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Developing Models of Designing to Enable Practice.

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Reconsideration of the nature of design and the exploration of the future scope of design practice and its role within society is recurrent within academe. This has been represented recently by discussion about the role of design in the development of services rather than products.

This paper describes an investigation of complex system design, which led to the derivation of a content-based model of design practice. It also describes the process of determining the utility of the model, based on the perceptions of design practitioners.

The model was originally derived to assist the understanding of activists involved in complex system design projects, such as public services. This process of derivation was based on a case study of a complex system design project that sought to refine the process for that area of design activity. The study used quantitative and qualitative methods; involving a performance evaluation of the case study project and a repertory grid analysis of its design failings to examine the proposition that the strategy that manages the design techniques used to find the solution can be improved by understanding more about the role and attitude of the designers in the context of the process in which they are applied. The conclusions to this analysis were devised specifically with the role of the designer in mind, in order to maximize his/her effectiveness in minimizing design failings. The conclusions were derived from failings, which were found to occur at a high level in the decision-making hierarchy of the case study project. A correlation of the conclusions with existing design literature was undertaken. A comparison was then carried out of both the conclusions and existing pertinent literature with the reflections of other design practitioners who have experience of complex systems design projects. The practitioners were drawn from a cross-section of notable, best-practice design organizations and their reflections were recorded in response to semi-structured interviews based upon the specific example of a complex systems design project that they had undertaken for their organization.

The study resulted in a set of five influential design factors, one of which was concerned with levels of design thinking, which was found to correlate strongly with Archer's model of levels of design decision-making. From this factor a new model was derived to assist the understanding of the context in which design does and can operate, thereby assisting the practice of designers. This model recognises three levels of complexity of design practice, namely: design at the level of product configuration and detail, design at the level of systems thinking, and design at the level of policy formation.

Since its development, the model has been used in the educational process of industrial design students. This process has been guided by an action research programme to assist them to understand the nature of complexity in the design activities implied by the major project design briefs that they devise for their final year undergraduate studies.

More recently the utility of the model has been reassessed to assist the development of a design initiative seeking to promote innovation in design education and practice. The purpose of this initiative is to develop design knowledge and expertise at the levels of system design and the design of policy. A related project (DIEC) that has grown from the initiative has used the model to prime attendees at a week-long workshop to explore the future of design education and practice, with the aim of supporting the development of expertise in the area of service design. This paper ends by reporting on the reflections of a sample of attendees to the workshop, concerning their perception of the usefulness of the model following their experience of it.

The paper concludes with a brief description of other research that has been carried out as part of the on-going, recurrent study of content-based models of design practice.

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Abstract
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Developing Models of Designing to Enable Practice

Background

Reconsideration of the nature of design and the exploration of the future scope of design practice and its role within society is recurrent within academe (Thomas, 1993). This has recently been seen in discussion about the role of design in the development of services rather than products (Hollins, 2003). The ethical basis of the function of design in the service of industry has also been brought into question by a number of design conferences and researchers (Young, Cooper & Blair, 2001). Improving the range of influence of design to enable better policies and strategies for responsible product development is a latent agenda of design academics and practitioners alike and many conferences have debated how design theory and practice might be brought into better association to deliver this improvement (Swan, 2000), (Cooper & Press, 2003).

This paper describes an investigation of complex system design, which led to the derivation of a content-based model of design practice. The model was devised specifically with the role of the designer in mind, in order to maximize his/her effectiveness in minimizing design failings. The research has been recurrent over a fifteen-year period, in keeping with the latent agenda described above. During this time the author's role has developed from that of designer to case study researcher to action researcher in the subject.

A Case Study of Complex System Design

The model was initially derived to assist the understanding of activists in complex system design projects, such as public services. This derivation was based on the case study of a project to develop an emergency service communications system (Young, 1989). The study sought to refine the design process and involved a thorough assimilation of the records of the original project. It used quantitative and qualitative methods; involving a performance evaluation of the case study project (Chapanis, 1962) and a repertory grid analysis of its design failings (Stewart and Stewart, 1981), to examine the proposition that the strategy that manages the design techniques used to find the solution can be improved by understanding more about the role and attitude of the designers in the context of the process in which they are applied.

