that structure is used for in designing. The reformulation step $B_rB_r',&F'$ is supported by prototypes because prototypes indexed by a given behaviour $B_r'$ yield information about possible alternative functions $F'$ linked to this behaviour $B_r'$. That is, prototypes at least enable the transformation $B_r',_F'$ part of reformulation.

Gero’s claim that designers use knowledge in the design process they have collected during earlier design tasks, is primarily a claim about how designers acquire their knowledge. It implies that they acquire design knowledge only by designing, or, less strictly, by designing and by taking in knowledge other designers have acquired while designing. Gero’s claim is liberal about the types of knowledge that can become design knowledge: any bit of knowledge that can play a role in a design task can become design knowledge. The claim thus does not impose some kind of constraint or upper bound on design knowledge. On the other hand, design knowledge should enable designers to make the different steps discerned by the model. It should therefore minimally consist of knowledge that enables the designer to transform function into behaviours, behaviours into structure, and vice versa. Design knowledge may, for instance, consist of experiential trial-and-error knowledge collected by craftsmen. In our modern times design knowledge consists of all types of knowledge, ranging from design skills to pure scientific knowledge, and from technological knowledge about operational principles, fabrications techniques and norms, to commercial knowledge.

In the remainder of this paper I now consider the following rather academic question: Can design knowledge, taken as that knowledge that enables designers to transform functions into structure of artefacts, in principle consist of solely scientific knowledge? It is not my intention to argue that designers indeed do or can design on the basis of only scientific knowledge, nor to argue that Gero assumes that this is the case.[3] I merely use this question as a tool to analyse Gero’s model of designing. As I have said, a precise understanding of Gero’s model depends on the precise meanings of the notions function, behaviour and structure. Let’s therefore consider attempts to characterise these notions.

**Gero’s original characterisation of functions, behaviours and structure**

Gero (1990) does not give explicit definitions of what he means with the notions function, behaviour and structure of artefacts; he limits himself to giving examples of functions, behaviours and structure of a window. Functions of a window are the provision of daylight, the control of ventilation, and the provision of view. Behaviour is light transmission, ventilation restriction and view transmission. And the structure of a window consists of the dimensions of the glazing and the frame. Most of these examples suggest that function, behaviour and structure are all physical concepts. Some examples, however, counter this suggestion. The function ‘provision of view’ and the behaviour ‘transmission of view’ seem to introduce concepts that fall partly outside the domain of the natural sciences and to refer to more human related or intentional concepts as well.

In Gero and Rosenman (1990) more examples of functions, behaviours and structure of artefacts are given, and these confirm this latter conclusion. Gero and Rosenman write that functions of artefacts may refer to the goals associated with artefacts. The goal of a shelter may, for instance, be that it is portable. Examples of behaviours are ‘that the portable shelter can be erected within a specific time span’ and the ‘security’ and ‘costs’ of a door. ‘Goals’, ‘times to erect a shelter’, and ‘costs’ are clearly concepts that fall outside the domain of the natural sciences.[4]

By these characterisations of functions, behaviours and structure, it is plausible that scientific knowledge is not sufficient for designing. In order to make, for instance, the formulation step $F_B$, designers sometimes have to be able to transform the goal ‘portability’ of a shelter into a required
maximum time to erect that shelter. And since these features of artefact are not fully physical concepts, science cannot provide for the knowledge sufficient for making this transformation. Hence, designers need to draw from other sources of knowledge as well.

A characterisation of functions, behaviour and structure by means of Cummins

If one tries to be more precise about what is meant by functions, behaviours and structure of artefacts, structure probably does not yield too much difficulty: the structure of an artefact refers to the materials it consists of including the topology and the geometry of these materials. The definition of function and behaviour is, on the other hand, more problematic. For defining functions one may take one's recourses to philosophy because there much work has been done on the conceptual analysis of functions. One, for instance, could turn to Robert Cummins' (1975) theory of functions. If one does so, the understanding of Gero's model changes considerably.

In Cummins' (1975) theory the functions of a system — e.g., biological organs, human behaviour, artefacts — are those capacities of the system that figure in an explanation of a capacity of a larger, containing system. For instance, the propellers on a plane have the function to provide thrust because they have the capacity to provide thrust and because the plane's capacity to fly is in part explained by this capacity of the propellers to provide thrust. And the heart has the function to pump because it can pump and this capacity explains the capacity of the circulatory system to transport oxygen, waste, \textit{et cetera}, through the body. Capacities of material systems are on their turn taken by Cummins as the \textit{physical dispositions} of those systems. Physical dispositions are properties of systems that manifest themselves conditional on specific antecedent occurrences: when a system has the disposition breakable, it falls to pieces conditional on that it hits a hard object; a propeller has the capacity to provide thrust if it is rotating and provided with fuel. If now the behaviours of an artefact are identified with these physical capacities or dispositions of an artefact, one obtains a clear set of definitions. The structure of an artefact refers to the materials the artefact consists of, and to the topology and the geometry of these materials. The behaviours of an artefact refer to the ways in which the artefact reacts physically to physical occurrences. And the functions of the artefact refer to those behaviours that figure in explanations of behaviours of larger systems that contain the artefact.

A consequence of this set of definitions is that Gero's model simplifies considerably. For instance, the formulation step $F \rightarrow B$, becomes trivial: the desired functions $F$ become identical to the required behaviours $B$: both refer to the same dispositions of the artefact to be designed. (Cummins' definition of function requires that this disposition figures in an explanation of a disposition of a larger system that contains the artefact. At the end of this paper I describe how this disposition and larger system can be chosen.) A second consequence is that scientific knowledge seems almost sufficient to making the other steps in Gero's model. Both behaviour and structure are now physical notions. Hence, the analysis step $S \rightarrow B_a$ can in principle be made by deduction from scientific laws, and synthesis $B_r \rightarrow S$ can in principle be made by abduction from these laws. Evaluation $B_a \rightarrow B_r$ is simply a logical comparison. The only role non-scientific knowledge still can play is to provide for the means to cleverly choose the laws used in the analysis and synthesis steps, and for the transformation $B_a \rightarrow B_r'$ in the reformulation step $B_a \rightarrow B_r' \& F'$ (the $B_r' \& F'$ part of reformulation is again trivial).

An obvious response to this conclusion is that one thus clearly should not adopt this set of definitions if one wants to properly understand Gero's model of designing. However, as I show next, Gero himself seems to accept in Rosenman and Gero (1998) definitions that come close to Cummins'.
**Rosenman and Gero’s characterisation of functions, behaviour and structure**

In Rosenman and Gero (1998) Gero’s model of designing is revisited, and now definitions of functions, behaviours and structure of artefacts are given. In the definition of structure, a difference is made between homogeneous and complex artefacts: the structure of an artefact that consists of one homogeneous element is the artefact’s material arrangement; the structure of an artefact that consists of a complex of homogeneous elements includes the identification of the elements of the artefact, the material arrangement of these elements and their connectivity. The behaviours of an artefact are defined as the artefact’s actions or processes in response to given circumstances of the physical environment. And the functions of an artefact are the results of those actions or processes of the artefact in response to the physical circumstances (i.e., the results of the artefact’s behaviours).

By these definitions, functions, behaviours and structure all are physical concepts. The structure of the artefact refers to the physical make up of the artefact including its topology and geometry. The artefact exhibits by its structure certain physical responses to circumstance in its physical environment, and these are the behaviours of the artefact. These physical behaviours effect certain results, and these are the functions of the artefact.

When Rosenman and Gero’s definitions are compared to those developed on the basis of Cummins, one can conclude that the definitions of behaviours and structure are basically the same, and that those of functions differ on two points. Firstly, Rosenman and Gero take a function as the result of a behaviour, whereas in Cummins a function refers to the behaviour as a whole. Secondly, Cummins is much more selective than Rosenman and Gero: by Rosenman and Gero all possible behaviours of an artefact yield functions of those artefacts (artefacts thus have many functions in addition to those for which they were designed), whereas by Cummins only those behaviours that figure in explanations are functions.

The consequences of Rosenman and Gero’s definitions for Gero’s model are now the following. The formulation step $F_B$ becomes an abduction step in which one determines a physical behaviour $B$, on the basis of the result $F$ of this behaviour. The synthesis step $B_S$ also becomes an abduction step in which one determines the physical structure of an artefact on the basis of its physical behaviour. The analysis step $S_B$ becomes a deduction step in which the physical behaviours of a given structure are derived. It thus again looks as if scientific knowledge is almost sufficient to making all the steps part of designing.

This latter conclusion may be challenged because Rosenman and Gero (1998) not only have given precise definitions of function, behaviour and structure but also elaborated Gero’s (1990) model. By this elaboration, which I introduce next, new steps have been introduced that cannot be made by scientific knowledge only.

**Rosenman and Gero’s elaborated purpose-function-behaviour-structure model**

By Gero and Rosenman’s (1990) original examples functions of artefacts were allowed to include goals assigned to the artefact. In their (1998) paper they separated functions and goals by identifying the purposes of an artefact as distinct to its functions. The general outlook on designing is that humans exist in a natural physical environment and operate in a socio-cultural environment. This latter environment prescribes values and goals and establishes together with the former environment the needs of humans. In order to satisfy these needs humans create intentionally artefacts. Rosenman and Gero (1998) now define the purposes of an artefact as the answers to the question of why the artefact does what it does, or what it is for. That is, the purposes of an artefact are the needs of humans that can be achieved with it. By this outlook designing becomes a process
that transforms purposes into a design description of artefacts with which those purposes can be achieved.

Rosenman and Gero’s elaborated model of design is now Gero’s original model modified in the following way: Firstly, in order to incorporate purposes, they introduce two new steps. The first step is one in which required purposes are transformed into required functions. This step \( P_r \rightarrow F_r \), together with the original formulation step \( F_r \rightarrow B_r \), is called problem formulation. The second step is one in which the actual functions are interpreted for purposes. This step \( F_a \rightarrow P_a \) is called realisation of utility. Secondly, Rosenman and Gero make a more systematic distinction between what is required and what is actual; they not only differentiate between required and actual behaviours, but also between required and actual functions and between required and actual purposes. Thirdly, they consider explicitly the decomposition of purposes, functions and behaviours into subpurposes, subfunctions and subbehaviours, respectively. Fourthly, Rosenman and Gero seem to drop the distinction between a description of the structure of an artefact and a design description that tells how the artefact can be manufactured. Fifthly, the analysis and evaluation steps are made more general. Analysis now consists of the transformation \( S \rightarrow B_a \rightarrow F_a \). And evaluation consists of a comparison of the actual and required behaviours, functions and purposes.

The extended model for designing can be captured by the following sequence (I have omitted steps which represent the decomposition of purposes, functions and behaviours):

\[
P_r \rightarrow F_r \rightarrow B_r \rightarrow S \rightarrow B_a \rightarrow F_a \rightarrow P_a \rightarrow B_a \rightarrow F_a \left( B_a, F_a, P_a \right) \leftrightarrow \{ B_r, F_r, P_r \}
\]

Figure 2: Rosenman and Gero’s elaborated model of designing

The evaluation steps can lead to acceptance of \( S \) as the structure of the artefact or to reiteration via a new synthesis step \( B_a \rightarrow S' \) or via reformulation \( B_a \rightarrow B', F_a ', P_a ' \).

Rosenman and Gero again speak about design prototypes that capture the knowledge that enable designers to make these steps. They seem to hold that these prototypes include knowledge about the decomposition of functions and behaviours. But they seem not to expand prototypes in such a way that they also include knowledge about the two new steps \( P_r \rightarrow F_r \) and \( F_a \rightarrow P_a \). Hence, the way in which designers make these purpose-functions steps is left mysterious; Rosenman and Gero (1998) only characterise these two new steps as teleological reasoning (for a philosopher, intentional reasoning) whereas all other steps are characterised as physical or causal reasoning.

Let’s again return to the question of whether scientific knowledge suffices to design. Function, behaviour and structure are physical concepts by Rosenman and Gero’s (1998) definitions. Hence, the steps \( F_r \rightarrow B_r \rightarrow S \rightarrow B_a \rightarrow F_a \rightarrow P_a \) can in principle be made on the basis of scientific knowledge. But purpose is an intentional concept. The new transformations \( P_r \rightarrow F_r \) and \( F_a \rightarrow P_a \) thus fall partly outside the domain of science, yielding the conclusion that designers, when designing, need to draw also from other knowledge sources. The same conclusion holds for the decomposition of purposes into subpurposes. The decompositions of functions and behaviours, on the other hand, fall again in the domain of the natural sciences, and can therefore in principle be made on the basis of scientific knowledge. Hence, by the inclusion of the concept purpose Rosenman and Gero’s (1998) model again rules out that design knowledge can consist of scientific knowledge only.

**From purposes to functions: plans**

The problem formulation step \( P_r \rightarrow F_r \) in Rosenman and Gero’s (1998) elaborated model may be analysed by means of the description of the design process as developed by Houkes *et al.* (2002). In this latter description it is assumed that the design process is primarily a process in which plans are
developed which users can carry out to achieve specific purposes. These plans consist of a series of considered actions where some of these actions typically involve the employment of artefacts. It is not claimed by Houkes et al. that the design process is concerned mainly with developing plans for users — designers are of course most of the time occupied with designing the artefacts that are used as part of the plan. Instead it is claimed that, conceptually speaking, the development of plans comes first, and the designing of the artefacts part of these plans comes second.

Spelled out in more detail (and tailored to the model of Rosenman and Gero (1998)), designers start with required purposes $P_r$. Then they develop a user plan $U$ that consists of a series of considered actions $\{A^i\}$ for which holds that when they are carried out by users, the required purposes are achieved. This plan $U$ is called a user plan because it is a plan developed for users by designers (although, of course, users can also develop their own user plans). The actions $\{A^i\}$ part of the user plan, are to result in a specific state of affairs and may involve the use of artefacts. The functions of an artefact used within an action $A^i$ are now defined as those physical dispositions of the artefact that explain that the action $A^i$ results in its specific state of affairs (here Cummins’ (1975) theory of functions is adopted: the artefact is taken as part of the action $A^i$ and the disposition of this action to result in a specific state of affairs is the disposition that is to be explained by the artefact its functions). To give an example, assume that the required purpose is to have a bottle of milk warm enough to feed a baby with. The plan can then consist of the following three actions: put a bottle of cold milk in a container with warm water, wait a couple of minutes, and take the bottle out. The container of warm water used in the second action has heating up the bottle of milk as one of its dispositions, and this disposition explains that this action results in a warm bottle of milk. Hence, the function of the container is to heat up the bottle of milk.

The formulation step $P_rF_r$ can thus be analysed as consisting of a planning step $P_rU=\{A^i\}$ and a function determination step $A^iF_r^i$. The concepts of purposes, plans and actions are not physical concepts, hence it is clear that these transformations of purposes into user plan and actions into functions cannot be made on the basis of scientific knowledge only. Other knowledge about, for instance, human plans and actions, has to be invoked as well.

Conclusions

According to Gero’s (1990) original function-behaviour-structure model designing is a process in which required functions are transformed into design descriptions of artefacts via the behaviours and structure of those artefacts. A first conclusion is that given Gero’s original characterisation of the concepts function, behaviour and structure, scientific knowledge does not give sufficient means to designers to make these transformations since by that characterisation, functions and behaviours of artefacts are not physical concepts. Secondly, attempts on the basis of Cummins (1975) and by Rosenman and Gero (1998) to make Gero’s model more precise by defining the concepts’ function, behaviour and structure, yield that these concepts are physical concepts. It follows that scientific knowledge is now in principle almost sufficient for designing. Hence, these attempts changed the understanding of Gero’s model considerably.Thirdly, Rosenman and Gero (1998) have elaborated Gero’s model to a purpose-function-behaviour-structure model in which designing is a process in which required purposes are transformed into design descriptions of artefacts via the functions, behaviours and structure of those artefacts. This elaborated model adds transformations between purposes and functions to Gero’s original model, and it can be argued that science does not give the means to make these transformations since purpose is not a scientific concept. Hence, scientific knowledge is again not sufficient to design, although it still is almost sufficient for transforming functions to structures. Fourthly, the transformation of purposes into functions can be analysed by Houkes et al. (2002).
Acknowledgements
It is a pleasure to thank Kees Dorst, Wybo Houkes, Jeroen de Ridder, and especially Larry Bucciarelli for helpful discussions and comments. Research for this paper was part of the program ‘The Dual Nature of Technical Artefacts’, which is supported by the Netherlands Organisation of Scientific Research (NWO) and research efforts by the Technè group.

Footnotes
[1] More precisely, Gero assumes that direct transformations $F \_S$ exist occasionally, but that it is not considered designing if one uses such transformations.

[2] Gero (1990) uses a different terminology and notation. The actual behaviour of an artefact with structure $S$ is denote by $B_s$ and the required behaviour is called the expected behaviour and is denoted by $B_e$. The present terminology and notation conforms to the terminology used in Rosenman and Gero (1998).

[3] Gero (1990) gives a list of types of knowledge design knowledge consists of, and it seems evident that this list contains more than scientific knowledge.

[4] Gero and Rosenman’ (1990) examples of the structure of artefacts all fall within the domain of science.

[5] I here assume that science provides with ample laws.

[6] Rosenman and Gero (1998) sometimes discern ‘socio-cultural’ aspects of functions, behaviours and structure. These aspects refer to the interests of designers to pay attention to some functions, behaviours and structural features of the artefacts, and to ignore others. For instance, designers pay attention to only those functions of artefacts that are considered to be relevant for its prospective use. And they describe only those features of the structure of an artefact that enables its manufacturing and the derivation of its relevant actual behaviours. The existence of these ‘socio-cultural’ aspects of the descriptions of functions, behaviours and structure do, however, not force one to take function, behaviour and structure as ‘socio-cultural’ concepts themselves.

