Grounding Design in Complexity.

Silvia Pizzocaro
Politecnico di Milano

Grounding Design in Complexity.

Silvia Pizzocaro

Politecnico di Milano

As the frontier of present interdisciplinary sciences, complexity thinking can provide models to approach design research issues. Adaptation to the demands of a complex world requires to generate knowledge, and design knowledge, operating within a context of complexity, more than ever requires expanded and integrated ways of thought. Although the relationship between design and complexity has been explored for decades, the theory of complexity has only recently started to influence the debate in the professional community.

Considering design as a wide dimension of making and planning disciplines, here it will be assumed not only that design theory and design thinking are central frames of inquiry for design, but that design thinking goes beside complexity thinking. Without entering a detailed history of the sciences of complexity, this paper sketches a map of concepts derived from this thinking milieu. By outlining a number of these notions it is argued – as other have done – that key concepts central to handling complexity are already familiar to design culture. It is also argued that the task for designers is not to define or control complexity, but competent navigation through it.

The paper contents are articulated into a number of different pathways to complexity: the approach to the core of complexity, complexity as a paradigm and as history, the experience of complexity, complexity as a discourse, designer and complexity, a concept map for navigation, designing within complexity, designing complexity.

This paper is also an argument for a theory rich and interdisciplinary design education, providing the background to handle complexity from a design researcher perspective.

Submission of full paper to Future Ground

Abstract Title

Grounding Design in Complexity

Introduction

Although the relationship between design and complexity has been explored for decades, the theory of complexity has only recently started to influence the debate in the professional community.

Without entering a detailed history of the sciences of complexity, this paper sketches a map of concepts derived from this thinking *milieu.* By outlining a number of these notions it is argued - as other have done - that key concepts central to handling complexity are already familiar to design culture. It is also argued that the task for designers is not to define or control complexity, but competent navigation through it. Designing within complexity and designing complexity are two facets of this challenge.

This paper is also an argument for a theory rich and interdisciplinary design education, providing the background to handle complexity from a design researcher perspective.

Paths to comprehension (rather than definitions)

As Edgar Morin observed (1985:49), complexity can not be approached by means of a preliminary definition[1], the term itself lacking a precise epistemological statute: not a single complexity is usually considered, but many complexities, to be approached from multiple perspectives.

This paper will be articulated into a number of different paths to the notion of complexity. Paths are introduced as follows:

- n. 1: approaching the core of complexity
- n. 2: complexity as a paradigm, complexity as history
- n. 3: the experience of complexity
- n. 4: complexity as a discourse
- n. 5: designer and complexity
- n. 6: a concept map for navigation
- n. 7: designing within complexity
- n. 8: designing complexity

---

[1] Complexity has turned out to be very difficult to define. It has been observed (Heylighen 1996a) that many definitions fall short in one respect or another*, "classifying something as complex which we intuitively would see as simple, or denying an obviously complex phenomenon the label of complexity".* These definitions may result either only applicable to a very restricted domain, such as computer algorithms or genomes, or so vague as to be almost meaningless. For a review of different definitions see Edmonds (1996).

Path n. 1: Approaching the core of complexity

The core of the word complexity comes from the latin *complexus*[2], "entwined", "twisted together", and “embrace” as well, derived from *complecti,* from the late latin verb *plectere*, to wowen. Then: *complexus*, that which is wowen together.

There is a common objective core in the different concepts of complexity (Heylighen 1996a) and this may be interpreted in the following way: in order to have a complex you need two or more components, which are joined in such a way that it is difficult to separate them. It is from this entwined embrace that any further semantic extension of complex is derived. Similarly, the Oxford Dictionary defines something as "complex" if it is "made of (usually several) closely connected parts". Here we find the basic duality between parts which are at the same time distinct and connected. A system would then be more complex if more parts could be distinguished, and if more connections between them existed (Heylighen 1996a)**.** Since the components of complex can not be separated without destroying it, the method of analysis or decomposition into independent modules cannot be used to develop or simplify such models. This implies that complex entities will be difficult to model, that eventual model will be difficult to use for prediction or control, and that problems will be difficult to solve[3].

The aspects of distinction and connection determine the dimensions characterizing complexity. Distinction corresponds to variety and to the fact that different parts of the complex behave differently. Connection corresponds to constraint and to the fact that different parts are not independent, but that the knowledge of one part allows the determination of behaviours of the other parts. “*Distinction leads in the limit to disorder, chaos or entropy, like in a gas, where the position of any gas molecule is completely independent of the position of the other molecules. Connection leads to order or negentropy, like in a perfect crystal, where the position of a molecule is completely determined by the positions of the neighbouring molecules to which it is bound*” (Heylighen 1996a). Complexity can only exist if both aspects are present: neither perfect disorder, nor perfect order are complex. It thus can be said to be situated in between order and disorder, or, using a well known expression, "on the edge of chaos” (Prigogine and Stengers 1979; Waldrop 1992; Kaufmann 1993).