The performance evaluation (Young, 1989 pp 138-194) identified the various shortcomings that affected the design of the communication control consoles that were the main point of user interface of the communication system. It also assessed the significance of the shortcomings. The evaluation used a process of triangulation to compare the shortcomings at three different control room sites, in order to assess their significance, identify any bias which existed in the opinions of users, to substantiate the findings and to determine which conclusions might be specific to a particular site. The principal conclusion of the evaluation was that the most serious shortcomings were not directly related to decisions about the

console interface and therefore were outside the immediate control of the designer, e.g.:

- Sunlight and climate periodically had very adverse affects on the comfort of users and their working efficiency.
- Shortcomings in manufacturer's specifications for console equipment represented the most serious causes of discomfort and inefficiency to users.

The case study then analysed the design failings leading to the shortcomings by retracing the path of the design process reported in the detailed Assimilation Records (Young, 1984), (Young, 1989 pp 56-135). The resultant factors were categorized by deciding whether they were caused by:

- Errors on the part of the designer,
- Oversight of associated organisational conflicts, or
- Factors outside the control of the designer.

A summation of the frequency of the factors revealed the prevalence of the categories, and their interrelationship was determined by presenting the data in cross-reference matrices and compilation tables (Young, 1989 pp 238-265). The general conclusion to the analysis was that the number of factors that affected design failings directly attributable to the designer was very few. Whereas, the factors outside the control of the designer were the most common, particularly the nature and quality of communication about design decisions, their timing and level in the project hierarchy (Young, 1989 pp 264-265). The activists responsible for design issues in this area had been shown to give poor consideration to; user requirements, a systems design approach and advice offered to them about these. This resulted in ill-conceived solutions and the most adverse design failings. The majority of factors contributing to design failings were due to conflicts between the organisations involved in the project and it was thought that they were influenced by the attitudes of activists in the different organisations towards the design issues. The remainder of the case study resolved the affect of the influence of these factors on the role of the designer, to understand more about all of the factors that had affected the design process. The objectives and method to do is was by the following research phases:

1. Rank the relative importance of the factors,
2. Identify the criteria contributing to them,
3. Correlate their incidence with existing design literature and use interaction matrices to show the interdependencies, and
4. Validate the derived criteria by comparison with other complex system design projects.

A method of analysis was needed to enable the relative importance of factors to be ascertained and the criteria contributing to them to be identified. The process

of selecting this method was complicated because it concerned implicit knowledge and attitudinal information on the part of the designer (Magee, 1987) and it was not clear how this could be made explicit. The intention was to use the relative importance of the factors to prepare a rank order for them, based on the role and interests of the designer. A method was selected which allowed a map to be built up of how the designer had viewed the case study, with a minimum of observer bias (Stewart and Stewart, 1981). The map considered many different aspects for instance events, activities, people, bodies, objects and items, but the general conclusion from the performance evaluation indicated that the designer's perception of events in relation to the people and bodies involved in them had the greatest contribution to the purpose of the research. The review of methods showed a lack of suitable techniques and previous reviews had come to similar conclusions (Lansdown, 1987). Repertory grid technique was eventually selected as the knowledge elicitation tool because it minimizes observer bias (Bannister, 1977) and (Stewart and Stewart, 1981) and Bannister and Fransella, 1977). The suitability of the technique was confirmed by reference to Magee, who had carried out a review of different techniques for eliciting knowledge from designers (Magee, 1987).

The major concern of the repertory grid analysis became the construct elicitation process and the constructs that were elicited from the people-based elements (Young, 1989 pp 297-299) and (Kelly, 1955). These elements were found to have the greatest potential interest and relevance to other designers and design projects, because of their perceived utility by design practitioners. The process of drawing conclusions from the analysis began with a summary of all the important constructs thought to have this relevance and interest. The nature of these constructs was found to comprise combinations of five key subjects, i.e.:

- Communications,
- Knowledge and information,
- Personality, attitude and values,
- Design strategy and policy; and
- Levels of design decision-making.

Correlation of the findings from phases 1) and 2) enabled conclusions from the case study to be compared with other literature. The purpose of the correlation was to look more closely at the relationship between the key subject areas to understand more about their morphology. Many useful references were found to have an affinity with the attitudinal and experiential knowledge established to have been so influential in the case study. The richest source of correlation was in architectural design research. The correlation added to as well as reinforced the relevance of the conclusions to the case study. An interaction net was constructed to hold and show the relationship between the references in terms of their categorisation against the five key subject areas above. These diagrams (Young, 1989 pp 359-365) represent a view the complex morphology of all the influences affecting the design process.