References


Ontological depth of the designed object from instrumental reason to reflective judgement

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Abstract

This paper states that in order to contribute to epistemology design must clarify its ontological perspective. The act of designing occupies a position fundamentally different from the natural sciences that examine only things or matter and is also beyond the social sciences that deal with people and their relations. In this paper design departs from the relationship of people and objects. It proposes that within the relationship of subjects to objects, of people to things and thus also of designers to the products they design, there are three different ontological positions. A corresponding epistemological position of people and things is to be found in the notion of a material culture. Because things have become aesthetic objects, they are finalities, not instrumentalities, not means to an end. Kant’s notion of the aesthetic judgement shows a train of thought that links to the conceptual aspects of the design process. Design as a material practice condenses, transforms and materializes concepts. These concepts are singular and not universal. It is a perspective not of ‘things made’, but of ‘things in the making’, a discourse of designing itself and diagrammatic in nature. The notion of concept in design is an own level of analogous reasoning.
Ontological depth of the designed object from instrumental reason to reflective judgement

Ontological perspectives
Despite years of usability research in product design, design research has not really developed a philosophical understanding of the shift in thinking that has taken place. Usability perhaps correctly shifts the focus of attention of design research away from production to consumption and mirrors a similar shift in the fields of sociology and cultural studies. But the relationship of people and things, subjects and objects, entails more than just a shift of sides. At the same time we witness that objects are increasingly becoming part of what is called a ‘symbolic economy’ or an ‘Erlebnisgesellschaft’. This means we face experiencing subjects that are in the midst of things, in and among objects. Designers thus need to imagine and understand the experience of objects by subjects. This experiencing is much more an act of aesthetic judgement by a singular subject than the cognitive reasoning of a universal subject. How does this shift in thinking from universal subject to singular subject take place. It starts with a difference in ontological perspective and in my opinion it would be important for every design research to very carefully look at the ontological position it departs from [1]. This paper postulates that there are three different positions within the relationship of subjects to objects that design is concerned with.

The first ontological perspective is what I would call the Cartesian position of subjects that are (supposedly) in control of objects – the subjects handle purposeful and the objects they create are thought to be meaningless. “The entire problematic of subjects and objects in modern western thought is conventionally, if crudely, traced to Descartes’ ‘cogito’, which sees the world in terms of, on the one hand, human subjects (a mind or consciousness which thinks, knows, believes and ascribes meanings and values to the world) and, on the other hand, objects (the world seen as ‘matter in motion’, as a collection of things which interact, which can be observed and grasped in the form of facts, but which are in and of themselves devoid of subjectivity, of mind or spirit, of meaning or essence).” (Slater 1997: 101). This has generally been the predominant view of the making of things – the epistemic view of engineering. For this position knowledge about things is in the first instance instrumental and objective. Things, products are generally without meaning and people are considered to be universal subjects. It is a world of arguments of ‘pure reason’.

Secondly, out of a certain opposition to the Cartesian point of view another position developed, which is perhaps exemplified most radically by Baudrillard. This position acknowledges the fact that probably more of our daily lives is spent interacting with material objects than interacting with other people. “Strictly speaking, the humans of the age of affluence are surrounded not so much by other human beings, as they were in all previous ages, but by objects.” (Baudrillard 1998:25). He turns the Cartesian position around and departs from the fact that in contemporary society the objects now control the subjects. At first this may seem ridiculous, but if we look more carefully a lot speaks for the fact that we in our daily choices of things are perhaps the victims of fashion, maybe without even realising it. This position developed with the growing awareness of the emerging ‘consumer society’. It influenced the ‘cultural’ turn of sociology and the rise of cultural studies to a dominant field of research on ‘consumption’.

This position has a long and complex history and partly reaches back to Hegel’s Phenomenology of Spirit first published in 1807 as it was offering a way out of the dilemma how objects relate to subjects, how human subjects can know the world of objects, how they can assimilate it intellectually, and how they can know that their knowledge is valid. “The profoundly influential insight of Hegel ..., is that the relation between subject and object is in reality dialectical and interrelated, not external and mechanical. It is a relationship or process of mutual constitution of
subject by object and object by subject. Human subjects actively engage with the object world, transforming, moulding and creating it through their intellectual and practical efforts. In working on the world, individuals and societies recreate it in relation to their needs and projects. Their needs – their subjectivity, their meanings for the world – are thus ‘objectivated’, take material form, in the objects they produce.” (Slater 1997: 102-3). The object world is thus human subjectivity made manifest, but in contrast to non-dialectical, positivistic views the world works back on subjects. In transforming the world we also transform ourselves. The world we have made is indeed objective and becomes the new environment in which we live, by which our subjective experiences are formed and in which we define and refine our needs, desires, projects and plans (Slater 1997).

A third position has lately become more manifest, which states that objects and subjects are both meaningful – perhaps on a sort of ‘equal footing’. Within sociology and communication theory, for example, that until recently only dealt with relations between subjects, a repositioning of the artefact seems to be at stake. It concerns the view that interaction and communication are factually not possible without the mediation of things, of objects (Dant 1999; Schiffer 1999). One of the many aspects of this view is that objects in our present condition of society have increasingly become a part of flows – global flows that comprise of information, of images, of money, of goods and of people that are increasingly being connected and that circulate ever faster (Lash and Urry 1994; Castells 1996). What happens is that there is less and less difference between the nature of these flows: from those of objects (goods) to those of subjects (people). Further, the flows of images through the cable networks increasingly represent objects that are made up of signs, no longer symbols. As a consequence their meaning becomes more aesthetic and less cognitive. This is a change in the condition of objects – in the form of their presentation and therefore also of what they represent – and thus of the way they interact with people. There are more and lengthier explanations for this phenomenon, but the consequence is that objects, things, products take on a new dimension, no longer being able to be subsumed as a particular by a universal and knowing subject. The process of subsuming refers to the way people appropriate things and judge them as in Kant’s Critique of Judgement that we will come back to later.

A material culture based on object form
This ontological perspective of meaningful subjects and meaningful objects has an epistemological body of knowledge that corresponds to our position of subjects and objects. For this the author suggests the notion of a material culture based on object form as the culture of our contemporary society that characterizes the relationship of people to things, products and spaces. It answers to the question how we, under modern social conditions, relate to the thing-like nature of much of our social life. Modern consumption has increasingly become a question of object relations: a question of how human and social subjects with needs relate to things in the world, which tend to satisfy them. Obviously design comes into the picture here and it includes the design of material and symbolic goods, services and experiences. Instead of an idea of consumption as ‘subjects using objects’ I argue that the world of things is really culture in its objective form, it is the form that humans have given the world through their mental and material practices.

A major shortcoming of many theories on culture is that they identify culture with a set of objects, such as the arts in themselves, rather than seeing it as an evaluation of the relationship through which objects are constituted as social forms. Culture is always a process and is never reducible to either its object or its subject form (Miller 1987). For this reason this paper is based on the notion of a dynamic relationship of people and objects. In the same way I want to argue for the idea of a process also of the making of things, the design process. People appropriate objects, but how do ideas ‘get into things’ and what happens with them afterwards? [2]
If we accept that things have ideas, intention in them (what we might call the design process) and that the knowledge of the making (what we might call the production process) is embodied in the artefact, the question becomes: How do we get it out, how can we extract it and what form does this extracted intention take? The hypothesis of this paper is that this intention can only be verified through conceptualisation and that the form therefore is conceptual or diagrammatic. Within the design process exists a level of concepts [3]. These concepts are part of the decision-making process of a project and do not belong to the universality of ‘pure reason’. Instead they are singular, individual concepts that have a similar mode of operating as reflective judgements do for Kant.

**Judgement**

There is, as we have seen, increasing evidence that a particular object, a product is now judged as an aesthetic experience, as part of an event, by a subject that needs to be singular and make its own choices. As subjects become singular and experiencing, a shift from epistemology (universal knowledge) to ontology (existential meaning) is involved. Epistemology logically entails instrumental rationality, because theorein is the understanding of the natural sciences and positivism. Instrumental rationality is thus the use of the scientific rationality of ‘pure reason’. In the natural sciences and in positivism things and social things are reduced to what are more or less ‘variables’ of Newtonian time-space. The Cartesian ‘I think’ is determined by the universalism of the logical categories. Traditionally the epistemological subject would know things according to these categories of classical logic, but, if we follow Kant, then the experiencing subject needs to know things in terms of the ontological structures proper to things themselves. Therefore Lash (1999) states that the experiencing subject is no longer ‘above the world’ in a hierarchical sense of a subject-object relation with things in the world, but is situated in the world ‘among’ objects. Subjects therefore no longer know objects – instead they now experience them. As a consequence the (designed) object gains vastly in status. It comes to take on ontological structure – a structure of meaning. This meaning is not reduced to epistemological and utilitarian functions, but allows the object to be invested with affect, desire, and care, to be lived by and lived with (Lash 1999). For experiencing subjects these objects become finalities, ends in themselves and not instruments, not means to an ends that knowing, universal subjects deal with. Several authors (Lash 1999, Böhme 1999) have lately pointed out how Kant in *The Critique of Judgement* breaks with the notion of universalist individualism for an idea of freedom based on singular individuality. With *The Critique of Judgement* there is evidence for a meaning of being through reflexive judgement of objects, of things – in fact through ‘poesis’ [4].

Much has already been said about the limitations of positivistic, instrumental means-ends type thinking for design (see, for example, Nigel Cross: Designerly Ways of Knowing), but in my opinion these positions do not go far enough. This paper postulates that the only way out of theorein and its instrumental rationality, whose logic determines us to be positivist and utilitarian with regard to things and people is through the notion of poesis. Not through praxis and practical reason or its ethics, but through the notion of reflexive judgement that the problem of the located finality in the aesthetic object leads us to. It is judgement and particularly aesthetic judgement that connects us to the kind of conceptual thinking in the decision making of the design process.

**Aesthetic judgement**

What is judgement according to Kant? A judgement happens every time we think something about something. A ‘judgement’ is a mental act which in some way decides whether a thing is this or that (Burnham 2000). In the Introduction to his *Critique of Judgement* Kant makes a set of distinctions between different types of judgement. First he draws our attention to determinate judgements, which happens when we encounter something well-known from experience and we have a universal rule, principle or law that we can apply to the situation. A ‘determinate’ judgement is one that has a concept in advance. Other people can come along and use the same ‘concept’ that we applied – it
has a certain universal validity. A second type is ‘indeterminate’ judgement, which occurs, when a situation is rather new and no well-known concept can be applied. It is a judgement that creates the concept in the same act as making the judgement. In fact universal judgements of the first sort are rare, because they never have much to say about the particular detail of our real empirical experiences. Thus we constantly need to develop new (empirical) concepts out of given experiences by ‘indeterminate’ judgements. Once developed others can share these judgements – they have wider validity. Then there are judgements of sensual ‘interest’, concerning for example one’s taste for food. This judgement is entirely subjective and it is only valid for the person who makes it. The next type is teleological judgement. Teleological judgement happens when we judge something to have been produced according to an idea of it, seeing something caused by its telos (purpose).

Finally there is aesthetic judgement about things we call ‘beautiful’ (such as art): we do not have a well-known concept in advance and we do not have to form a new concept either, but the judgement takes place by way of feeling. It is as if we are ‘thrown back’ entirely onto our own resources as a thinking subject (Burnham 2000). But these judgements are not entirely subjective – they may have a wider validity; i.e. we can communicate about them. Both teleological and aesthetic judgements are reflective, that means not determined by given concepts and thus do not contribute to a knowledge (of universal subjects).

Kant in his *Critique of Judgement* is very concerned with the fact how such a judgement can happen and what its legislative principle may be. In this paper we are not. Lakoff and Johnson (1999) particularly criticise Kant’s notion of a priori constructions and deconstruct it. Their point is that in conceptual reasoning our minds operate along metaphors that are embodied in ourselves. The substance of their claim about the metaphorical grounding of cognition in our embodied situation is that conceptual structures resemble perceptual ones in interesting and explanatory ways. Imagination is the place where figurative meaning emerges from perception and metaphor is the place in language where this embodiment can be seen (we use metaphorical terms). This is not in contradiction with the part of Kant’s Critique of Judgement that is interesting for us: that aesthetic judgements are reflective and do not proceed by predetermined concepts. What does Kant have to say to us?

In Kant's *Critique of Judgement* there seems to be a train of thought that we can build upon for a hypothesis of the design process. It mainly is the part, where the gap between pure reason and practical reason is referred to and how in aesthetic judgement the faculty of judgement links with reason. Between the epistemological question ‘what can I know?’ of *theorein* and the ethical ‘what should I do?’ of ‘practical reason’ is no bridge except by the position of judgement that asks ‘what may I hope for?’ Kant states that it bridges that in an analogical way (through an ‘as if’ position). Thus the ‘singular’ individual no longer determined can engage in thoughts of a more bricolaging nature in the making of things. This is similar to the bridge that concepts in the design process need to make between the cognitive analytical level that belongs to the problem definition and the resolution of that problem as final form. No ethics or practical reasoning show a way out and in my opinion neither do any references to the praxis of design either.

**The design process**

Thus the idea of design as a material practice - an activity that works in and among the world of things – is also one that condenses, transforms and materializes concepts. This paper argues for a notion of concept as the need for an idea within the field of professional imagination that guides the concrete decision-making process in design projects, which keeps the design together – the concept as a generator of form. But this idea is not final or finished form (yet). Different disciplines operate with different ranges of imagination. Design imagination is fundamentally different from sociological or historical imagination as it has to operate ‘prescriptively’, as it has to generate form, not just descriptively, not just describe existing things. Consequently within the world of objects
exists a rupture between descriptive (design products) and prescriptive (design process) modes of operation. In other words, descriptive discourse in design (i.e., existing design history and theory) has not really led to design methods. My question is: what would it mean for design history and theory to think in relation not to ‘things made’ but to ‘things in the making’? [5]

This perspective of ‘things in the making’ is in this paper understood:
- as a discourse of the process of designing itself (as ‘prescriptive’ mode)
- as connected to a conceptual diagrammatic level of designing

The question that follows is: does an internal discourse of design, of projects and how they were thought exist? Peter Eisenman addresses this in the field of architecture and calls it architecture’s ‘interiority’. “Rarely has architecture theoretically examined its own discourse, its interiority. My work on the diagram is one such examination. It concerns the possibility that architecture can manifest itself, manifest its own interiority in a realized building. The diagram is part of a process that intends to open architecture to its own discourse, to its own rhetoric ….” (Eisenman 1999, 37)

Within a design process the notion of concept may be understood as the generation of a personal, singular idea illustrated by analogies, diagrams, sketches etc. that guide the design process. It helps to make coherent decisions by the designers. These concepts are increasingly being illustrated consciously, but in some cases need to be reconstructed analytically. In the contemporary design process they are often communicated and discussed in an early stage of the project.

Diagrammatic reasoning

In contemporary design processes a conceptual level seems to exist and it operates with diagrams as an intermediary for the negotiation of form. Noting how radically our reasoning differs from the rigorous standards of formal logic, we call it intuitive (Simon 1995). In this context I would like to introduce a scheme that represents the design process as a diagonal movement from immaterial thoughts originating as cultural, artistic ideas to the production of matter, where these ideas need to meet the requirements of production processes and engineering systems. It identifies three main levels within this diagonal movement that all represent design knowledge and praxis. The relationship between these levels is specific for each project, but may also have generic aspects within the oeuvre of one designer or a ‘school’ of designers. My hypothesis is that even if the design process appears as a fluid connection through all three levels, in reality there are large jumps in the kind of reasoning between these levels. These levels appear as:

- a level of analysis and theory. This is a terrain of cognitive theoretical logic, ‘pure’ reason, instrumental rationality and deterministic judgement. This level has grown rapidly in importance. The amount of data that a project is confronted with today show this. Even if we reject the logic of instrumental rationality, it still rules on this level and has to be adopted to as the ‘lingua franca’ of analysis and theory.

- a conceptual level at the edge between the virtual and the real that operates with diagrams as a sort of professional shorthand and that for different reasons (group work, participation) increasingly is developing an own life (generative diagrams, templates etc.). Here reflective judgement rules and instrumental rationality does not. Concepts are connected by analogy, not by pure reason. Within a professional discipline there are specific systems of thought that the concepts will need to relate to.

- a level of final form in which the things or products present themselves in their material form. This has for a great deal been the domain of categories of style and art history.
Although the concept develops out of the analysis of a problem, it does not do so mechanically or automatically [6]. Between analysis and concept in reality a complex ‘creative jump’ occurs. Much of the potential of the diagram as an abstract model (of design) lies between the virtual and the real. The variables in a diagram that emerge from analysis may include both formal and programmatic configurations. A diagram is therefore not so much a thing in itself but a description of potential relationships among elements, not only an abstract model of the way things behave in the world but a map of possible worlds. The diagram has an increased actuality, because professional practice is more and more characterised by providing open-ended solutions through mediating between production and distribution systems and through the participation of new groupings of actors in the design process (for example in mass-customisation).

In the past five years an increased interest in the diagram has led to a series of publications and mentions in conference presentations. In his introduction to Peter Eisenman’s Diagram Diaries Robert Somol (1999) traces the history of the diagram and states about its actuality in architecture that: “In general the fundamental technique and procedure of architectural knowledge has seemingly shifted over the second half of the twentieth century, from the drawing to the diagram.” (Somol 1999: 7). In this conflict it seems as if the conventional drawing is a static tool of the representation of a product (of final form) and the diagram a process tool that is dynamic and flexible. It is particularly this quality of the diagram that points to the kind of thought, the kind of reasoning that it works with and through.
Notes
1 A research needs to answer the question of how its specific research subject relates to the world of theory and knowledge (epistemology), which needs to be based on a statement of what the world must be like (ontology) in order for us to have knowledge of it. Thus the researcher approaches the world (being in the world) with a set of ideas, an ontological framework that specifies a set of questions (epistemology) that are then examined (methodology, analysis) in specific ways (Denzin and Lincoln 1998). In other words in every research there is always an ontological perspective which sees or encapsulates (our being in) the world in a specific sense and there is an epistemological position which suggests that knowledge or evidence of the world can be generated by observing, participating or interpreting certain sources.

2 Dant (1999) provides an interesting view on this question: “The process of cultural appropriation of material things is not reducible either to production or consumption but is to do with a series of types of interactions between people and objects. These interactions with things – touching, making, looking at, talking and reading about, using, storing, maintaining, remaking and so on – are social in that they are learnt and shared within culture. Material objects are physically formed within a culture but are also socially constructed in the ways that they are fitted into routine, everyday practices and ways of life. Culture is embedded and disembedded throughout the life of the object while the processes of production and consumption are organised around economic exchange.”

3 What is a concept generally? Concepts are ideas formed by the process of abstraction and provide categories for storing experience – in our case of projects and their relationship to other projects, their presence in the past. Abstraction is usually defined as the formation of an idea by mental separation from particular instances – in our case abstraction from final project form. Concepts are formed by removing some of the detail of particular instances so that what remains is only the essence of the thing, concentrated on the main, for example, poetic, organizational or technical response to the problem. Concepts make it possible to communicate knowledge and imagination. In addition to allowing to generalize knowledge and imagination and to communicate it to others, concepts give enormous powers of thought. Concepts allow to associate volumes of information (about other projects and cases) with a single idea and to communicate or process this information rapidly whenever we think of it or talk about it. Concepts are often connected by analogy, for example by colour, material, form, type, common experience (such as film, music, literature or bible/religion) etc. (Hatch 1997). It is the ‘conceptual slippage’ of analogical thinking that this paper argues for as the different kind of reasoning necessary for the introduction of the new as a concept for a project.