Path n. 2: Complexity as a paradigm, complexity as history

Some authors (among them Kampis 1991 and Morin 1984) use complexity as a paradigm of holism. In this case it indicates that the authors consider many systems to be unameanable to a reductionist/Newtonian scientific method or analysis,

---

[2] *Complexus, us*, embrace, from *complexus*, past participle of *complector, eris, plexus sum, plecti*, abbracciare, (L. Castiglioni, S. Mariotti. 1966. *Vocabolario della lingua latina*. Torino: Loescher, 230-231). On its turn, *complettere* comes from the late Latin *complectere*, for the classic *complecti*, ‘abbracciare’, composed of *cum* ‘con’ e *plectere* ‘intrecciare’ (Zingarelli. 1994. *Vocabolario della lingua italiana*, XII ed. Bologna: Zanichelli, 410).

[3] This accounts for the connotation of difficult, which the word "complex" has gained in later periods. Further semantic extensions refer to ignorance, size, variety, minimum description size (i.e. Kolmogorov complexity, the minimum possible length of a description in some language). See again B. Edmonds (1996).

suggesting that any attempt to cope with complexity using such traditional tools is doomed to failure.

An history of complex thought brings back to the tradition of the epistemological and scientific thought and to its development along the nineteenth century (Bocchi e Ceruti 1985:8), when complexity has been progressively growing from the studies in cognitive and evolutionary sciences and system thinking.

Systems theory was proposed in the 1940's by the biologist Ludwig von Bertalanffy who emphasized that real systems are open to, and interact with, their environments, and that they can acquire qualitatively new properties through emergence, resulting in continual evolution. System-environment boundary, input, output, process, state, hierarchy, goal-directedness, and information, are among system theory key concepts.

Many of these concepts and methods were proposed or used by cyberneticians. Subjects like complexity, self-organization, connectionism and adaptive systems had been extensively studied in the 1940's and 1950's, by researchers like Wiener, Ashby, von Neumann and von Foerster.

Immediately after the second world war, cybernetics was the first real transdisciplinary scientific experience, gathering mathematicians, neurophisiologists, economists, anthopologists.

In those years the first version of Warren Weaver (1948) *Science and complexity* appeared. Later contributions came from Gregory Bateson, Jean Piaget, Herbert Simon, Humberto Maturana, Warren McCulloch. The developments of systems theory are diverse: conceptual foundations and philosophy; mathematical modeling and information theory; practical applications including engineering, computing, ecology, management. Related ideas are used in the emerging sciences of complexity, studying self-organization and heterogeneous networks of interacting actors, and associated domains such as far-from-equilibrium thermodynamics, chaotic dynamics, artificial life, artificial intelligence, neural networks and computer modeling and simulation.

Cybernetics and systems theory constitute an academic domain that touches virtually all traditional disciplines, from mathematics, technology and biology to philosophy and the social sciences.

System theory or systems science argues that however complex or diverse the world that we experience, we will find different types of organization in it, and such organization can be described by principles which are independent from the specific domain at which we are looking. Hence, if we would uncover those general laws, we would be able to analyse and solve problems in any domain, pertaining to any type of system. The system approach distinguishes itself from the traditional analytic approach by emphasizing the interactions of the different components of a system.

Systems theory then can also be defined as the crossdisciplinary study of the abstract organization of phenomena, independent of their substance, type, or spatial or temporal scale of existence[4]. It investigates both the principles common to all

---

[4] As an interesting resource for fundamentals of system theory see the website of the *Principia Cybernetica Project* (PCP), an international project aimed at developing a complete philosophy or "world-view", based on the principles of evolutionary cybernetics. The PCP is a world-wide organization collaboratively developing a computer-supported evolutionary-systemic philosophy, in the context of the

complex entities and the usually mathematical models which can be used to describe them.

Path n. 3: the experience of complexity

The present developments of system thinking move around some crucial points of evolutionary sciences, oriented at outlining a unified science of the living and the artificial. Complexity can not be experienced if acting within the conventional disciplinary boundaries. In the last decades, contributes of different nature, either from investigation in epistemology, philosophy and history[5] - focusing at the generation, construction and circulation of ideas and research paradigms - gave shape to emergent contexts where unforeseable relations and interactions are possible among scientists belonging to different disciplines, between scientists and philosophers. Complexity can be perceived right at this crossing (where technological, scientific, epistemological, philosophical and anthropological questions intersect), thus enlightening the multidimensional nature of contemporary knowledge.