The complexity of the case study meant that, in keeping with other complex projects, there was a hierarchy to the structure of the design problems. Decisions had to be taken at different levels in the hierarchy at different times to progress the project and some important design failings were found to have been caused by difficulties in communicating information about design problems and recognizing their position in the hierarchy. In order to represent this hierarchy, Archer's model of levels of design decision-making (Archer, 1984) was adopted because its description correlated strongly with the nature of the context of design failings within the case study.

Archer's model consists of three levels:

- *'Design at the level of decision'* - where the individual designer takes a decision about one small factor in the design task, while a decision is made, the mainstream of the activity is 'frozen'. Once a decision has been made and the implications taken into account, the elements of the decision are forgotten as the interest switches again to the second level.
- *'Design at the level of the product'* – is usually the level at which people think and talk about design. Products can be taken as referring to things or systems, which can be designed by the individual designer working alone. The design of a product requires many decisions to be made.
- *'Design at the level of the project'* - is the highest level, and is communal activity of the team or organization. Archer reported that there were two important conclusions from studies completed in this area: Information flow has equal importance to creative solution finding and knowledge elicitation makes information public and therefore undermines power and authority. Archer concluded that power and authority are almost exclusively concerned with position in a hierarchy with respect to information, (Archer, 1984).

Validation of the Case Study Conclusions

It was decided to validate the conclusions from phases 1), 2) and 3) with similar complex design projects. This entailed a comparison of the reflections of other design practitioners who have experience of complex systems design projects, in order to determine the commonality of their experience and attitude to the findings highlighted by the previous phases. The practitioners were drawn from a cross-section of notable, best-practice design organizations; a national architectural design company, an international design consultancy and a national consultancy specialising in communication systems design. The reflections of the staff were recorded in response to semi-structured interviews (Robson, 2002) based upon the specific example of a complex systems design project that they had undertaken for their own organization. A cross case analysis method (Yin, 1994) was the used to relate and synthesize the reflections of the practitioners.

The validated conclusions from the comparison were reported in terms of relevant combinations of the five key subject areas. Representative quotations from design literature were used in the comparison to typify the conclusions from

the analysis of practitioner reflections. For the subject area; 'level of design decision making' the most important conclusion of the comparison again referred to the work of Archer, who stated that;

> 'Designers often work on complex projects at the level of the 'design decision' when they should be working at the level of 'product' or even 'project' (Archer, 1984).

The case study showed that the Designer often found it difficult to switch between levels when it was required, because there are no effective heuristics to help them do this. The general reason for this is that the organisations controlling projects are generally unprepared to give allowances of timescale and design costs for work at higher levels of decision-making. This is because the results of these activities are not as tangible as the design of details, or 'design at the level of decision'. This conclusion suggests that designers need a heuristic or model to help them monitor and direct their design practice across the different levels of the decision-making hierarchy.

Many models have been created to describe the nature of the design process based upon scientific method and philosophy. These models proved useful for describing design as a phenomenon of human social interaction, but they have not been used by designers, or revealed to design practitioners what the essential structure of the design process is or should be, or how they might monitor and direct their decision-making activities. Cross' re-evaluation of the rationale behind scientific method from an epistemological perspective, suggested that it relies on assumptions that are essentially contrary to the nature of design (Cross, 1984). This may be a fundamental reason why designers do not refer to design process models. Lawson's research into 'how designers think' over twenty-five years seems to bear out this reason (Lawson, 1991).

A Content-based Model of Design

The case study resulted in the development of a tentative new model to assist understanding of the context in which design does and can operate, thereby assisting the practice of designers, particularly those involved in complex system design projects. The new model recognises three levels of complexity of design practice, just like Archer's model, but cognisant of Lawson's research and in an attempt to arrive at a model which can be used in a more empathic way by designers it moves from a model that describes the process of design, to one that describes the nature of design content at successive levels of complexity. In this sense it is not prescriptive but heuristic. The translation from Archer's model is therefore:

- 'Design at the level of decision' - becomes - *design at the level of product configuration and detail*. This ensures that the designer does not fixate on details of the design process. Design content at this level is normally

monitored and directed by the design team, but individuals who make decisions on behalf of the team carry out the process.

- 'Design at the level of product' – becomes – *design at the level of systems thinking*. Design content at this level includes service design and interaction design for complex user interface systems, where the design process can only be effectively monitored, directed and undertaken by a multidisciplinary team. It is characterised by the systems thinking approach advocated by Simon in his seminal text on the subject (Simon, 1969) also (Flood, 1993).
- 'Design at the level of project' – becomes – *design at the level of policy formation.* Design content at this level involves the engagement of organisations. This is the most difficult level of designing for design teams to function at. It is the arena of design knowledge and expertise that is least known and written about.