4 Within the triangle of theorein, praxis and poesis, design research so far has almost always been based on theorein or epistemology and its instrumental reason. Further, a lot of design research increasingly refers to praxis (and its practical reason). This paper focuses not so much on praxis, but on the notion of project and its singularity. It will make a case for the element of poesis and the analogical reasoning of reflective judgement within the design process of a project.

5 This question, first posed by the philosopher William James, was the point of departure for The Pragmatist Imagination conference in May 2000 at Columbia University, New York (Ockman 2000).

6 It is perhaps possible to interpret ‘form follows function’ as a universal concept that operated at an intermediary level between the analysis of functional requirements and the outcome of final form. The problem of such a universal concept is that it works as a ‘modernistic’ meta-narrative of the sort that contemporary postmodernism has rejected. This rejection is a part of a
movement towards a singular individuality of design and also the designer versus the universal judgement and pure and instrumental reason that traditional modernism appealed to.
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Three dimensional models: a study of a virtual aquarium simulation in 3D WWW environments

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Abstract

The purpose of this research is to investigate and propose an expressing method of information making good use of 3-dimensional space. Under the theme of information design on a 3-dimensional space, we treated a virtual aquarium as a subject matter. This research focuses on development of effective methods of designing techniques which can be utilized in making interactive content on the internet through the actual development of "Aqua Project". Focusing particularly on real time 3D graphics, we will propose a representation technique that utilizes words, images, and geometric models all integrated into 3D space. We searched for ways to efficiently structure information, provide an intuitive user interface, and furthermore realize dynamic handling and interactive representation of information. In this research, we have constructed and investigated an experimental model, by the technology of Real Time 3DCG, which can show both of the information on observer's request and the simulated aquatic creatures and their surrounding environment in the virtual fish tank simultaneously in the 3-dimensional space. We have developed and verified "Aqua Place," a web contents of virtual aquarium containing 3-dimensional simulation by VRML and viewpoint technology (web3D technology) within a virtual fish tank. Through this development and verification, we focused on the functions for observation in 3-dimensional space and on the method for revealing information about creatures as a database. In conclusion, it demands an operating condition that makes it possible to observe each individual creature as well as an information design of 3-dimensional ecosystem simulation in a virtual fish tank.
Three dimensional models: a study of a virtual aquarium simulation in 3D WWW environments

This research was conducted under the theme of representation and communication of information in 3-dimensional space. We have constructed virtual aquarium making use of 3-dimensional WWW techniques in order to investigate inevitable functions and tools for our virtual aquarium and to consider the potentiality of the community with using our techniques as well.

In constructing an experimental virtual aquarium, we used VRML (Virtual Reality Modeling Language), which is general 3-dimensional WWW environment at present, and networking environment. The virtual aquarium is realized as an aquarium contents composed of three virtual fish tanks described in 3-dimensional modeling environment with VRML, which are accompanied by the database function providing information for each creature in the tanks, and linked mutually to the web pages described with HTML.

With this structure, we aim to propose a new study environment through the experience, discovery and observation in virtual space by practically operating the interactive environment to access the fish tanks which allow users to move freely in the 3-dimensional space and to access the information for simulated ecosystems and creatures in there.

The following points provide an overview of this research. The most important point in constructing a virtual aquarium on a network is that it is necessary to realize not a mere simulated representation of actual aquarium but to realize the features of VRML 3-dimensional space and the interactive environment of Internet.

One of the aims of this research project is to provide users with new viewpoints for observation without limitations of time and space, which is difficult to get in the real aquarium. In achieving this, we considered the subject under the following three headings: (1) Observer's Point of View; (2) Spatial Sailing Eyesight; and (3) Database Function.

In order to construct contents that can allow the users to experience the observation, we focused on observer's point of view. Generally in the actual aquarium, the mainstream for display is to show water tanks with the simulated model ecosystems of the certain sea areas getting the fish, inhabitants and ecological conditions such as coral of the area together.

It can be regarded that they serve the information centered on "watching" viewpoints in this style of display.

After conducting a survey on visitors' viewpoints in the aquarium, who are observers at the same time, we classified the result into following three groups.

1) Viewpoint for watching
   A viewpoint for looking the water tank as a whole including the surrounding environment and atmosphere of interesting fish and its behavior pattern or relation between other fish and inhabitants.

2) Viewpoint for observation
   A viewpoint for watching a certain fish or inhabitant in the water tank and comparing its peculiarity to others.
3) Viewpoint for studying

A viewpoint for studying far more detailed background information and reference materials than those of their observed result to compare with the subject for analysis.

It is no more necessary to watch the fish or inhabitants through the thick glass in the simulated 3-dimensional virtual fish tank. Users can get the same eyesight as fish to observe freely in the tank as if they sailed in the sea. This "spatial sailing eyesight" provides users with the following viewpoint or ways of observations:

1) Observation from various angles making good use of 3-dimensional virtual spaces
2) Viewpoints for experiencing the trailing and searching
3) The achievement of dynamic and interactive viewpoints for observation

Besides, we also considered that to provide a substantial database function is essential for users’ analytic observation. It is general in the real aquariums that the detailed information related to the subject is provided in the ways of indirect or supplemental, such as illustrated guides, reference books or videotapes. This may raise a question because the visitors cannot get the answer soon if they wonder or discover something while they are watching. In the virtual aquarium, on the contrary, users can use the reference function directly without changing pages or frames they are watching. This function was realized for providing the viewpoint of "studying," by directly linking the 3-dimensional model data of sailing fish and other inhabitants in the tank to the text data and picture data such as names or ecological conditions of them.

Let us now look at our configuration of the models in detail. "Aqua place," the virtual contents we have constructed this time, was constructed with the cooperation of Tokyo Sea Life Park. We considered their displaying aquatic inhabitants and ecosystems as a good model and sampled three water tanks for our virtual fish tank modeling. We also constructed a part for illustrated guide as a reference function, which is a linked library providing the information on the aquatic creatures in each virtual tank such as names and so on. This is useful for realizing the interactive environment that allows users to switch freely on either the virtual fish tank or on library.

This time, we realized the function for "observation" on a basis of standard VRML specification and as for the difficult part for VRML, such as representation of details for fish, was covered by the combination with interactive 3-dimensional WWW environments with viewpoint. The function for "studying" was realized as web contents by the mutual linkage between VRML files and HTML files.
The "aqua place" is, as you see in Illustration 1 “The sitemap of Aqua Place,” composed of following three parts: (1) Virtual fish tanks; (2) Illustrated Guide; and (3) Backyard. (See Illustration 1 “The sitemap of Aqua Place”)

1) Virtual Fish Tanks for Simulation
   This part is constructed by VRML modeling techniques and divided into three virtual fish tanks for simulation: (1) Voyagers of the Sea, A fish tank for Tuna; (2) The South China Sea; and (3) The Indian Ocean.

2) Illustrated Guide
   This is the part of providing information on the aquatic creatures sailing or inhabiting in three kinds of virtual fish tanks, such as names, classifications, characteristics and habitats. In constructing this part, we referred the common illustrated guide for Japanese elementary school children as a basis of information level.

3) Backyard
   This is the part of providing information on our web site, ways to link the download site of VRML browser, operation manual or document of our site.

Here under is the explanation of how to realize the Spatial Sailing Eyesight. The VRML browser serves two kinds of walk through mode called “walk” and “fly” that allow users to move around freely in the 3-dimensional space and subject centered 3-dimensional indication mode called “study.” It also serves the function to move the viewpoint freely by operating the mouse in the virtual space called “plan,” “pan,” “turn” or “roll” and so on. Followings are the conditions defined for movements in the space regarding the feature of each virtual fish tank.

1) "A virtual fish tank for Tuna" simulated the ecological condition of ocean migratory fish, so that there is no definition for seabed or the surface of sea. Therefore, users can move freely with the fly mode in 3-dimensional space of VRML browser.
2) As "The South China Sea" and "The Indian Ocean" simulated the environment of coral or rocky seabed, we defined "walk" mode to move on seabed as a default and to be modified into "fly" mode if it is necessary to move in the space.

Turning now to the point of realization of the viewpoint for observation. Not only for watching the relationship and movement of fish in the whole ecosystem, but with the definition of some other viewpoints, such as looking down from the top, looking up from the bottom, or eyesight of the sailing fish, we realized functions that allow users to change the viewpoint indication by the selection from the menu.

On the other hand, there is the possibility to have an analytic viewpoint for "observation" to pick up a target fish. There are viewpoints provided to observe the target more analytically by closing up a certain fish, observing from various angles or "trailing" to observe a sailing movement of a subject in a fixed frame.

As for the realization of the database function in our virtual aquarium, definition of anchor points for each fish make it possible to indicate the name of a fish or to link the specified web page by pointing with the mouse, so that we realized a handling function for specifying necessary information and referring them directly, which is related to the illustrated guide part which introduces the information on names of fish or on their ecological conditions.

For the moment let us look closely at modeling of the virtual fish tanks for simulation. We constructed our virtual aquarium on the basis of aquatic inhabitants and the ecosystems displayed at Tokyo Sea Life Park.

The first point is on modeling of the aquatic creatures and their fish tank. Modeling execution for fish, rocks or coral was done in the divided group according to the environment of each fish tank. We sampled three water tanks that show abundant kinds of fish among the water tanks of Tokyo Sea Life Park: (1) Voyagers of the Sea, A fish tank for Tuna; (2) The South China Sea; and (3) The Indian Ocean. We also selected the fish and inhabitants that have a characteristic forms and ways of sailing for modeling: six kinds from "A fish tank for Tuna"; seven kinds from "The South China Sea"; and eight kinds of fish and coral from "The Indian Ocean." Here are the names of fish in each fish tank: Katsuwonus pelamis, Thunnus albacares, Thunnus thynnus, Euthynnus affinis, Thunnus alalunga and Mola mola are in "Voyagers of the Sea, A fish tank for Tuna;" Neoniphon samara, Naso vlamingii, Sargocentron spiniferum, Gymnothorax javanicus and Diodon hystrix are in "The South China Sea;" and eight kinds of fish and coral are in "The Indian Ocean." Constructing platform was Windows personal computer and MetasequoiaLE R2.0, which is a standard modeler. WindowsNT was used as a server for data and 3-dimensional WWW and description format was based upon VRML 2.0. These models were converted into VRML format with utility software and were laid in each fish tank.

Second point is how to optimize the complex model. In the case of modeling multiple kinds of models such as a fish tank of an aquarium including fish, coral and rocks, it becomes difficult to execute real time rendering process for enormous polygon data. We have developed "Aqua Pallet," the utility software in order to reduce the amount of polygons and to optimize the form of the polygon itself (See Illustration 2 “The operating panel of Aqua pallet”). This software converts the polygon data that are composed of quadrangle patches made up by MetasequoiaLE into triangular ones and reduces the amount of polygons at the same time. Therefore, we made it possible to realize a complex form with fewer amount of polygons (See Illustration 3 “The reducing the amount of polygons”).
It is also possible to define the texture with using "Aqua Pallet." We can easily specify the texture with the definition of color, coefficient of reflection or diffusion for the model. We also applied the texture mapping to add the marking pattern and texture that are peculiar to the fish. With this process, we made it possible to make up models and to provide specific details of the fish, coral and the rocks.

The next point is on simulation of the sailing. In order to simulate the model fish as if they are sailing (swimming) about in the tank, it is necessary to simulate model of each fish's sailing way. According to their form and ways of sailing, fish are roughly divided into following three groups (See Illustration 4).
Illustration 4: Three groups of the fish

1) Sprinter type (Shape of a round fan, Japanese UCHIWA)
Using whole of flat body and show sudden movements such as acceleration from the slow movement, agile. The fish of this type sails slowly in an ordinary way, but in the case of catching food or sailing away from enemies, they accelerate with a swing of their body or tail fin. Cheilinus undulates is an example of this group.

2) Fin operating type
Fish of this type are good at controlling the complex and close movement of the pectoral fin to stop and turn suddenly. When they are hurrying, they fold their pectoral fins and sail with swinging tail and tail fin. Diodon hystrix is an example of this group.

3) Type of long distance runner (Tail fin operating type with streamlined and flashing surface)
As they cruise the ocean at a high speed, they can cruise with less movement by tail fin. They fit their pectoral, dorsal and pelvic fin to the trunk of the body and sail with swinging of the crescent-shaped tail fin. In reducing speed, they open the fins. Thunnus thynnus is an example of this group.

We made good use of morphing, one of the basic functions of the VRML, in order to realize the above features in the VRML environment. Morphing is a function that connects two polygon models that have the same number of polygons, and forms automatically the intermediate shape between them (See Illustration 5).
Illustration 5: A sample of morphing

In the shape transformation of the animation, generally used are the techniques of a bone animation, sometimes called a skeleton animation, which is to define the frame of the shape to show the transformed outward appearance along with the transformed movement of the frame.

However, it is impossible to define the frame for the modeling in the VRML environment, we developed a utility software based on FFD (Free Form Deformation) method for the shape transformation. This method is hard to occur the twisting, cracking or boring between the adjoining polygons, by transforming the space itself, which defined the 3-dimensional shape (See Illustration 6). Making use of this advantage to represent the movements of fin and tail fin, it becomes possible to simulate characteristic sailing way of each fish, and resulted in three simulation models of fish tanks with kinds of fish (See Illustrations 7,8 and 9).
Illustration 6: Transformation of coordinates by FFD method

Illustration 7: Fish tank of voyagers of the sea
As we aimed to provide an experience of observation in our virtual aquarium, realization of the observation for the details is also an important question. Therefore at the part of illustrated guide, we prepared the embedded window to represent the targeted 3-dimensional model for observation in details. This function is constructed with the basis of 3-dimensional WWW environment of Viewpoint corporation, which can realize the 3-dimensional representing environment by installing a personal plug-in to web browser and can realize interactive 3-dimensional environment that enables to zoom up, zoom out and parallel translation with the mouse operation. The 3-dimensional WWW environment by Viewpoint corporation is a technique that can provide highly qualified 3-dimensional visual images by a description of compact 3-dimensional model data and unique mapping techniques which does not become rough even in the case of enlarging. With this, we have got the model data that is fine and shaped in detail beside the modeling and mapping data for VRML, we achieved the detail representation for observation as is seen in Illustration 10.
With the environmental simulation in the fish tank, it is difficult to represent a certain subject centered in a window or represent a subject in a close up mode, because it moves to follow the sailing simulation. Our mode for observation in Illustrated Guide explained above, on the contrary, can provide the observation in fine detail that we cannot see in the simulating fish tanks. We embedded the 3D view window to the guide page to observe the target freely such as using zooming up or zooming out.

Realization of the above functions enables users to experience the studying process of observation, discovery, studying and investigating, through the action of "watching," "observation" and "studying" by the interactive mouse operation. Followings are the result of investigation on our models.

As we used a standard web browser and describe the 3-dimensional environment and models by VRML, the common 3-dimensional WWW environment, we found out the problems and questions as follows.

1) Problems of representation with HTML
Representing related information in an independent window is suitable for observation one by one, but a new window hides the subject and operation that the users have done on the former window. The operating environment described in HTML doesn't follow the direct and interactive operation.
2) Problems of representation with VRML
The problem for representing the quality of 3D real time rendering
The problem for representing the quality of 3D real time rendering response
The necessity for correspondence with the bone animation when animating the model

3) Functional questions on Viewpoint
The necessity for correspondence with the bone animation when animating the model
The necessity for correspondence to the multi object
The necessity for developing the data converting utility, which should work independently

Considering the questions and problems listed above, we got the subjects as follows for further investigation or to be improved in the future.

1) The subjects related to the representation
Representation of the environment that provides information without taking the eyes off from the subjects
The 3-dimensional ways of representing information that correspond to the 3-dimensional subjects.

2) Viewpoint for observation
Making it possible to control the time axis such as set back, put forward or stop the linear flow of the time.
Taking steps against the decline of quality in representing patterns or details with zooming mode.
Simulating characteristic sailing way of each subject represented by animation.
Simulating to represent the behavior pattern of the fish in the ecosystem of the virtual fish tank.

It is concluded that showing the information within the observed fish tank is effective in expressing the relation between the objects and information, attribute itself of information or background information. On the other hand, it is necessary to conduct a further investigation on the way of showing information and on the types of information varied according to the aims and conditions of observation.

With the VRML, the processing of the 3-dimensional data is executed in the client computer, so that the representing conditions are influenced by the users’ environment. Smooth representation with the various conditions, such as the processing load for animating on the VRML browser, may be the important question to be answered so that it is necessary to have higher techniques for real time rendering or a better representing format of 3-dimensional data.

As for the operating possibility, jumping to other pages by the linkage button is the basic operating steps for interaction. Therefore, to realize an interactive operating environment like getting response for the operation in the same page, it is essential to have original extensions and to introduce new plug-in modules for establishing the unique operating environment such as FLASH or Director. The further investigation is necessary on the points of operating environment in 3-dimensional space and of representing information, including the introducing and development of new interactive environment described above.

Besides, in the case of observation environment for studying, the sorts and ways of indicating the information according to the aims or conditions of observation, become important subjects to be investigated. It is also necessary to investigate the user interface on the basis of reconsideration of
the user model and of representing ways for information to make good use of the features of 3-dimensional space with the model constructed this time.
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Determining the effectiveness of shape manipulations by observing designers at work

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Abstract

Little is known about the effectiveness of shape manipulation activities carried out by designers, especially in the early phases of design. For the development of improved shape manipulation tools it is necessary that their effectiveness can be evaluated. We propose a method to gather empirical data on designers' shape manipulation activities and to analyze the effectiveness of these activities. We applied this method and conducted an experiment to observe designers at work. The test subjects worked on three clay modeling assignments. We compared what would be an ideal way for designers to create shape, to how they actually did it in practice, when using clay. We identified the modeling activities the designers performed, how these activities could be systematically described, and which parameters played a role. Finally, we analyzed the effectiveness of some of the activities. Further research could investigate in which contexts an increase in effectiveness can be achieved.
Determining the effectiveness of shape manipulations by observing designers at work

Introduction
Current CAD systems support shape generation in many ways, but they are not appropriate for the very early stages of shape design. Ideating designers may think of complex shape elements and at the same time leave parts of the shape vague or undefined. They need computer support for easier manipulation of complex curves and surfaces, but not at the cost of reduced freedom of form and creativity (Wiegers and Vergeest 2001).

CAD systems have been evolving for some decades, and they supported parametric design for regular shapes (Shah and Mäntylä 1995). For freeform shapes, researchers have proposed several methods (Elsas and Vergeest 1996; Bidarra and Bronsvort 2000; Marsan, Chen and Stewart 2001) and new interaction devices (Murakami and Nakajima 2000; Djajadiningrat 1998). But still, reports on effective CAD methods for free form ideation hardly exist. Even empirical data on early free form manipulation is scarce.

To fill this gap, we observed designers to gain insight into their methods of free form modeling. The designers had to perform shape modeling assignments in a laboratory setting. Their performances were video taped and their shape manipulation activities were identified. A geometric description of the change in shape was made, and the required time was noted. Furthermore, it was considered which alternative activities could achieve the same shape.

The ultimate objective of this research is to support the development of more effective and intuitive free form manipulation methods. This paper reports a method to describe observed freeform shape manipulation activities. The method will be used to identify those activities that can be done more effectively if appropriate computer support is developed. Future research will address the feasibility of the proposed support means, and designers’ expectations of their relevance and applicability.

Approach
During shape conceptualization, designers often express their ideas in some way, not only to communicate them to co-designers, but also to enable reflection on their own concepts. To express ideated shapes, various methods are used, such as sketches, spoken descriptions, gestures and physical models. Freeform shapes, however, are difficult to describe. Sketching and physical modeling of freeform shapes generally requires much time and effort and therefore interferes with the designer’s creative flow of thoughts. Traditional CAD (Computer-Aided Design) suffers from the same problem. It is our goal to develop means that improve the effectiveness of shape conceptualization.

It is difficult to gather generalizable data on a design process. No design can be created twice by the same designer under the same circumstances. If we want to gather data about multiple, similar design processes, we need different designers. Even if their grade is the same, they will differ in experience, personal approach, favorite methods, etc. Another problem is the large variety of products that are conceptualized in different industries. Furthermore, there is the question whether observations should be done in a real, industrial, environment or in a laboratory setting. Companies usually do not perform the same design assignment twice. A laboratory experiment, however, can be questioned on its relevance for the industrial situation.

One approach to minimize the effect of these influences of differences among designers would be to observe hundreds of designers who are performing the same design assignment. However, this
would be an expensive and time consuming approach. Another approach is to perform an experiment that demonstrates that at least in some cases the effectiveness can be improved. In the situation where little is known about the effectiveness of individual activities, and about the methods to gather data and analyze it, such a demonstration would be an important step forward. If it can be shown that an increase in effectiveness is possible, further research can be done to investigate in which contexts this increase can be achieved. For these reasons we decided to take the latter approach.

For conceptualizing a satisfactory shape, designers often want full freedom of shape, as with clay modeling. However, for many shape manipulations it is advantageous to impose specific constraints, e.g. preserving the ratios when scaling a shape element. Apparently, which method is most effective depends on the context of the shape modification. To develop effective support for shape conceptualization, we need to know which activities a designer can use to realize the intended shape, and how effective these activities are. The effectiveness of shape manipulation can be improved if ineffective activities can be identified and replaced by more effective alternatives. To estimate the effectiveness of modeling activities, criteria should be specified. These criteria are needed both for observed activities and for proposed ones. The following sections will discuss what criteria can be used and which problems we should be aware of.

**Estimating effectiveness**

Shape models often support a kind of discussion between a designer and his ideas. If the shape a designer intends is available as a tangible model, the designer can evaluate and further develop his ideas, without the need to keep all the details of the current shape in his mind. An ideal situation might be when a designer can have an exact, tangible model of the intended shape, as soon as he has conceptualized it. However, in practice, such a model is often not exactly as intended, and it may take much time and effort to generate it. The more time is taken up by generating the model, the longer the ideation task will be delayed. Similarly, the more mental effort the modeling takes, the more the designer's attention will be focussed on the modeling instead of the ideation. Also, the more a shape model differs from the intended shape, the more awareness is required from the designer during the evaluation and the subsequent development of the shape. In summary, the effectiveness of a designer's modeling activity depends on its duration, on the amount of cognitive effort it requires and on the degree to which the result of the activity reflects the intended shape.

Measuring the duration seems relatively easy. However, it is not always clear where a specific modeling activity ends and where the next one starts. Another problem arises when a designer combines activities, e.g. a designer may press a clay model to flatten its top surface and simultaneously shrink its height. In such cases, an estimation can be done, based on the data available on a video tape and the expertise of the researcher. For a systematic description of modeling activities, activity sequences should be selected that do not contain many ambiguities for interpretation. The designer's mental effort too cannot be seen from the video tape. Therefore, the test subjects will be interviewed after they have finished the assignments. For each assignment, the subjects will be asked whether they thought the task was difficult. Also, the resemblance of the model to the intended shape will be tested through an interview question.

**Elaboration of the research method**

To gather the required data and analyze it, the method should contain the following steps:

1. Conducting an experiment in which designers work on modeling assignments.
2. Comparing the ideal way for designers to create shape, to how they actually did it in practice.
3. Identifying the modeling activities the designers performed, and the parameters that played a role.
4. Describing the modeling activities as a mapping of an initial shape onto the resulting shape.
5. Analyzing the effectiveness of the different shape modeling activities.

The experiment
An experiment was conducted in which the test subjects had to perform three clay modeling assignments:

1 Modeling an existing soap box in clay. The modeling was only concerned with the appearance of the outside. The box could be modeled as one solid, without a hollow inside or a separable lid.
2 Enlarging the box by 20%, for a larger bar of soap.
3 Rounding the top of the box, to make the box suitable for holding a larger, rounder bar of soap.

The experiment was performed by 17 test subjects, all students of the Delft University of Technology. All sessions were video taped and analyzed. The results of the first analyses are reported by Baak and Groeneboom (2001) and by Toledo and Weelderen (2001). Figure 2 shows the clay models generated by one of the subjects. A comparison was made between how designers ideally could create shape and what was observed during the experiment (Wiegers, Vergeest and Dumitrescu, 2002).

For this study, one of the sessions was selected for a more detailed analysis. The analysis concerned the identification and the description of the subject’s shape manipulation activities. We zoom in on a part of the subject’s work to record his activities in detail. The observed activities have been described by recording:

- the initial shape, i.e. the shape before the activity started
- the shape the subject intended
- the shape the subject actually achieved  
- the operations the subject used to achieve that shape  
- the duration of the activity  
- the shape parameters that were changed  
- the effort it took.

Figure 3: A depression along the length axis and the width axis of the box

The shape manipulation activities described in this paper are part of a sequence that was performed by the first test subject. These activities concern the generation of a depression, which runs over the length axis all around the box, and also along the width axis, see Figure 3.

![Figure 3](image)

We consider in particular the profile of the depression. Before the subject generated the depression, the top of the box had a cross section as shown in Figure 4. We call this the initial shape $S_i$. In the same figure, $S_n$ depicts what we assume was the intended shape.

![Figure 4](image)
To achieve the intended shape, first a metal stick was pressed into the top surface of the clay model, see Figure 5. This resulted in the shape $S_{i+1}$. The intended shape can be recognized, but there are some imperfections. At the top, some clay protruded and at the bottom the surface is irregular. Furthermore, the walls of the depression are not quite perpendicular. The subject used a knife to remove the protrusions at the top. This results in shape $S_{i+2}$. Next, the stick and the knife were used to remove clay and sharpen the inner edges of the depression. The subject ends up with shape $S_{i+3}$, which shows a slight deviation from the intended shape.

The activity sequence described above contains some simplifications. Actually, several repetitions of activities occurred. For example, the stick was first pressed into the top surface of the box, along its length axis and along its width axis. The stick was also pressed into the side walls of the box and into its bottom surface. Other simplifications are:

- The course of the depression is not considered. However, some manipulations influenced the profile and the course at the same time (e.g. the pressing of the stick into the surface).

- The cross sections $S_n$ in figure 5 are not precise. Actually, the cross section of the depression varied along its course.
- The geometric expressions of the achieved shapes are not exact; they are an approach to describe the basic problem.

- The order of the activities is not analyzed in detail. For example, pressing the stick into the clay model had to be done in several steps.

- Transitions from one activity to the next were sometimes gradually, not discrete.

**Geometric description**

![Figure 6: The change from $S_i$ into $S_n$](image)

$P_1$, $P_2$, $P_3$ and $P_4$ (Figure 6) are points in $\mathbb{R}^2$. $P_1$ and $P_4$ define the line $S_i$, $S_i \subseteq \mathbb{R}^2$. $S_i$ can be described as a mapping from the parameter space $u$ ($u \in \mathbb{R}$) as follows:

$$S_i(u) = (1-u)P_1 + uP_4$$

$u \in [0,1]$

$S_n$ is the polyline defined by the points $P_1$, $P_2$, $P_3$ and $P_4$, where $S_n \subseteq \mathbb{R}^2$. $S_n$ can be described as a mapping of $u$ as follows:

$$S_n(u) = \begin{cases} 
\frac{u_2-u}{u_2}P_1 + \frac{u}{u_2}P_2 & \text{if } u \in [0, u_2) \\
\frac{u_3-u}{u_3-u_2}P_2 + \frac{u-u_2}{u_3-u_2}P_3 & \text{if } u \in [u_2, u_3] \\
\frac{1-u}{1-u_3}P_3 + \frac{u-u_3}{1-u_3}P_4 & \text{if } u \in [u_3,1] 
\end{cases}$$

$u, u_2, u_3 \in [0,1]$

where $u_2$ maps the parameter space to point $P_2$ and $u_3$ maps the parameter space to point $P_3$.

A hypothetical shape manipulation activity that changes $S_i$ into $S_n$ can be described as a mapping of $\alpha$ from $S_i$ to $S_n$ as follows:

$$M(S_i, \alpha) = (1-\alpha)S_i + \alpha S_n$$

$\alpha \in [0,1]$

where $\alpha$ ($\alpha \in \mathbb{R}$) is a new parameter space that maps the initial shape to the intended shape. Parameter $\alpha$ in this expression controls the depth of the depression to be made. $\alpha$ takes over the function of the applied force and duration of pressing the stick. Below the expression is elaborated for the separate parts of $S_n$. 
The line $P_1P_4$ is mapped onto the polyline $P_1P_2P_3P_4$. The distance between the original line $P_1P_4$ and the new line $P_2P_3$ is controlled by $\alpha$.

The above expressions describe the change from $S_i$ into $S_n$. Other shape manipulation activities can be expressed in a similar way.

**Discussion**

The actual performed activity sequence appears to be rather complex. A large part of the time was spent on activities that were in fact only refinements of the first activity, which was pressing a stick into the clay box. That activity itself could be considered in more detail as a process in which the groove grows in depth. The activity could also be subdivided into separate subactivities, each generating a part of the groove, at different positions on the clay box. After the first activity, an intermediate shape $S_{i+1}$ was achieved (Figure 5). In $S_{i+1}$ the intended shape can already be recognized, though extensive elaboration was done on $S_{i+1}$. This recognition can be considered as a quick feedback and may help the designer to evaluate already while manipulating the shape.

We note some differences with other common methods. In many CAD systems, for example, the details of a shape element must be defined completely, before a 3D representation can be shown. However, once the shape element is fully defined, no additional smoothening is necessary, like with clay modeling.

Which method is preferable depends on the context. If the designer already knows the exact shape and dimensions, using a CAD system may be appropriate. This method may be especially advantageous for large models, because working a shape element in clay requires more time if the shape element is larger.

If the designer is just playing with the shape, clay modeling may be used because the designer already receives tactile and visual feedback while manipulating the model. This immediate feedback enables early evaluation, while the designer need not yet worry about exact details. At the faculty of Industrial Design of the Delft University of Technology, one of the assignments is to design a new product and build a working model. During this assignment, several student teams choose clay modeling for their shape ideation. Also, in the automotive industry small clay models are used for ideation. By creating small-scale clay models, designers exploit the advantages of clay modeling and minimize the time needed for smoothing the surfaces and other finishing activities. CAD models are often generated in a later phase, when more has already been decided about the model.

This study shows that it is possible to describe designers' shape manipulation activities by geometric expressions. Computers can easily calculate these expressions. This paper presents the description of activities that were actually performed with traditional modeling methods. However, for the description of modeling activities, it is not necessary that the activities actually have been performed, or can be performed with traditional methods. Sometimes, a physical modeling activity is very laborious, but its geometric description is simple. For example, the second assignment in our
experiment was the enlargement of the soap box that had just been made. The subjects had to re-model virtually every detail. The scaling can be described geometrically as a mapping of $\alpha$ from $S_i$ to $S_n$. The scaling can then be controlled by only varying the value of $\alpha$.

**Conclusions**

A method was presented to describe shape manipulation activities. The shapes before and after the activities are recorded in geometric expressions. The activities themselves are characterized as a change of a parameter value within the expression. The effectiveness of the activity sequence is influenced by multiple characteristics, such as the durations of the activities, the amount of effort that was required and the degree to which the generated shape reflects the intended shape. The method was applied to describe a sequence of activities that were actually performed by a test subject. The results show how the time spent was divided over the identified activities, and how these activities contributed to the generation of the intended shape. The proposed method can be used to describe not only activities that can be actually performed, but also hypothetical ones. Some shape ideation activities are laborious when performed by physical modeling, while their geometric description can be simple. Such activities are good opportunities for the development of more effective support methods.
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Designing supply chain innovation

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Abstract

Increasingly connected, empowered and informed consumers have ever higher demands and expectations of product and service provision. Organisations which are not sufficiently agile and responsive to meet such expectations will face failure.

Collaborative Envisioning - a methodology for enabling collaboration across supply chains using design tools to meet consumer demands in the new economy - has been developed by the authors in a demonstration project titled Beyond the Fridge which was described and discussed in a paper given at the 10th International Forum on Design Management Research & Education and analysed with recommendations in a paper given at the 4th European Academy of Design Conference.

Beyond the Fridge considered large corporations with effective control over their own supply chains. The barriers to SMEs developing new business models in response to new customer, user and consumer requirements are quite different from those faced by large corporations and tend to centre around the fragility of the company’s position in the supply chain and its defence of this position.

This paper reports on the development of the Collaborative Envisioning methodology to engage with SMEs, the utilisation of design skills within this process and the role of universities and design academics as partners with SMEs.
Designing supply chain innovation

Review of current practice
Typically technology transfer and product innovation rely on a transfer, from one sector to another, of ready made solutions in the form of technology, materials and processes which have proven performance in an equivalent application, or a commercial buyer / seller relationship between an employer and a service provider, whether internal or external. These models imply a one way, solution driven transaction and are generally predicated upon a financial contract or driven by a technology promoting agency or product champion, acting either alone or pursuing an individual goal within an organisation.

Technology transfer is normally tied to defined technical performance indicators associated with product or process outcomes and a solution will be judged to have been achieved when these indicators are met. The solution driven nature of technology transfer is described by 3M: “Successful innovations in one industry result in innovative solutions in another” (Meads 1998).

Lambe and Spekman ask the question ‘how do corporations renew their core technology, products, and processes as a basis for continued competitive vitality’ and identify inter-company alliances as a key route to external technology acquisition:

“An alliance is defined as a collaborative relationship among firms to achieve a common goal that each firm could not easily accomplish alone. Within this context, the most common forms of alliances include joint ventures, technology licensing agreements, and various forms of R&D consortia” (Lambe and Spekman 1997).

That one or more organisations should form a relationship to achieve a common goal presupposes that each firm has identified the goal and is confident that achievement of that goal will generate commercial benefit to the firm. Innovation and technology transfer are thus explicitly solution driven.

Solution driven alliances are becoming increasingly common in buyer / supplier relationships in the automotive industry:

“Since a large portion of the production of complex products is done by outside suppliers, particularly in Japan, it has become increasingly clear to researchers that the success of many of the foremost Japanese firms has depended on their ability to gain competitive advantage based on establishing strategically important relationships with suppliers” (Wasti and Liker 1997).

Alliances and co-development partnerships offer frameworks for the transfer of technology and joint new product development but they do not alter the underlying transactional nature of the buyer / supplier relationship.

Collaborative models have been developed to overcome the linearity of a new product development process where a project is passed from department to department within an organisation in discrete phases with each department signing-off on the project before the next takes it up a methodology of cross-functional linkages has been developed to facilitate “overcoming rigid interdepartmental boundaries, building cooperation, and accelerating the development of new products from new technologies” (Jassawalla and Sashittal 1998). An example of a cross-functional linked process is concurrent engineering (CE):
CE has become a widely recognised means for achieving improved product development performance by challenging the logic and practice of the traditionally sequential product development processes (Clausing, 1994). The aim is to avoid the unnatural separation of work into upstream and downstream activities through increased integration, most successfully achieved through multifunctional teamworking. CE can be defined as: “...the delivery of better, cheaper, faster products to market, by a lean way of working, using multidisciplined teams, right first time methods and parallel processing activities to consider continuously all constraints”.

This requires radically changing the way products have been traditionally developed within western manufacturing organisations and impacts all aspects of the business (Jukes et al., 1997).

Jassawalla and Sashittal have proposed that while ‘there is a clear consensus ... that high level cross-functional integration improves new product development processes’, there is now a need to re-evaluate the methodology, especially for high-technology industries (Jassawalla and Sashittal 1998):

“We contend that although the concern for cross-functional integration endures, major shifts have occurred within and outside high-technology firms that call for a re-examination of the ways in which cross-functional linkages are conceptualized. Many firms have integrated leading customers and suppliers in technology/product development processes, adopted features of horizontal, boundary-less organizations and innovative ways of managing technology and people, and experimented with cross-functional teams to manage NPD task environments. These developments call not only for a re-evaluation of traditional thinking about cross-functional linkages but also for the adoption of a more up-dated vocabulary that speaks to the practical realities of managers responsible for NPD processes in leading high-technology firms” (ibid.).

The term which the authors select to describe “the next generation of cross-functional linkage relevant to NPD processes” is collaboration (ibid.).

Both concurrent engineering and Jassawalla and Sashittal’s concept of collaboration are predicated upon cross-functional, multidisciplinary teams. The key difference between these methodologies is that collaboration within the team is not an absolute requirement of CE, where the emphasis is upon parallel processing.

The methodologies are united in their intent to integrate upstream and downstream activities within a horizontal new product development process. Such horizontality, however, while being cross-functional and multidisciplinary, does not extend beyond the limits of the established supply chain of customers and suppliers, and is thus, essentially, product and technology focused.

**The need for new models**

In an article in the September 1999 issue of ID, Stefano Marzano, Managing Director of Philips Design, expressed his conviction that:

“in the coming decade we'll see a whole raft of cross-industry partnerships springing up - between electronics and telecommunications companies on the one hand, say, and furniture manufacturers, textile manufacturers, soft furnishers or ceramic tile producers on the other.......................