The following diagram represents the new content-based model of levels of design (Figure 1)

Figure 1

Validating the Utility of the Content Based Model of Levels of Design
Following its development, the model was used in the educational process of industrial design students, to assist them to understand the complexity of design activities implied by the major project design briefs that they devise for their final year undergraduate studies. An action research process of enquiry (McKernan, 1994) has been used since the early 1990s to determine the utility of the model as a learning aid with successive year groups of final year students. The process has involved lecturing about levels of design activity to students. The lecture is part of a seminar series, which provides training and support in appropriate design project research methods and contextual theory, to enable students to produce a critical justification of their major project work (Young, 2003).

Following the seminar and the submission of the students' major project brief, each brief is analysed in a cross-reference matrix, which contrasts the aims and objectives of the project against the model's structure of levels of design engagement and activity. The design brief is seen as the mechanism for monitoring and directing the student's progress and determining the criteria for the assessment of their performance. The outcome of the analysis is an interpretation of the content of each brief, which is then shared with the students at another seminar. This allows each student to confirm or reject the interpretation as it is presented in the matrix for the project. The interpretation is then discussed in a tutorial, at the request of the student; to resolve the cause of any misinterpretations, or at the request of the tutor; if there is any cause for concern that the student is not aware of. In this sense the model acts as a

mechanism to aid understanding of the complexity of design problems and a mechanism to clarify the mutual understanding of aims and objectives of project work. Use of the matrix in the feedback loop means that the student and tutor have a diagrammatic and powerful medium to focus on as a common point of reference.

The feedback loop with the student, combined with the action research process of evaluation and reflection has enabled the refinement of this educational process over a period of nearly ten years. It has also indicated the mutual value of the content-based model of design as a tool for monitoring and directing project start-up and improving the understanding and communication of design content and intent. The action research is cyclical and on-going.

Over the last year, the utility of the model has been reassessed in relation to the latent agenda described in the background of this paper, and has been used to assist the development of a design initiative seeking to promote innovation in design education and practice. The purpose of this initiative is to develop design knowledge and expertise at the levels of system design and the design of policy. A related project titled Design Innovation Education Centre (DIEC) (ONE North East, 2003), sponsored by the North East of England Regional Development Agency; ONE North East, has grown from the initiative and has used the model (Young & Blair, 2001) to prime attendees at a week long workshop concerning; 'Designing Design Education' in November 2003, with the aim of exploring and influencing the future of design education. The invitation to the attendees to join the workshop was based on their interest in the belief that for economic, social, scientific and environmental reasons, design can and must develop to support society's needs in the future, and that their existing knowledge, experience and standing across a diverse range of disciplines would enable them to contribute ideas to the workshop. A latent agenda of the organisers of the workshop was to develop a better understanding of the nature of the learning process needed to support service design education. This paper reports on reflections recorded from a representative sample of the workshop's forty-three attendees' from six different countries.

Semi-structured telephone interviews were used to collect reflections after the workshop (Fielding, 1993), based on the sample's perceptions about the usefulness of the model, following their discussion of it in the context of the workshop experience. The reflections were collated in a meta-matrix (Yin) and the main conclusions were that:

- Very few could recall or describe a model of the design process.
- They were not in the habit of referring to models of design in their work, although a science-based respondent was aware of other models specific to his area of expertise.
- One respondent had subsequently used the model as to check the progress of work on a complex systems project.

- The model is best applied at the beginning or end of a project, or at set review points.
- The model has greatest potential as a tool for monitoring complex projects, to balance design activities in relation to the plan for the project.

Conclusions

This research concerns the development of a model describing the content of design activities, to develop an understanding of the context in which design does and can operate, thereby assisting the practice of designers. The paper has explained how such a model was derived through case study research and reflection about the nature of the levels of design complexity over a fifteen-year period. The model is based on an analysis of real-world complex system design problems and a development of Archer's model of levels of design decision-making. The research has shown the value of building a content-based model of design to assist designers and that these models appear to have a greater perceived utility by practitioners, compared to models that seek to understand and represent the process of designing. However, the research has not yet determined whether such a model has the utility to reduce the incidence of design failings.

On-going research

The on-going research of this initiative shows that there are many other instances where content-based models of design are currently being developed. These are being compared and contrasted with the derived model to highlight essential similarities and differences in an attempt to understand the general nature and range of concerns of contemporary researchers working within this field. On-going research is focused on the ontological nature of these models and the potential of content-based models of design to reduce the incidence of design failings.

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