Companies need to seek fresh inspiration beyond the limited horizons of their own fields and markets. Only in that way will they be able to embrace new paradigms and create new value tomorrow” (Marzano 1999).
The need to embrace new paradigms through collaboration to develop innovative solutions is discussed in ‘Design Export News’ (Vol. 14, 1999). The Department of Trade and Industry defines innovation as ‘the successful exploitation of new ideas’ and Maxine J. Horn, CEO of The British Design Initiative argues, like Stefano Marzano, that such success can best be achieved through collaboration:

“The real issue is that if key members of the supply chain worked collaboratively then all parties would benefit from the involvement of the others and more successful innovation should result.

Mostly, organisations do not need convincing that innovation is good for business, they know that already. What they need is a change in attitude towards sharing the costs and risks involved. Members of a potential supply chain need to be open to collaborative shared risks and reward deals, rather than straight cash” (Horn 1999).

The change in attitude from normal transactional models, which Ms Horn describes as ‘off the shelf’ or ‘in a narrow context’, to the involvement and sharing of a collaborative partnership opens up opportunities for innovation in all aspects of new product development not available in the normal new product development sequence of problem identification or technology availability, brief, specification and solution. The need for a shift away from transactions in strategic partnerships (Davis and Meyer 1998) and the benefit of alliance over transaction (Lewis 1999) will create the need for multidisciplinary collaboration outside established supply chains.

Arrogance and design education
Search for new models of design practice raises fundamental questions about the commissioned and transactional nature of product design/client relationships in practice and the origins and precepts on which this model is based.

It is now the norm rather than the exception for design students to graduate with a high level of professional skills and exemplars of project work which will ensure employment. However it could be argued that in the time compressed/curriculum overloaded environment of higher education we may be guilty of producing students who are good at doing 'that' but may not have been encouraged to find answers to 'why design' and 'how design'.

As American industrial designer J. Gordon Lippincott explained in 1947

“Good industrial design means mass acceptance.”

One only needs to replace 'mass' with 'niche' to understand how relevant this philosophy is to today's commodified market place. Design has always had a strong political dimension - Rosy Martin in 'Feminist Design: A Contradiction' identified that:

“Design at its broadest sense is power, control and defining new possibilities to aim for.”

If we accept that products communicate ideas, values and aspirations then it may be fruitful to examine some of the assumptions which underpin the educational model of product design practice and binds to manufacturing, markets and society.

Design can be radical and reforming; “Design at its best is potent,” said Graham Vickers in 1992. However design is also very good at recycling ideas (many of which may be inherently ill conceived, perform badly and are far from radical). Small incremental steps may be in the interests
of a stable market place but it leaves both manufacturers and end users vulnerable to factors of change which may be qualitative and unpredictable.

Design is democratic, or is it? Margaret Bruce declared that:

“Women are invisible in the profession of industrial design. The consequences of this are two fold. First women's 'tactic knowledge' is not drawn upon during the design process and secondly design opportunities and markets which met women's needs and concerns are underdeveloped.”

The tacit knowledge of women is not the only area not drawn upon - much of the 'design process' learned in HE pays lip service to inclusivity of human experience and wisdom.

'Design solutions' is a phrase which is in itself dangerously value loaded. We know of no absolutes; design solutions have an emotional/social shelf life that is fragile and the wrong kind of design intervention is as likely to exacerbate problems as resolve them. 'Problem solving activity' is a notion which links the idea of 'good design' with a set of moral values where 'fitness for purpose' is tied into a life of honest toil. These ideas just won’t do in today's sophisticated and empowered market place.

It is not uncommon to hear the benefits of 'added value' and branding preached in University design studios - the question is whose values are we adding here. One person's 'added value' benefit in a product may be another person's barrier to accessibility. Products are not necessarily purchased to fulfil primary functions. Lessons from the recent past (G3, etc) demonstrate the problems associated with 'value added' driven by single/technological concerns over all else may fail.

In spite of design being promoted as having an economic purpose from Henry Cole in the 1850's through Henry Dreyfuss in 1950:

“There is only one reason for hiring an industrial designer and that is to increase sales of a product”

to the NEDC and DTI slogans of the 1980's 'design business' movement.

'Good design is good business'

'Design is good for growth'

'Design for Profit.'

There is very little real evidence to support the claims that our current state of financial stability and wealth is related to these claims for design.

The promise of the social benefits of design and the promise of 'labour saving-time saving' machines and 'paperless-offices' which has often underpinned justification for innovation in appliances do not deliver either, housework has actually increased since the original labour saving products (vacuum cleaners and washing machines) with technology rich machines demanding increasing attention and expertise from the user. To be effective design education has to challenge traditional transactional models of practice. Taking a client brief without greater levels of exchange and immersion in contextual issues will no longer serve students career interests, or the clients or the customers and end users. A research culture which seeks to reposition the product designer and redefine the design offer is a must in curriculum design and delivery.
Evidence from this research indicates that many clients, SMEs and corporates require design help to help themselves to grow their own businesses. The limits of the design offer in this case may cover much more or much less than traditional transactional model. Questions about how design can be embedded in an SME supply chain become as important as the product concept itself. To continue the way we are is at best an inadequate preparation for professional practice and at worst it is arrogant.

**Beyond the fridge**

As a platform to develop a new methodology for multidisciplinary collaboration outside established supply chains, a collaborative partnership was established between Electrolux Group, Sainsbury's Supermarkets 3M UK plc, University College Northampton and University of East London, resulting in a demonstration project titled Beyond the Fridge.

The demonstration project addressed commercial food safety, marketing and technological issues existing in the storage and delivery of chill and frozen foods, from production to consumption (the chill chain).

The commercial aim was to develop a physical system to improve chill chain compliance at a critical point in the chain where a trial could best demonstrate consumer, retailer and manufacturer benefit at reasonable cost. The project aimed to integrate the overlapping and complementary concerns of the food retailer to improve customer service efficiency and the white goods manufacturer to add value to domestic refrigeration products.

Other technological issues concerning logistics and retailer/consumer relationships with regard to electronic shopping, stock control and emerging high performance materials were significant in shaping the project.

Commercial aims were developed through a number of stages of realisation based on the development of short, medium and long term visions of the retail and domestic food supply chain tied to an identified gradient of current, near and future technologies.

An iterative process of new product development across the technology gradient was generated by the partners in the project, resulting in physical models and proof of principle test rigs. Storyboarding describing the commercial and user benefits at each level of technology enabled the partners in Beyond the Fridge to relate the models to the vision at each step.

This approach also facilitated the presentation of Beyond the Fridge principles to a wider audience, particularly senior management outside the project team, and confirmed the vision as a mutually supported concept.

The outputs from Beyond the Fridge exceeded the original project objectives and, in terms of input and output the hypothesis, now described in the term 'Collaborative Envisioning', has succeeded in passing the test of the demonstration project. The level of success is assessed below, where guidelines will be proposed for the initiation of Collaborative Envisioning projects in fields other than the retail food supply chain.

Other outcomes were achieved, perhaps the most important of which are the ongoing relationships between the collaborators who share an eagerness and commitment to developing Beyond the Fridge concepts. However, it is significant that these relationships are generally at a personal rather than corporate level and have begun to shift and migrate as individual careers develop and partner organisations restructure and realign.
The process of Collaborative Envisioning necessarily requires working across and through corporate boundaries and thus reverses the normal, exclusive and introspective approach to new product development to become an outward-going, shared and inclusive process. The enthusiasm for Collaborative Envisioning amongst those who took part in Beyond the Fridge has allowed the network of formal and informal linkages around the project to continue to grow.

**Issues arising from beyond the fridge**

Two aspects of Beyond the Fridge which could have been viewed as positive or partly positive may actually have acted as brakes on the dissemination of the project outcomes within the collaborating commercial organisations.

Modest budgetary requirements, which could be resourced at division or section level without board approval, allowed the project to be flexible and responsive but meant that the value of the project had to be resold into the company from operational to board responsibility, effectively grouping a mid to long term strategic initiative with immediate tactical issues and competing prototypes and test rigs against off-the-shelf solutions.

Similarly the relationships which have been established have been at an operational level within the project team. Although a high level of awareness at divisional board level was raised within Sainsbury’s and Electrolux, the ‘user’ collaborators, at the project presentation, Beyond the Fridge has not forged new connections between the boards of the two companies because the project was already funded from existing budgets and the presentation was not part of a staffing or capital expenditure bid. This meant that board members were able to be supportive and enthusiastic without committing to the project or becoming further involved.

That the project was able to be responsive has already been noted and, during the course of Beyond the Fridge, both Sainsbury’s and Electrolux underwent restructuring which necessitated changes within the project team in terms of skills, job function and business focus. In the context of bringing the project back into the businesses, this is both a strength and a weakness: the project was able to evolve rapidly to maintain the collaborators’ engagement through periods of change but the characteristics of tactical rather than strategic support, discussed above, meant that the project did not drive new business in the manner predicted by Stefano Marzano: the culture of Collaborative Envisioning developed within the project team and those closely associated with it but Collaborative Envisioning did not become a corporate driver.

**A methodology for collaborative envisioning**

The work carried out by the academic partners in the formative stages of Beyond the Fridge in summarising existing supply chains and proposing ideal supply chains, presented using the design tools such as storyboarding, conceptualisation and prototyping, indicates that the process of Collaborative Envisioning, and establishing a common language to describe a mutually shared vision which is the corner stone of the process, begins before the collaboration is in any sense formalised. The experience of Beyond the Fridge indicates that the skills necessary to embody a mutually shared and supported vision must be central to the project from the outset.

Thus it can be stated that partners initiating a Collaborative Envisioning project must:

- be able to generate measurable benefit from a process which may not generate any commercial or financial gain
- have the skills to communicate a vision across cultural, commercial and disciplinary boundaries.

It is argued above that academics and designers are well placed to fulfil these two roles, and, in the case of Beyond the Fridge, the initiators were design academics.

Analysis of the project indicates that the academic partners were key actors at every stage, from data gathering to prototyping. The intention at the outset of the project had been that ownership of the project would steadily shift from academic to commercial partners, reflecting the tightening of the focus of the vision, the increasing reality of the tools used to express it, from icons to test rigs, and the opportunity for commercial partners to become more actively involved in the generation of the tools through for example, beta-prototyping, testing and on-site trialling.

It is likely that ownership tended to reside with the academics throughout the project for similar reasons to those already noted for the lack of success in implementing tactical solutions derived from the Beyond the Fridge strategy. A remedy for this might be described as ‘Selling the project back into the businesses’ through the development and implementation of separately funded tactical solutions derived from a long term collaborative vision. Whilst these tactical solutions would be owned by the commercial partners and, if taken up, would drive migration of the Collaborative Envisioning project from an academic into a commercial environment, the success of the Collaborative Envisioning process is not contingent upon the commercial partners buying tactical elements out of it.

To build upon and consolidate the successes of Beyond the Fridge, it is therefore further proposed that stop/go critical decision points be written in through the course of the project at the project definition stage. The anticipated effect of this will be to underline and reinforce the commitment of the individual partners in achieving each deliverable output, rather than leaving responsibility with the academics and whoever happened to be available from the commercial partners.

In summary, it can be proposed at this point in the development of the Collaborative Envisioning methodology that key requisites for successful multidisciplinary, trans-sectoral innovation include:

- initiation by partners able to accrue tangible benefit where no conventional commercial return can be demonstrated
- integration of envisioning skills from the outset
- low-level, non-restrictive intellectual and non-disclosure agreement
- early trust building activities
- frequent critical decision points, including at least one to carry the project to a future phase
- strategic commitment with tactical gains costed and deliverable subject to separate funding.

**The SME supply chain environment**

SMEs unlike large corporates are often unfamiliar with what goes into a new product development process and may be unused to working with external specialist agencies, or to the idea of partnership.
Early feedback from SMEs on current research at UCN and UEL indicate that SMEs are less permeable to the introduction of new knowledge and practices. SME manufacturers may have developed a highly personal or specialised area of expertise which represents their 'life-line' to survival in their supply chain. SME culture may be defensive of that knowledge and the idea of sharing knowledge or creating new opportunities in product or process in partnerships with others an anathema to business development.

As with corporates a lengthy 'honeymoon' period may be necessary between the academic partner and SME to build confidence and understand what is on offer, the nature of the relationship and where design effort might be most effective. It is important that the standardised 'design solution' offer is not promoted early on. In the experience of the authors pressure for an immediate results driven scenario may close down space for more strategic discussions.

Several SMEs that UEL and UCN are now working with have had an unrewarding experience of working within the conventional transactional design model, and are seeking help which is tailored to and inclusive of their own requirements within the supply chain.

The scope of trust building activities between SMEs and university design agencies can be varied and may cover some or all of the following:

- transfer of know-how, knowledge and information between partners
- introduction to research methods to increase knowledge of upstream and downstream issues
- exposure to university technical facilities
- audit of SMEs in-house resources, protocols and facilities
- creating a forum for discussion on strategic issues
- brief framing and writing
- sourcing other partners
- advice on development of in-house resources
- agreeing IPR framework and way of proceeding
- buy into the partnership offer including a network of NPD skill providers.

Many SMEs also have limited new product development and testing facilities and the offer to the SME may include this resource or help and advice in acquiring these facilities.

It is a characteristic of many SMEs that they are centrally controlled by an entrepreneur who may quite rightly have strong feelings of ownership and responsibility towards the business and employed staff. It may be that key negotiation, flow of information and decision-making activities are all focused on this one person. Whereas the dynamic state of many corporates and their staff makes collaborative team working difficult for outside agencies as partners, so the reverse is true of SMEs where because of the small scale of organisation changing the way something is done may radically impact on all other systems and processes and many internal staff.
A collaborative project which is not properly embedded in an SME is itself vulnerable to failure. There is a real danger to projects which are the sole ownership of the MD. A project must be seen and understood to be of critical concern and benefit to all major players within the SME.

To summarise, the evidence of this research work as far as it has gone indicates design interventions in SME supply chains require designers to rethink much of the offer they have been trained to deliver.

Within many SME environments a traditional closely proscribed design consultancy ‘solution’ may be leaving the SME with something they have not contributed to, find it difficult to have confidence in and do not know how to take further or continue to work with. A more flexible, ‘closer-in’, and bespoke response to individual SME circumstances may ensure an increase of design effectiveness in this sector. While the research in this area continues it is a conclusion of the authors at this stage that linkage between design research of this nature and what is taught and learned in design education is critical towards evolving a new theory of practice towards curriculum development.

The barriers to SMEs developing new business models in response to new customer, user and consumer requirements are quite different from those faced by large corporations and tend to centre around the fragility of the company’s position in the supply chain and its defence of this position.

Further challenges to SMEs are presented by the strategic fragmentation of large corporations, such as that occurring in the telecommunications industry where smaller, more agile specialist groups are being spun out of debt-laden parent companies. Typically in these circumstances, the spin-off is helped and guided into the market place, with a phased programme of support prior to achieving full profitability.

Existing small specialist companies without external support in the market place are thus threatened by new entrants with large company backing and reduced financial targets. These existing small companies are equally threatened if the large corporations in their sector are consolidating rather than fragmenting because, if a large company identifies a smaller one’s activity as being a potential source of revenue, the larger company may either force a takeover of the smaller’s business or become a competitor in its field of activity with an artificially discounted price structure and big player leverage.

The challenge for designers in working with SMEs to develop opportunities in and around their supply chains lies in developing enabling strategies that are effective for innovation in a threatened and defensive business environment.
References


The role of interface mock ups in establishing common ground in a distributed development team

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Abstract

This paper uses a software development project, comprising of end user representatives, evaluators and developers to consider the value of an interface mock up in establishing common ground within a large, distributed software development team. It introduces the scope of the project - to develop an integrated, web-based, platform to support team working (UNITE) - and then considers the role of the mock up of the interface in helping the team understand the underlying concepts behind the project, and in facilitating discussion, agreement and understanding between stakeholders. Lastly the paper evaluates the success of the mock up in achieving these aims.
The role of interface mock ups in establishing common ground in a distributed development team

Introduction
The UNITE project has been funded by the EU-IST Programme for 2 years and concerns the development of a web based, Ubiquitous and Integrated Teamwork Environment to support the needs of mobile workers, acting as members of virtual project teams. This requires the integration of traditional computer supported co-operative working (CSCW) tools (e.g. joint calendars, video conferencing, email) in a seamless environment structured around tasks and communication needs. The development of such an environment involves the contribution of a number different research groups from UK (Coventry University), Holland (Pentascope), France (IBM and Steria), Germany (FhG-IAO and FhG-SIT), Portugal (ADETTI) and Israel (IBM) with different groups responsible for software development and integration, evaluation and user testing.

Since there was no pre-existing system, a Semantic Model (SM) was developed to forward an underlying understanding of the proposed system, and to allow communication between the different stakeholders (especially developers) at the early stages of the project (i.e. before and during the iterative development of the system) about the UNITE concept and its implications. The SM was used to drive, and became embedded in, the interface mock up (a version of which is shown in Figure 1). The role of the SM was to provide a framework to guide development and to provide a communication environment and overview to facilitate the rapid development of a coherent system.

The SM defines a set of concepts and a basic framework about what the UNITE platform should be (see below for more details). The inspection of the SM and interaction with the mock up (in particular) could potentially enable end user representatives to talk to the developers (in a shared language) about the functionality and where the mock up did not meet their previously described requirements.

Previous papers (e.g. Reinema. et al 1998 and 2000, Woodcock et al, 2002) have described the organization of the consortium, the UNITE concept and the progress of the project towards developing an integrated platform. In summary, UNITE provides a platform which integrates different collaboration modes and requirements, and provides a project/task centred environment allowing its users to concentrate on the task in hand, rather than becoming distracted for example, by having to memorise the addresses of team members, their location and preferred working practices, and application centred information. Additionally, as a web based environment, the platform is available for users wherever they happen to be working. By providing a virtual working space for all project members tacit knowledge (Polanyi, 1966) can also be spread more easily around the group – so promoting group learning, awareness and camaraderie between a team which may rarely meet face to face (Woodcock et al, 2001).

This paper considers the role of the mock up during system development with regard to its embodiment of the SM and as a communication support for encouraging interaction and reflection amongst the project members, i.e. as a means of establishing common ground between project members. The paper is divided in to three parts. It commences with a section outlining the interface and its key components. From this, we will introduce the SM, which is the theoretical basis of the system development. The rest of the paper examines the nature of discussions centred on the interface and will present the results of a survey of team members to consider whether the interface was successful in achieving its aims.
The interface mock up

The need for a mock up interface was postulated in the first quarter of the project. The end user representatives wanted a physical representation of the UNITE concept as they found the written specifications of the requirements and the SM hard to understand and relate to practical experience. The developments of the mock up culminated in the production of a web-based demonstrator system, see Figure 1 below, which developed into a vehicle for discussing the Semantic Model and its implications for user behaviour.

As can be seen from Figure 1, the system offers a message centre, document repository, shared calendar, address book, bookmarks, meeting management, support for communication and collaboration, and security services centred around the needs of the project team. The message centre for instance presents a unified view of all forms of messages, whether these are voice mail, email etc enabling all asynchronous communication between team members to be sent and received from one place. For synchronous (real time) communication, users gather in 'collaboration areas' which are defined by the project team at project initiation, to suit their needs and the communication preferences of the team members. These are shown as discrete areas (top right) of the interface where different collaboration 'scenarios' are available, without showing the technical details of the required tools and services. By entering one of these collaboration areas, services such as text chat and application sharing are automatically opened and become available to everyone who has been invited to and enters the area.

![Figure 1: The UNITE interface](image)
A UNITE virtual workplace as shown by the mock up provides users with a number of tools or services, which can be assembled from a pre-existing reservoir of current services. Each project manager, when initiating a new project, can select from these services those facilities that best suit the needs of the project and its members. For example, a project team may consist of people, who spend a lot of time travelling, and working from different offices, using different communication tools. In setting up the Virtual Project Office (VPO), the contact details and preferences for each team member are added to the system and the services and tools required to contact individuals will be configured. This means that if you go into the VPO, for example to discuss a forthcoming meeting with colleagues, the UNITE platform will contact them for you whether this is by phone, email, SMS, or text chat. You are thereby freed from the onus of trying to remember different phone numbers, the location of the rest of the team, etc., and so can remain focussed on the task in hand. Also, by using one of the collaboration areas, a predetermined set of tools and services is provided for use by your team (for example, application sharing, videoconferencing) without any of the team having to select and open applications.

The platform hides the details of each tool or service behind a unified user interface, manages them and provides a consistent look and feel across all elements, functional modules, and windows. It clearly indicates a user's location in the Virtual Project Office (VPO) at all times; in particular, it indicates the user's current collaborative work context unambiguously. The VPO offers users awareness and intuitive navigation like a real team office, but without imaging an office in 2D or 3D. The majority of user activities take place within the Web browser window, although collaboration tools do launch their own application windows. At the moment, UNITE users can access the platform from a desktop PC via the UNITE project Portal using a regular Web Browser. In the future, they will also be able to use mobile phones (e.g. WAP browser) or other portable devices (e.g. PDA).

As each development partner (i.e. IBM, Steria, FHg-SIT, ADETTI and Coventry University) is responsible for the development of one or more modules (Figure 2), the integration of the elements into a unified and consistent whole was paramount. In order to reduce the inconsistencies and maintain an overall framework for the project a semantic model was used to guide development.
The Semantic Model

It is not the aim of this paper to discuss the semantic model, or its adequacy as a representation of teamworking. Rather we are concerned with its usefulness in helping the project team understand the basic concepts behind UNITE and their implications.

The semantic model (shown diagrammatically) in Figure 3 was used from the start of the project to specify a set of relationships which governed the behaviour and functionality of the UNITE platform. It is its theoretical base and deals with context closure in team collaboration. It defines two kinds of work contexts and their relationship: the personal and teamwork context. For the users, the personal work context contains a set of tools and interfaces just valid for the individual; the teamwork context contains collaboration services and interfaces built from another set of tools and shared with the team members within one project. For example, when in the personal context area (the circles in Figure 3), the user is able to get into contact with their Personal Assistant (for e.g. messages from a teamwork context), export resources to a teamwork context, and select to enter a teamwork context (also called Virtual Project Office). Likewise the SM gives rise to the following types of relationships:

- when at or from his/ her personal desk in the Virtual Project Office the user can see all team members, get contacted by others, access all project resources, change to a collaboration area or move to another personal desk to initiate communication.
- when meeting at a personal desk, each member has to agree to the collaboration and access to each others resources.
- when meeting in a collaboration area: the possibilities are defined by a collaboration scenario and available collaborative resources. These are under the control of the team.

Clearly, if the development team were to produce an integrated, coherent and usable system they all needed to understand the Semantic Model and its implications. The SM also had to fulfill the requirements of the end users and help in their instantiation in a usable and effective system. Although it was not essential for the user representatives and evaluators to understand the SM it was believed that its accurate embodiment in the user interface would enable a coherent, integrated
system to be produced which would facilitate the acquisition of a user model of the system and reduce the number of usability issues. The mock up was one of a number of vehicles for doing this.

**The role of the mock up in the project**

To gain insight into the role of the mock up, a questionnaire was sent to the technical and management leaders of the project to determine what role they thought the mock up had in the project and the extent to which they believed it had fulfilled that role. The mock up was believed to be able to fulfill the following roles:

- to guide the project team in sharing a common understanding of the UNITE platform. For example, ‘experience with previous projects had shown that paper descriptions were always insufficient to visualise implementations ahead of time, thereby leaving people with their own interpretation. This may be due to the fact that people do not take the time to sufficiently analyse paper documents, and the difficulty of representing something that does not already exist. Looking at a realisation of concepts is much more efficient.’ G. Lacoste, project manager
- to save resources. Without mock ups, assembling prototype implementations would be more costly/ elaborate and difficult because of lack of common understanding. While the actual implementation has to realize a specific set of features and services down to the fine details and may be restricted in scope by limited time and resources, the mock-up could present a gross overview and be more free in sketching features and services.
- to enable the refinement of the user interface through iterative development and feedback.
- to be the forerunner of an actual implementation and thus guide developers in implementation planning. In an implementation such as UNITE’s (which is research driven), a lot of decisions have to be taken in the process from design, specification, coding, unit tests to final integration tests, which cannot always be predetermined. A mock-up can help in such situations to clearly recall what the original design specification was - at least from the user interface point of view; it can help in the experimentation with alternatives and their consequences; and it allows feedback on these.
- to be a promotional tool. The mock up should allow light-weight demonstrations of the UNITE platform without the need of the surrounding, heavy infrastructure (Internet access, servers of many types, etc) thereby demonstrating to potential users what a UNITE implementation could provide to them in terms of benefits, functions and services and help users in preparing for an installation.
- to help users understand advanced features. It could help in discussing with users which specific features, out of a set of possible ones, would have which effect, and would be appropriate for them. It can help to explain to users that a current implementation is just an intermediate step in the evolution of more powerful versions.
- to serve as a bridge between the semantic model (SM) and the actual implementation. The SM provides a formal framework for the purpose of specifying and verifying the basic concepts of UNITE platforms, the mock-up although it draws on the SM, is more informal and is put in terms that are closer to users.

To summarise the mock up was supposed to facilitate understanding within the project team, act as a promotional tool, provide a means of interpreting the SM and provide insight into future systems.

**Assessing the role of the mock up in the project**

The evaluation of the utility of the mock up by the managers and the end user representatives showed that it was not thought to be as useful as it could have. This might have been due to the difficulties in its development and relatively late manifestation in the project lifecycle.
Whilst everyone had agreed that the mock up would be a valuable tool in the project, its actual role was controversial, and indeed some of the intended functions became contradictory. For example, the underlying semantic model was not well enough understood by the developers. This lack of understanding became manifest during the production of the mock up, derived from information in the project documents. The mismatch between the mock up and the SM meant that the mock up had to be more closely aligned to the SM before it could be released to the user representatives. This alignment was brought about by pre-releasing mock-ups to developers, who would engage in their own iterative development cycle, prior to release to the user representatives. This lengthened the mock up development time, and deferred in depth user representative involvement in project development.

The third version of the mock up (shown in Figure 1) allowed the basic concepts of UNITE (personal context, teamwork context, personal desks within teamwork context) to become clear to all developers and from then on it was used as a common base. The iterative development and achievement of a common understanding took longer to establish than had been anticipated, so there was not enough time left in the given timeframe to get feedback from the users on either the GUI or the Basic Platform functional view. In terms of easy trials the mock up partly achieved this, as it was possible to show users efficiently what UNITE can be.

**Communication regarding the mock up interface**

In terms of communication and management, the two-year project has scheduled quarterly face-to-face meetings, supplemented by more focused workshops to address user/evaluator or developer issues, and teleconferencing sessions on a needs basis, on-line chat and uses BSCW for document sharing and email. In this section, we examine some of the emails to determine what issues were discussed in relation to the mock up and analyse the transcript of a teleconferencing session to illustrate the way in which the use of the mock up promoted further discussion amongst the team.

During the development of the mock-up, one set of emails centred on the discussion of the meaning and understanding of the Semantic Model. Of these, a sample of 155 emails was collected during the first year of the project. In terms of the project lifecycle, the emails occurred at the stage when the mock up was conceived to the time when the first version was mature enough to be subjected to initial evaluation, and a partial understanding of the semantic model had been achieved within the project.

The emails were analyzed to determine who initiated discussion, who was involved in the discussion, what was its focus and severity, the cause of the discussion and whether issues were resolved. 40 of the emails focused on the semantic model and the mock up. In all instances the developers initiated discussion, e.g. by proposing a mock up to the agreement of the project (especially the end user representatives). In the iterative development stages, when developers produced a new version of mock-up, the users commented on it, sometimes resulting in conflicts. Such comments related to interface features, such as the size of text, online help, colour of background, and location of some functions; project management and the semantic model. Also specific issues were raised indicating that the mock up was not seen as a true representation of the SM such as “the mock-up does not separate personal work context and team work context clearly from each other”, and “Ambiguity in collaboration areas” was noted. Important, deep issues were not resolved through emails but at face to face meetings, or through teleconferences.

Crucially, the analysis of the emails (and the questionnaires) regarding the interface shows that the semantic model was not well understood at that time, and that a common ground from which to proceed and resolve misunderstandings could not be successfully established asynchronously. This
necessitated additional teleconferences and workshops, some of which were minuted and published as open documents on 'BSCW' - the shared project's document repository.

Discussion showed that a significant amount of work was still required for the mock up to appropriately represent the missing functions. Especially it needed to be improved to reflect the main concepts of UNITE, with regard to the integration of team members in the project office. For example, central to the UNITE concept is the personal context area, under full control of its owner, which provides the UNITE user with a private space to perform work outside any project space. However, this personal work area should also provide an overview/peripheral view on all projects that the owner is involved in, in particular notifications related to these projects. Secondly, the personal desk of a team member supports individual work within the context of a given project. When a personal desk is occupied, its owner can use all objects relevant to that context, and he or she has control over other team members that attempt to enter this personal desk. Thirdly, the collaboration area provides team members with a series of collaboration scenarios that they can use without specific permission from any of the other team members.

There had been a problem communicating some of these issues and their implications. The early mock up was criticised for not addressing these basic concepts, and in its representation of the working space as a 2D floor plan, which was found not to be meaningful. Rather it was felt that the user’s screen needed to be structured as a collection of different areas including ones to:

- indicate that a team member requests entering the user’s personal desk (e.g. in order to contact that user), and to enable the user to control entry to his or her personal desk;
- provide information on the team membership, independently from who is currently working in the team’s office;
- indicate who is working where, in an area at the top of the screen (as shown in Figure 1);
- enable navigation within the various contexts and sub-contexts available at the team’s office;
- provide details on the current context the user is in, e.g. on a collaboration scenario, on the work performed at a personal desk, etc.

Whilst it is obvious that a representation of these issues may not be most appropriately represented as a 2D virtual office, it is not clear what form of representation would in fact be most appropriate. In order to get the system up and working the functionality had to be represented in some way. It was appreciated that the mock up could not simulate every feature. However, all those features stated for inclusion in the Basic Platform had to be present so that they could be visualised by the users and the developers, and everyone could share the same view through a concrete representation of the user interface.

It was agreed that in order to achieve this common ground much closer interaction was required to clarify issues that were difficult to resolve with the semantic model as described in project reports. Closer interaction was also required between the developers to define the set of detailed interactions that needed to take place between each of the platform features and the user interface. Subsequently one of a series of developer’s workshop was organized to discuss implementation issues.

To summarise, the inspection of the emails shows that although problems were raised about the mock up and the SM, they were not immediately resolved. This is also noted in the responses to the questionnaire (see below). At this stage of the project neither email nor synchronous chat was used successfully to support in depth discussion of complex issues relating to the semantic model. The analysis of the minutes of the teleconference illustrated that the mock up was seen as having different roles and that these might be conflictual (e.g. the notion of an evolving interface based on
increased understanding, conflicted with the notion of it having to be an accurate representation of
the SM).

**Semantic model and the mock up**

A questionnaire was distributed by email to project members to consider the role of the semantic
model in relation to the mock up. Responses were received from the major stakeholders of the
project i.e. user representatives, project manager, developer, evaluators and the interface developer.

The results are summarized below:

Most of the respondents thought that the mock up was helpful in clarifying issues relating to the
Semantic Model. User representatives and the evaluators in particular saw it as their most accessible
way of gaining insight into what the project was about. It therefore provided an opportunity for
common ground to be achieved in the project which had not been possible through inspection of
project documents or in meetings.

Clearly, the mock up was a focal point for discussions, usually because it did not adhere closely
enough to Semantic Model. For example 'the earlier mock ups with avatars provided a better
representation of the SM’, although these were criticized by others for their inappropriate use of
room metaphors. The mock ups ‘force discussion about the scope of the model which was
undoubtedly valuable and deepened understanding.’ The mock up was seen as ‘an essential step, as
it is not necessarily easy for everyone to discuss concepts in abstract terms only’. Through it the
whole development team was brought into the discussion of the SM and misunderstandings became
apparent.

So we would argue that the value of the mock up lay in its ability to uncover subtle difference in
interpretation of the SM. Without the mock up the developers would not have achieved such a clear
understanding of the SM. However, their reluctance to release any version of the mock up which
did not closely adhere to the SM, or might have raised the users expectations seriously curtailed its
opportunity for the evaluators and user representatives to have the same level of input at the
conceptual stages of the project.

The early mock up’s lack of functionality meant that it was not possible at this point to assess the
extent to which a system and interface architecture based on the semantic model is useful, so that
the user representatives did not have a clear picture of the overall concept. It took a while to resolve
the remaining conflicts of SM and mock up interface in a number of areas such as the users
relationship with collaboration areas, the centrality and importance of collaboration on the interface
(i.e. it is a major concept of UNITE but only a small part of the interface); the way in which people
and their collaboration with others are represented on the interface. It was felt that when
misunderstandings regarding the functionality of the system had arisen they were never fully
resolved in email correspondence.

In summary it was important for the project to share the UNITE concept or vision. This has been
variously articulated through the SM, mock up, meetings and project documents. All of these have
played a role in articulating and bringing to life the UNITE vision for the different stakeholders in
the project. However, it is believed that the mock up has played a crucial role in furthering common
understanding amongst the team. This has been at the cost of other roles the mock up could have
played in the project.
Discussion and recommendations
The need to establish quickly a common understanding of the system concept is central to many software development projects. Where the team are highly distributed and working in a modular fashion (see Figure 2), having inconsistent or partial understandings of the overall system may lead to costly delays, overspending of resources and lowering of satisfaction.

The UNITE project attempted to develop a common ground amongst project members by presenting the UNITE vision, firstly as a SM. However, there was either some reticence to discuss the implications and relationships within this model at the start of the project, or these had not been fully understood. Time was lost because misunderstandings of the SM led to a premature generation of code, which subsequently had to be revised and/or did not integrate with that in other modules (see Figure 2 for the importance of integration between modules).

The interface mock ups did provide a means of opening up the SM for those who could not fully understand the implications of the SM. However, the necessity for the mock up to adhere closely to the SM guidelines, and not raise user expectations by providing functionality which would not be supported in the final system, limited its usefulness as a means of providing early, iterative feedback from potential users and a wider discussion of the implications of the SM on real work. When the mock ups were produced they fulfilled most of their functions and were used by the team to understand the UNITE concepts.

The analysis of the emails and the questionnaire regarding the mock up clearly shows that communication in distributed, technology driven teams remains an issue. Emails providing comments are sent but there is no feedback as to whether they have been read or their contents acted upon. Additionally, asynchronous communication does not seem to be the best mode for discussing complex issues of this type – thereby necessitating additional, unscheduled meetings between sub groups at which real work is done.

In conclusion, the establishment of a common ground, with regard to the underlying concept of UNITE was hard to achieve, without the mock up it may well have been impossible. It may be supposed that distributed, software development projects of this nature may suffer from similar handicaps.

In terms of recommendations for the conduct of future research and development projects we would emphasise the need for a theoretical base, such as UNITE's semantic model to guide development. However, merely documenting this formally is clearly insufficient. Adequate time should be allotted at the start of the project to ensure that everyone has a clear overall picture of the project. It is obvious that long, technical documents are not reader friendly, and have a negative effect on the ability of people to take in new knowledge and concepts.

To facilitate this, and provide an equal opportunity for all project members to understand underlying concepts, many different representations may have to be produced, geared towards each member’s needs. For example, system specifications drawn up by development team may be accurate, but unintelligible to those without technical training, who need to understand the basic concepts and what these mean for them at the level of 'doing work'. Figure 1, may be flawed in terms of its representation of the SM, but it provides a concrete, comprehensible example of most of the underlying concepts. In all projects there is a rush to coding, to meeting the first set of deadlines. This emphasis causes people to progress on the basis of incomplete understanding, whether it is a software or product design project.
Additionally, steps must be undertaken to facilitate, rather than inhibit discussion of underlying concepts, for example time should be allocated in meetings to discuss underlying concepts to ensure that there is a real common understanding, each members opinions should be received non-judgmentally and responses made to queries.

In summary, in the past the role of mock ups has been seen primarily in terms of facilitating user centred design, and in terms of generating early, iterative feedback to the developers (for example on functionality and usability). In this paper we have considered a different and somewhat overlooked role of the mock up in distributed projects, which is in their ability to provide a common ground and language for people to discuss and understand theoretical issues underpinning the project.

**Acknowledgements**
This project is funded by the European Union under the Information Society Technologies (IST) Programme (Project No. IST-2000-25436). This work was partially supported by the IST UNITE project; however, it represents the view of the authors only. The authors would like to thank the members of the UNITE project for providing the information and material on which this was based.
References


The study of shape elements in conveying pleasurable image

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Abstract

People’s lifestyle and living quality have changed dramatically in the 21st century. Nowadays, more and more consumers are concerned about looking for a product which is not only for functional and aesthetic pleasure but also emotional satisfaction. Products are objects that can make people happy, angry, proud or ashamed, secure or anxious. Products can empower, infuriate or delight – they have personality (Marzano 1998). This new trend has pushed the market toward a more emotionally-orientated approach in the manufacture of many future products. Today, consumers have a desire to see the extra value for the satisfaction at emotional level. Therefore, the study of product value at emotional pleasure will be a benefit to the future design for product designers. As we know, the frame structure of creating a pleasurable product has involved many aspects: cognition, cultural value, and the expression of physical feature on such a product. This paper tries to focus on the study of product’s physical form towards pleasure. The major issues in this study focus on the contours and complexity of the product form to the pleasurable emotion. The research includes visual psychology and perception. Arnheim’s theory of pictures, symbols and signs has provided a basic concept of designing the experiment. An experiment is conducted to demonstrate the relation between complexity and contours in product form. Hopefully, the result of this study will make a contribution to the future study in design areas.
The study of shape elements in conveying pleasurable image

The motivation and background OR introduction
With the growth of the lifestyle quality, consumers have a dramatic change in the needs of product quality in terms of more sophisticated concepts and emotional attached products. In other words, consumers require a new product, which has not only functional intelligence, economic fit, but also emotional satisfaction. Mr. Marzano, the manager of Phillips Corporation, believes that products are objects that can make people happy or angry, proud or ashamed, secure or anxious. Products can empower, infuriate or delight – they have personality (Marzano, 1998). This has implied that products should be able to carry an emotional function in order to fulfill the trends in the future market. A designer should notice the sensation, perception, and feeling in consumers’ minds in order to ensure their satisfaction and psychological happiness in both function and aesthetics. Facing this new marketing, manufacturers should pay more attention to the consumers desire and needs, and also, the product’s image, which has become more important in ensuring a high corporation identity in comparative markets. Nowadays, it is believed that the research in pleasurable products becomes more convincing and important during the design process.

Pleasurable products psychologically and physiologically affect our daily lives in many aspects. For instance, the impact of iMac demonstrates a success in computer market. Through a transparent material and an elegant form, the passion derived from iMac conveys a fresh, sweet like jelly-look image which arouses the warm and sweet feeling of the users when they confront it. This is a very convincing example to a designer in approaching pleasurable design, especially the cool High-Tech products. The warmth and friendliness of a material or of a shape can provide a magnificent sensation to replace the traditional feeling of the cool technology products. The same successful product, new Beetle, has also shown the power of its elegant shape, cultural meaning, and memory connection to the users. The streamline body with soft and bright pastel colors gives a pleasure element to the drivers. Compared with the heavy industrial environment of other automobiles, new Beetle demonstrates a perfect sample to connect with nature by using the metaphor of a bug shape and bright colors, which appears to be more harmonic, peaceful and pleasurable. Hence, if a designer can take advantage of these affective elements and integrate them into a design, it can create extra value in a product (Jordan 2000 & Desmet 2001).

President of Frog design, Mr. Hartmut Esslinger, believes that form should follow emotion. All products without emotional elements cannot be durable in the comparative market. (Sweet, 1999) The challenge to a designer in the future is how to create a product with a pleasurable factor.

Study purpose
This paper purposes to focus on the study of visual elements to a shape towards the affection in pleasurable vocabularies such as cute, pleasure, happy, friendly and so on. The experiment tries to focus on the study of information delivering in the difference of contours and complexity related to the pleasurable vocabularies. The study realms include three different typical contours and five different levels of elements. These five levels of complexity are created by using facial elements, since facial changes can reflect the emotion directly deep in the mind and also people can detect easily through a physical change of the mouth, eyes, muscle of the cheeks and so on.

Literature reviews
The process of reaching a goal involves a lot of emotional reaction and experiment retrospection, and it can bring out pleasure, sadness, depression and many other reactions. Those emotional
reactions can be detected through the changes of the face. The facial change appears more physical reaction in terms of skin movement, which can be easy to identify (Butler: 1999).

Eyes and mouth have been considered to be the best expression features and emotion reaction on our face. In the combination of all the facial features such as eyes, eyelashes, nose, and mouth, it is able to express the complicated emotion: happiness, enjoyment, anger, sadness and so on. In 1992, Aronof, a psychologist, uses 12 adjectives as the keywords to describe the emotion such as friendly, good, pleasure, harmony, simple and brightness in design. Lundqvist (1999) uses these 12 pairs of adjectives for the study of facial emotion. The result of the experiment proved that the features combination of eyes and mouth on the face have the most powerful intergradient of delivering very strong emotion.

As we know, there are many emotional interactions between people and people, and between people and objects. It can be reflected through consumers’ decision making when they purchase a product. Thus, to create a good strategy, the study of consumers’ emotion has become more and more important in the field of marketing research. A case study in personal mobile phone conducted by telecommunication research center in Holland (KPN) tends to analyze the emotional factors of the consumers. And the result is valuable for the guidelines of the future design. In the study, EMOcard are applied to the emotional measurement in order to evaluate the value for the products. The result of that experiment demonstrates that consumers’ emotion and attitude are directly connected with the affective elements appearing on the product shapes. A positive conclusion goes to those products carrying these factors: Pleasant, Professional, Enjoyment, and Sophisticated appear to be more emotional affection to the consumers (Desmet: 2001).

Kansei Engineering is a new method to evaluate the image to a product. Furthermore, it allows designers to control or understand users’ emotion and perception to a product, through systematic processes. This method becomes more useful for researchers in doing emotional study. With the research results, a designer can take advantage of understanding lifestyle as well as the consumer’s behaviour, and finally integrate these fragments into his products. This process definitely can help corporations win a lot of marketing share.

The images, somehow conceived by a different person, can communicate different levels of meaning. They can demonstrate a realistic object or represent a highly abstract social meaning through visual shape. They also can describe the things of our environment themselves. Like abstract paintings, they commonly show the style that is more abstract than the way these people, or happenings would register on a photographic plate. Images deliver the meaning of the reality in two opposite directions. They can demonstrate between the realm of practical and abstract things. The interpretation/decoding process to the images involves many factors, for instance, the culture and the age of viewers. A young boy rationally may see images in a more realistic way, while adults can see the same images with more abstract minds. Thus, the different level of this mind process will create a different interpretation of the things/images.

Visual psychologist, Arnheim states that the image can be served as a picture or as a symbol. They can also be used as mere signs. The theory consists of three functions of images: sign, picture, and symbol. A simple line can state a visual form or structural quality through a created image. Hence, it can represent an abstract social meaning in our living environment. For instance, it can be represented as a nice-marriage through a created form with very smooth curves, to represent a bad-marriage through a zigzag shape. It is because, when people perceive the image, the image constructed by lines can represent three levels of meaning: sign, picture and symbol. Those three functions will not stand only into one particular image, but some other images, which can also represent the above three functions at the same time. For example, a triangle can mean a sign of
danger, or a picture of a mountain, or a symbol of a tree-hierarchy. In this case, the image itself does not tell which function is intended.

An image serves merely as a sign to the extent to which it stands for a particular content without reflecting visually its characteristics, words, and alphabets (ex. “a”, “b” and so on). The letter and words are considered as a sign because, in this case, they are created for serving similar purposes of identification and distinction. This is also shown to the portrayal. It is because the portrayals operate as the references to the particular figures for whom they stand.

Images are pictures to the extent to which they portray things located at a lower level of abstractness than they are themselves (Arnheim, 1969). The pictures are created by catching or rendering the relevant elements- shape, color, movement- of the objects or activities they depict. For instance, a child may draw a rough circle and two straight lines to identify the papa’s head and two legs. He does not describe all the details of the face features on the head, but we still can understand it. It is because we can complete the image in our mind based on the past experience or knowledge we have. The fact is that a picture or image can be completed at any level of abstractness, even if different viewers perceive with different interpretations.

An image acts as a symbol to the extent to which it portrays things which are at a higher level of abstractness than is the symbol itself (Arnheim, 1969) for instance, a portrait of King Henry III, is a picture of king. At the same time, it can stand as a symbol of kingship and of the quality of strength, and brutality.

The human mind can be forced to produce replicas of things, but it is not naturally geared to it (Arnheim, 1969). This has implied that the shape of a product could confuse a user through appearance since visual perception of a user is connected to the significant form of a product. The complexity of line construction and line shape can cause part of the affections through the form generation, and this has given the user a random imagination during the visual interaction. It is also true that the smoothness of a swelling curve tends to be more friendly, soothing, warm, and pleasurable.

To the extent of visual perception, the different degrees of abstractness in product shape could deliver different levels of function in three categories: sign, picture and symbol. And each level will cause different arousal or meaning to a user when perceiving it. In other words, all the details of the product shape should deliver some sorts of meaning to the users, both in a still image and in a dynamic interaction. In product design, being a designer, we should know what the shape means to the users. The different scale of abstraction of product shape is associated with the cultural difference, contours and complexity of the form. To clarify the meaning of the shape, designers have to understand the needs and the perception of consumers to the products. This study tends to answer this question through a theoretical research and an experiment.

Methods

Selected subjects
Thirty subjects including 17 females and 13 males were involved in this experiment. The average age is 20 years old. They are second year college students currently studying in industrial design department (10 persons), medical management (10 persons), and industrial engineering management department (10 persons). All subjects consented to the experiment.
Stimuli
Fifteen stimuli were used in this experiment, which include three columns and five levels (3x5). (See Fig. 1) At vertical columns, three basic contour shapes were created for each column: rectangular, circle, and the combination of straight line and curve. Within each column, there are five levels from very simple feature to very complicated feature. Level V is considered to be the most complicated feature in this experiment. It contains two eyes, a nose, and a mouth. Level IV is considered to be less complicated than level V. It contains two eyes, and a mouth. Followed with the sequence, level I does not carry any detail on the top surface. (See Fig 1)

Each stimulus was generated in the 3D Allias software. Each stimulus is created with almost the same amount of volume and surface, and presented with the same view angle and the same quality of light source in the screen. When processing the experiment, stimuli were randomised to appear in the computer screen at the front of subjects. Thirty subjects were divided into two groups. The second group started with the test from the opposite sequence of the first group in order to avoid peer/learning affect.

Questionnaire
The adjectives adopted in the questionnaire were quoted from Aronoff’s research, a psychological research study in facial emotional psychology (Lundqvist, 1999). Some adjectives were derived from author’s previous study in emotion to the can opener project. In the questionnaire, it includes seven pair of adjectives: boring/ fun, not pleasure/ very pleasure, unfriendly/ very friendly, unfamiliar/ very familiar, not cute/ very cute, ugly/ pretty, and dislike/ like. Seven scaling measurement evaluation system is used to evaluate the subjects’ emotion to the stimulus.

Experiment procedures
In the experiment, every 15 subjects were arranged in the same room at an appropriate distance where subjects can see the computer image clearly. The subjects were asked to watch the stimuli in the computer screen for enough time, and then answer the identical questions “intuitionally” in the questionnaire. The sequence of stimulus had been randomized organized. Two groups of subjects (15 each) took the test followed with the opposite order of the randomized stimulus.
Data mining and analysis
After gathering 30 questionnaires, MANOVA software in Window SPSS is given to analyze the difference between the contours of shape and the complexity of elements. In addition, the Duncan’s Multiple Range Test is used to test if there is a significant difference within the complexity between each two of the levels.

Result and analysis
a) The result of statistic
The result of MANOVA test demonstrates as follows:

1. Six pairs of adjectives (cute, fun, like, friendly, pleasurable, pretty) to the type of contours and complexity of elements do not have a statistic significant difference. The result states that there is no interaction between the type of contours and complexity of line elements. Although P value is less than .05 only in “familiar” adjective, it shows that there is a significant difference (See Table 1).

2. The statistic result shows that seven pairs of adjectives to the complexity have a significant difference (See Table 2). In addition, the result shows that six pairs of adjectives to the contours have a significant difference (See table 3).

<table>
<thead>
<tr>
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<tr>
<td>Not pretty/ Very Pretty</td>
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<td>.761</td>
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Table 1: Complexity and contours

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Table 2: Complexity

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<td>Not Pleasurable/Very Pleasurable</td>
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<tr>
<td>Not pretty/Very Pretty</td>
<td>8.90</td>
<td>.000</td>
</tr>
</tbody>
</table>

Table 3: Contours
3. Duncan’s Multiple Range Test is given to test if there is any significant difference between each two levels of complexity.

(A) Based on the statistic result of “cute” adjective on table 4, the average demonstrates that the more complex stimulus is, the cuter stimulus is. Among five levels of element complexity, the average of the max. and min. value between (group 1, 2), (group 2, 3), and (group 4, 5) shows no significant difference. Hence, it can be concluded that there is a significant difference in the complexity among 1, 3, 5 levels.

(B) Based on the statistic result of ‘familiar’ adjective on the table 5, the average of statistic result demonstrates that the more complex stimulus is, the more familiar stimulus is. Among five levels of element complexity, the average of the max. and min. value between (group 2,3), and (group 1,4,5) shows no significant difference. Hence, it can be concluded that there is a significant difference on the complexity between 2, 3 and 4, 5 levels.

(C) Based on the statistic result of “fun” adjective on the table 6, the average of statistic result demonstrates that the more complex stimulus is, the more fun stimulus is. Among five levels of element complexity, the average of the max. and min. value between (group 1), (group 2, 3) and (group 4, 5) shows no significant difference. Hence, it can be concluded that there is a significant difference on the complexity among 1, 3, 5 level.

(D) Based on the statistic result of “like” adjective on the table 7, the average of statistic result demonstrates that the more complex stimulus is, the more likeness stimulus is. Among five levels of element complexity, the average of the max. and min. value between (group 1, 2), (group 2,3) and (group 4, 5) shows no significant difference. Hence, it can be concluded that there is a significant difference on the complexity among 1, 3, 5 level.

(E) Based on the statistic result of “pleasurable” adjective on table 8, the average of statistic result demonstrates that the more complex stimulus is, the more pleasurable stimulus is. Among five levels of element complexity, the average of the max. and min. value between (group 1), (group 2, 3) and (group 4, 5) shows no significant difference. Hence, it can be concluded that there is a significant difference on the complexity among 1, 3, 5 level.

(F) Based on the statistic result of “pretty” adjective on table 9, the average of statistic result demonstrates that the more complex stimulus is, the prettier stimulus is. Among five levels of element complexity, the average of the max. and min. value between (group 1, 2), (group 4, 5) shows no significant difference. Hence, it can be concluded that there is a significant difference on the complexity among level 1, 2, 3, and 4, 5.

(G) Based on the statistic result of “friendly” adjective on table 10, the average of statistic result demonstrates that the more complex stimulus is, the friendlier stimulus is. Among five levels of element complexity, the average of the max. and min. value between (group 1, 2, 3) and (group 4, 5) shows no significant difference. Hence, it can be concluded that there is a significant difference on the complexity among level 1, 2, 3 and level 4, 5.
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Table 4

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Table 6

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Table 8

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Table 10
The result of statistic analysis
(a) According to the MANOVA result, the adjective “familiar” does not have significance to contours. It is assumed that the complexity of elements is more dominated than contours are. Therefore, subjects might lose the focus, and lay more stress on the complexity when tested.

(b) Within 7 pairs of adjectives, 4 pairs of adjectives (cute, fun, likeness, pleasurable) are grouped into 3 levels (level 1,3,5), which suggest 3 levels of stimuli can represent 5 levels in this case.

(c) It is shown that there is a positive relation between complexity and adjective. In other words, the more abstract (the less complexity), the more fun, cute, pleasurable, and likable is. Beside “familiar” adjective, it proves, the more concrete, the better expression is (See table 11). This result can refer to Arnheim’s theory.

Conclusion
In this study, three conclusions were found. First, the complexity of product shapes can affect consumer’s perception to the product. Based on Arnheim’s theory, less complexity shape can provide more imagination spacing, while more complexity shape can provide more concreted form to the product and also give clearer image to the consumers. This result is confirmed through a toy design, which requires a funny shape and perhaps a smile feature, which catch many attentions from children. Second, the result of statistic shows that pleasurable adjective has a positive relationship with others (Fig. 2). For instance, the cuter, the more pleasurable. The more friendly, the more pleasurable. Third, the complexity of the product shape has a positive relation with seven adjectives. The less complexity shape has lack of demonstrating a pleasurable semantic, such as cute, friendly, fun and so on. For example, in Florida, a facade of Disney’s hotel designed by a famous architect, Michael Gray, is constructed by seven figures in snow-white story, which demonstrate the happiness and pleasure to the customers. Fourth, the consumer’s emotion has a preference of liking more complexity shape in this case. Fifth, based on this result, it will be more efficient by illuminating some of stimulus for the future experiment. Therefore, simply, level 1,3,5 are suggested to represent the whole range of 5 levels in the future experiment.
In this study, because of the limitation of using facial features as stimuli, it is lack of the representation of whole aspects of a product shape such as general cognition and visual perception. In the reality, far more complicated factors within a product shape such as the color affection, material sensitivity, and operation cognition should also be involved. In order to understand the meaning of form completely, the study of compound factors will be the suggestion for future research.
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Desperately seeking common ground: the emergence of design management in Greece

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Abstract

“Common ground,” defined as the “ability to communicate across fields,” provides the background for this paper. Communicating across fields is very significant in the design domain in general and particularly in design management, as both areas are highly interdisciplinary. The paper traces the “common ground” theme in the contemporary practice of design and design management in the Greek context. The state of Greek design is briefly presented and then the issue of design management is discussed through a number of interviews with related professionals. The cultivation of a common ground, by all parties involved, appears to be a crucial factor in the establishment and development of design management in the country. Further research is suggested in specific sectors of the local industry.
Desperately seeking common ground: the emergence of design management in Greece

Introduction
The theme for this conference is “common ground” and it provides the key concept for this paper. Herbert Simon (1996: 137) describes common ground as the “ability to communicate across fields.” This ability is very significant in the design domain, which is interdisciplinary par excellence (Scrivener et.al., 2000). Furthermore, this ability is particularly important in design management, a sub-discipline resulting from the interaction between design and management, two “cultures” with different interests and values. This paper will explore the “common ground” theme in relation to design management in a specific local context, that of Greece.

More specifically, the paper will present recent research on the development of design management in Greece. The main objectives of the research consist in tracing the past of design management in the country, identifying its current problems, and suggesting directions for its future development. As the field of design history and theory is practically virgin in Greece, it was decided that the research would have to take two forms.

Firstly, the research consisted of a bibliographic survey on the state of Greek design in general and of Greek product design in particular. A concise presentation of this bibliographic survey provides the necessary background. Despite the significant dearth of sources on the state of design in Greece, this brief historical account gives a basic view of this domain and indicates some of its shortcomings.

Secondly, a series of semi-structured interviews were conducted with a number of individuals who have been active in the last two decades in Greece, in the fields of design, design education, design management, and administration. The interviews focus on the state of design management in Greece and they have been used to explore the “common ground” issue in relation to the design sector in Greece.

The state of the design domain in Greece
It is generally acknowledged that in Greece the design domain in general is in a state of chronic underdevelopment, and produces very poor results compared to most European countries (Tzirtzilakis, 1989) (Vokotopoulos et.al., 1992; Adamou, 2001). This might be generally attributed to the orientation of the Greek economy to non-productive sectors, and to the direct or indirect dependency of the local economy from foreign capital (Mouzelis, 1978; Tsoukalas, 1992).

Pre-war developments of the design sector were limited in scope and the production of Greek firms was mainly based on copying foreign designs, in order to suppress cost. To give a characteristic example, copying or adapting foreign designs constituted standard practice in the furniture sector in the mid-war period, when a certain blooming of industry and design was taking place (Parmenidis and Roupa, 2002: 61, 99-100). After the war, there was a brief rise of design-related activities in the late fifties and early sixties, thanks to a group of art theorists, architects, businessmen, and other professionals. In 1962 they established the Centre and the Society of Industrial Morphology, aiming at creating the foundations for local design development, but this initiative was short-lived (Tzirtzilakis, 1989: 115).

State support has been non-existent until the late seventies. Then, design-related activities in Greece were relatively developed and reached a peak during the late eighties and the early nineties, thanks to the activities of the Hellenic Product Design Centre, which was founded in 1979 and operated...
under the auspices of the Hellenic Organization of Small and Medium-Sized Industries (EOMMEX). However, funding was discontinued and the Hellenic Product Design Centre was shut down in 1993 (Vokotopoulos et al., 1992: 21-22) (Private communication with C. Karabelas and G. Adamopoulos of EOMMEX). Generally, the competitiveness of many Greek products is based on low prices rather than quality (Vokotopoulos et al., 1992: 9). A clear indication of the present shortcomings of the local design scene compared to other European countries is provided by the limited or non-existent representation of Greece in the activities of the European Community Design Prize (ECDP), which was launched in 1988 as a joint initiative between the design promotion organizations of the Member States and the Commission of the European Communities (Thackara, 1997).

One of the main reasons that hinder the development of product design activities in Greece is the fact that there are no Industrial Design Departments in Greek Universities. Design is taught as an elective course in some engineering or architectural departments, or in occasional seminars by various private or public institutions. Autonomous product design departments belong to private design colleges, which, however, do not have higher education status, according to the Greek law (Vokotopoulos et al., 1992: 23-24). The inadequacy of formal design education in Greece is responsible to a great extent for the fragmentation of design activities and discourse in the country. Design activities are primarily carried out by architects, engineers of various specializations, or designers educated in private institutions or abroad (Karabelas, 1993). A survey of contemporary design in Greece reveals that most of it never reaches mass production but remains at prototype level or is produced as one-off (Karabelas, 1993). The public awareness of design is very limited and design is practically equated with styling (Yagou, 2001: 134; Vokotopoulos et al., 1992: 9).

However, there are positive signs of change. There are some indications that the related professional and academic communities are gradually becoming more mature and, therefore, more interested in the combination of design with management, which appears to be a challenging direction for the near future. In March 2002, the founding meeting of the Hellenic Design Society took place in Athens. The Society aims to promote design activities in this country and revitalize the design discourse. A number of design competitions recently organized by private and public bodies will also perhaps support this aim. Finally, new design-related departments have been established in private and public institutions.

**Attitudes of Greek firms towards design and design management**

The “common ground” theme appears to be a crucial one in the formation of the design management domain in general: “Design management was created because in practice it was discovered that there is a large communication gap between managers and designers. It’s as if we’re talking about two different tribes speaking a different language and having different cultures. They don’t understand each other. And they can’t communicate with each other. The need to unite gave birth to an intermediate common aim, somebody who doesn’t have to be industrial designer or manager to deal with design, in order to be able to understand and translate, to speak both languages, to know both cultures and understand the demands of one side so that he/she can express them to the other side and vice versa” (Interview with economist/administrator) (Tsironi, 2002: 76). How does this apply to the Greek reality? Following the presentation of the state of design in Greece in the previous subchapter, we will now use the material of the interviews in order to focus on specific issues of design management, and relate these to the general structural and organizational problems of the Greek design domain.

The practice of design management in the Greek business context becomes complicated by the way firms are structured and managed. The size of Greek firms is a key factor in the way such firms tend to organise and develop themselves. “The problem with Greek firms is that, because they don’t
have the range and, respectively, the production runs of foreign firms, they try to reduce the size of the company or to keep it as small as possible, with the minimum number of employees. [...] Greek firms are essentially family-based (Interview with designer A) (Tsironi, 2002: 82). Duties are not distributed, but usually gathered under the authority of a single member of the family, who acts as the “boss” and has practically full responsibility for running the company. “Generally, in the Greek firm, one has to deal with the boss. [...] In a sense, firms are structured like this, the starting point is the family, so there is basically one person who has all the responsibility and makes all the decisions” (Interview with designer A) (Tsironi, 2002: 80-81). This means further that this person generally undertakes a variety of roles, usually including both roles of designer and manager. “[It is] one-man show. He is the businessman, the manager, the designer” (Interview with designer/educator) (Tsironi, 2002: 69). “In the Greek company, it is the general director who, in a sense, does everything” (Interview with designer A) (Tsironi, 2002: 80). In this case, the dialogue between design and management, which has been mentioned as forming the foundation of design management, doesn’t really exist. Both activities are essentially carried out by the same person.

This situation is exacerbated by the fact that firms are generally ignorant about design. “At this moment, Greek firms don’t know about design” (Interview with design theorist/educator) (Tsironi, 2002: 95). Even when they do know about it, it doesn’t attract much attention and it is not considered as an activity which might be relegated to specialists. As a result, it is dealt with in an informal way. Design is performed either by the businessman/director himself, or is even left to technical staff. “First of all, we have to perform this leap, to decide that it is not the businessman who does the design, or it is not the chief technician who does the design” (Interview with architect/designer/educator) (Tsironi, 2002: 101). The need for design expertise is not recognised. “They think they don’t need it. They act intuitively” (Interview with design theorist/educator) (Tsironi, 2002: 97). Similarly, other disciplines closely related to design, such as ergonomics, are not considered as demanding a specialist treatment. “Ergonomics? No, they think they can do it themselves” (Interview with design theorist/educator) (Tsironi, 2002: 98). This casual attitude towards design implies that professional design input is not valued in Greece and is in low demand. “I do not have the experience of a firm in Greece that deals with industrial designers. [...] From what I know, the situation is not so good. [...] I hear about things happening here and there, but in the end very few things are happening” (Interview with design theorist/educator) (Tsironi, 2002: 97). Even when design expertise is sought after, this often happens in a non-systematic, ad hoc basis. “Here in Greece, there are few companies who employ designers. Some employ them occasionally, some perhaps not at all. They might simply be getting a few ideas [from them] from time to time” (Interview with design theorist/educator) (Tsironi, 2002: 87-88).

The product development process is quite informal and unstructured, if it exists at all. New products often result from copying foreign products which have been successful. “Market research exists, to a certain extent, primarily through trade fairs, in which [Greek businesspeople] participate and which they visit. There is, to a small extent, production; they are informed about it to some point. What definitely doesn’t exist is new product development. Very few people know about this. What happens primarily, or at least what has been happening so far, is small modifications in existing products. There is no substantial new product development from scratch” (Interview with designer A) (Tsironi, 2002: 81). The complexity and cost of new product development appears daunting for Greek firms, and is therefore avoided. “There is a tendency [in Greek firms] to start new product development and in the course of the project they realise that there are many difficulties in applying all these innovations that exist in a new product. So there are many cases when several firms suspend the product development process” (Interview with designer A) (Tsironi, 2002: 83).

Given the doubt “whether [Greek firms] have realised the value of design itself” (Interview with architect/designer/educator) (Tsironi, 2002: 101), it is probably wildly optimistic to consider the
role of design management in their activities. “How can design management exist, when design itself doesn’t have a secure place in the Greek company?” (Interview with designer/educator) (Tsironi, 2002: 69) “There is hardly a need for design. […] Companies are still on a medieval level of thinking about what a product is, […] a thing, not even an object, “a thing which I sell” ” (Interview with designer B) (Tsironi, 2002: 119). “In Greece, we designers are forced to act as design managers. Because nobody knows the meaning of the term and nobody thinks that it is necessary” (Interview with designer B) (Tsironi, 2002: 115). The general impression is that design management is practically non-existent, despite its great potential for small and medium sized industries. “I have the feeling that in Greece nobody has a clue about design management. […] They have not understood what a powerful weapon design management could be in Greece” (Interview with economist/administrator) (Tsironi, 2002: 76-77). More specifically, discussing the furniture sector, it is stated: “Design management […] I haven’t seen it” (Interview with designer/educator) (Tsironi, 2002: 69). In more general terms, it is claimed that “[…] management in general is something new for Greece, not to mention design management” (Interview with designer A) (Tsironi, 2002: 82). There seems to be an issue of maturity, which Greek companies fail to reach. Their activities remain on an elementary level, where design management is probably a luxury they can’t afford. “The companies which collaborate with the Design Management Institute have reached a high degree of maturity. [In Greece], we’re talking about companies who need much more basic things, to be able to take advantage of more basic things. So perhaps design management has a very low priority” (Interview with design theorist/educator) (Tsironi, 2002: 98). This of course becomes in turn a major drawback to any further development.

Focus on the issue of design teams: members and problems

We will now focus on some remarks on design group work and on the interaction between various specialists involved in the design and design management process. We will comment on some of the views expressed by the people interviewed, which are related to the attribution of roles in design management and to issues of communication.

First of all we observe that there seems to be no consensus regarding the question of “who does what”. This lack of “common ground” might be attributed to the background of the interviewees, in other words, each one of them seems to assign a more important role in the design team to people of one’s own specialisation: “The third level of design management is the project itself. The first and most important thing for a design project to start is the existence of the so-called design brief. What is the design brief? It is design before design. The design brief is not the job of the designer. It is the job of anyone but the designer” (Interview with economist/administrator) (Tsironi, 2002: 74). “An economist? I’m afraid he won’t understand things very well” (Interview with architect/designer/educator) (Tsironi, 2002: 103). “It is difficult […] for somebody who is an economist or of a different specialization, to suddenly become the head of the [design] team” (Interview with designer/educator) (Tsironi, 2002: 66).

The variety of opinions extends to educational issues, specifically regarding the area of education in which design management belongs. It is acknowledged that “designers should know the business side of design” (Interview with design theorist/educator) (Tsironi, 2002: 86). Also, the view is expressed that design management courses “would be attended by management and administration students, […] also by specialists from this area, i.e. production managers, engineers, administration people, as well as designers” (Interview with design theorist/educator) (Tsironi, 2002: 86). However, the relevance of design management to studies of economics is questioned, and the view is expressed that design management belongs “[…] definitely in a technical faculty. It’s not a financial matter. Economists can’t do it” (Interview with architect/designer/educator) (Tsironi, 2002: 102). Given the interdisciplinary character of knowledge in general and of design management in particular, the attempt to label and classify design management in this way is rather
worrying. Furthermore, it is believed that a design manager “is very important […] especially as a good assistant of the design department. Not as the person who will take the final decisions. If this kind of cooperation exists, I consider it very important. Otherwise, it shouldn’t exist at all” (Interview with designer/educator) (Tsironi, 2002: 66). We sense here the conception of the lone, creative designer/hero, who faces the reactions of “the others”. This might be an indication that the concept of the design team itself is not assimilated by Greek designers. This conjecture should be further explored, but it is underpinned by the fact that Greek designers generally have very limited interaction with team work in industry, as already mentioned in the survey of local design.

Where opinions do not differ is the realisation that there are no design management specialists to be found in Greece. “I follow the people who write about design management abroad, I have never seen any Greek name. This is a very new area of management and a Greek person who goes abroad will not choose to deal with it, he/she will choose Finance or Marketing. They are established, design management is very new” (Interview with design theorist/educator) (Tsironi, 2002: 93). This of course obstructs any potential developments in the field, even in the case of firms with a positive stance towards design. “Perhaps the firms wanted to employ a design manager and could not find one. I can’t rule this out” (Interview with designer/educator) (Tsironi, 2002: 70). Which is in turn emphasised by a sharp but possibly true realisation: “We say that there are no Greek design managers. But are there many Greek designers who could be serious and adequate enough in order to realise a project from A to Z with all its demands? My feeling is that there aren’t” (economist/administrator) (Tsironi, 2002: 77).

Conclusions and implications
Our research findings have provided an introduction to the current state of the Greek design domain in general, and of design management in particular. The combination of the bibliographic search with the interviews point to a wide range of issues, which directly affect the state of design management in Greece. Innovations are usually “imported,” often with significant time-lag, and most companies do not recognize the need of adding value to products through local design input. On the executive level, the need to commission and manage design is inadequately understood and leads to confusion of professional roles. On the level of public administration, support for any initiatives related to the management of design is lacking. Also, the academic environment is not sufficiently developed to encompass design management. These shortcomings in turn affect the quality of professional design available today in the country, as designers are forced to operate in an underdeveloped and adverse context, which offers them limited opportunities.

In more general terms, [in Greece] “it is very clear that one has borrowed a design ideology primarily produced abroad, in other words forms that are beautiful, forms that one can see their evolution, can understand the rules to design and transform them, and here one doesn’t have the technostructure. The structure of tools, of people, of knowledge, etc.” (Interview with architect/designer/educator) (Tsironi, 2002: 107) This quote expresses the fact that an aesthetic/formal ideology has been borrowed, adapted, and used, whereas the technical/professional/managerial ideology remains in an embryonic state. What could be done to face this situation? During the recent founding meeting of the Hellenic Design Society in Athens, the designer and educator G. Haidopoulos made a sharp and substantial remark: “The post-war history of design in Greece has been fragmented and heroic. It is no longer possible to have a heroic attitude against design in this country.” In other words, it is absolutely vital to develop a coherent and systematic approach against design, with the contribution of all related parties. This is supported by the fact that Greek companies are nowadays forced to operate in a pan-European and often global context, which presents unforeseen problems and demands new and highly creative solutions.
A minimum of consensus, as well as a high level of communication between all interested parties, is an absolute prerequisite for further development, given the fragmentation of design-related activities in Greece. The “common ground” of each other’s language should be discovered and cultivated, if anything significant is to be achieved in the near future. Further research is necessary on the subject, especially in the form of extensive, sector-specific case studies. Such studies would identify and demonstrate the range and variety of problems faced by certain sectors, as far as the interaction between design and management is concerned.
References


Biographical notes

This section provides brief biographical notes on all authors and co-authors, listed in alphabetical order.
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Linden J. Ball is a Senior Lecturer in the Psychology Department at Lancaster University. Following research positions at Plymouth and Loughborough Universities, he joined the University of Derby in 1993 as a Senior Lecturer, and held various posts (including Head of Psychology and Reader in Cognitive Psychology) before moving to Lancaster in 2000. Linden’s general research interests relate to theoretical and applied issues concerning the nature, development and computer-based support of expert thinking and reasoning. Much of his research has focused on design expertise, and he is currently investigating the nature of decision-making and solution-generation processes in design, and the links between sketching and cognition. He is also keen on triangulating research data on design deriving from different methodologies such as cognitive ethnography and verbal protocol analysis. Linden has produced over 80 publications, including journal papers, book chapters, edited books, conference papers and professional articles.
Twan Basten (1969) is an assistant professor in the Department of Electrical Engineering at the Technische Universiteit Eindhoven. In 1993, he received a Master's degree (with honours) in Computing Science from the Technische Universiteit Eindhoven; in 1998, he received his PhD degree in Computing Science from the same university, with a thesis titled "In Terms of Nets: System Design with Petri Nets and Process Algebra." His current research interest is the design of complex, resource-constrained embedded systems, based on a solid mathematical foundation, with a special focus on multiprocessor systems. Twan Basten has publications in the areas of workflow management, formal methods, and system design. He is an associate member of the IEEE.
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John Broadbent is a Senior Lecturer in the Faculty of Design, Architecture and Building at the University of Technology Sydney in Australia. He graduated and received his doctorate in the biological sciences at Reading University. John worked as a microbiologist in Nigeria and Australia for almost a decade. Having gained a Graduate Diploma in Environmental Studies, he then worked as environmental consultant for over a decade. During this latter period John lectured in the Design School of the (then) Sydney College of the Arts, which merged with the University of Technology Sydney in 1988. His lecturing today spans information retrieval, research methods, technological change, design futures, systems thinking. His current research is into design as a sociocultural evolutionary guidance system. This work is based broadly on the holistic sciences of chaos and complexity, and more specifically on Ervin Laszlo’s General Evolution Theory. John has published some 20 journal articles, 40 book chapters/reviews/reports and 15 conference papers.
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John Fraser's area of interest concerns the use of Communication and Information Technology for collaborative design work in international educational contexts. Some of the questions he addresses are - does the use of ICT influence the decision making strategies of students? - and - do the structural aspects of a problem-solving process significantly determine outcomes? Currently he is involved in a research project called DesignLink. This has been set up to give students the opportunity to work collaboratively across national and cultural borders. The intention of the project is to examine the idea generating, solution-seeking and decision-making methods and processes that design students adopt when using information and communication technology (ICT) in computer-supported co-operative work. The research concentrates on distributed teams of design students drawn from Indiana University-Purdue University-Indianapolis (USA), University of Missouri-Columbia (USA), Southampton Institute of Higher Education (UK), the University of Ulster (Northern Ireland), Cali-Colombia (South America), Toronto (Canada), Denver (USA), Nebraska (USA), and from Richmond American International University in London.

http://www.richmond.ac.uk/academ/spprog/designlink.htm
The author would be very interested to know of anyone who might be interested in joining the third phase of DesignLink.
Ken Friedman is associate professor of leadership and strategic design at the Norwegian School of Management, Department of Knowledge Management, and visiting professor at the Advanced Research Institute of the Staffordshire University School of Art and Design, UK. Friedman's research on the foundations of design is an attempt to develop a philosophy and theory that will anchor robust practice in the field. Friedman has published articles and books on management and organization, information science, philosophy and art. In the 1980s, he was publisher and CEO of The Art Economist Corporation in New York. He serves on the Editorial Advisory Board of ARTbibliographies Modern. He is also a practicing artist and designer who has been active in the international laboratory known as Fluxus. Friedman has edited special issues of such journals as Built Environment and Performance Research. With David Durling, he was co-chair of the La Clusaz conference Doctoral Education in Design: Foundations for the Future.
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Franca Giannini graduated in Mathematics at the University of Genova in 1986. From 1986 to 1989 she worked in the research and development department of Italcad Tecnologie e Sistemi where she was integrating boundary and CSG representations in the Autotrol S7000 solid modeller. Since 1989 she has been working as a researcher at I.M.A., where she has been involved in some National and International Projects on geometric modelling, production automation and graphical user interface. She has also acted as program committee member of International Conferences on the topic, like Eurographics99, FEATS'2001, SMI, ACM SoCG2001. She is also the co-author of a patented system for automatic feature extraction and has developed hierarchical boundary models for feature based representation. Her research interests include product modelling and methods and tools for distributed design.
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