Ervin Laszlo (1985:362-400) remarked that the analysis of the current new order and structure of reality needs the elaboration of a "science of change" capable to get over the separation between natural sciences and social sciences, outlining the profile of a scientist whose task is to select results from heterogeneous disciplinary fields, so to reveal analogies and isomorphisms, activating a transdisciplinary circulation of concepts within societies asked to act as resilient systems: that is capable to react to a wider range of turbulence, progressively adapting to new forms of stability.

The developments of system thinking have been sided by a new meaning for the concept of evolution, now conceived as "general evolution" or "general theory of evolution", describing changes in the living world and in societies, allowing common models of evolution to be applied to biological, ecological, social and human systems (Laszlo 1986:13).

Path n. 4: Complexity as a discourse

Isabelle Stengers (1985:61) has observed that the notion of complexity *belongs to a discourse around science* and does not refer to any specialised discipline or specific technique.

Further, the "discovery of complexity" indicates something that is radically diverse from any discovery to be encountered in the history of science, where a discovery is the transition from the unknown to knowledge, an aswer following questions: here, discovery stands for the awakening of a problem, or a form of related awareness.

Complexity as a discourse implies that radically new forms of (scientific) questions and answers are to be expected in a context where technological, epistemological, philosophical and antropological problems are entwined.

---

transdisciplinary academic fields of Systems Science and Cybernetics. At the URL http://pespmc1.vub.ac.be/.

[5] See E. Jantsch. 1980. *The Self-Organizing Universe*. Oxford: Pergamon Press; J.H. Holland*. 1975. Adaptation in Natural and Artificial Systems*. Ann Arbour: the University of Michigan Press; L. van Bertalanffy. 1968. *General Systems Theory*. New York: Braziller; H. Maturana, F. Varela. 1980. *Authopoiesis and cognition. The realization of the living*. Dordrecht: Reidel, 1980; G. Bateson. 1972. *Steps to an Ecology of Mind*. New York: Ballantine.

In this context:
(i) knowledge and thinking are multidimensional (Bocchi e Ceruti 1985:10), absorbing different disciplinary categories of knowledge as multifaceted aspects of a unique reality,
(ii) knowledge and thinking are constantly facing uncertitude,
(iii) a science of change emerges as the alliance of natural sciences and social sciences,
(iv) a need for strategy emerges (Morin 1985:59), as the skill to face and handle uncertainty.

Path n. 5: Designer and complexity
Faced with new, uncertain, unexpected, dynamic events of reality, the relevance of flexible approaches and creative thinking becomes strategical for design (Boutin and Davis 1997:117), meaning the opportunity to re-define and re-invent according to the specific evolution of each situation.
What we we may indicate as *the designer's paradox*[6] directly pertains to the role of the designer and its scale and limits of intervention in a complex world.
Here we suggest that the thought of complexity crosses the designers's problem at least at two essential levels, that we may label as "designing within complexity" and "designing complexity", as in Le Moigne (1985:84-102).
Designing within complexity may be recognized as an act of awareness.
Designing complexity may be seen as the transition through which the discovery and challenge of complexity turn into methods to handle complexity (Morin 1977:386).
Both levels are part of the discipline of design, intended as one of those making disciplines that act on the physical world, address human needs and generate the built environment (Friedman 1999).
Although the exploration of the relation between design and complexity is not new, complexity theory as really started to influence the debate within professional communities only recently (Boutin and Davies 1997)[7].

---

[6] We refer to Edgar Morin "*le paradoxe de l'observateur-concepteur"* as in E. Morin, *La Méthode. I. La nature de la nature*, Le Seuil, Paris 1977, p. 179.
[7] Recent literature is in particular addressing the complexity of innovation situations, an area not yet well represented in design research. Although this paper does not offer an outlook on this area, we wish to pin point a number of promising contributions relevant to design research offering groundwork analysis and data for design researchers and potential design research projects. Most contributions come from management and organizational learning (for collections of interesting papers see: http://www-mmd.eng.cam.ac.uk/mcn/proceedings.htm and http://isce.edu/site/mtc4papers.html).
Management - as many other disciplines - was affected by the consequences of complex thinking. Within the french context of professional disciplines the *Programme Européen pour* la *Modélisation de la Complexité*, crossdisciplinary and multi-professional society, has been active for more than two decades under the epistemological supervision of Jean-Luis Le Moigne. Its source is available at URL http://www.mcxapc.org.
The *Complexity and Management Centre* of the Business *School* of the University of Hertfordshire was set up in 1995 to create links between academic work and

By both accepting and clarifying some elements of complexity theory and its role in revolutionizing thinking in scientific and managements milieu, some efforts have been directed to demonstrate how the notion of complexity can open promizing horizons for designers and educators in design. As a recurrent starting point, it has been recognized (Boutin and Davis 1997:115) that the problem is not that of understanding complexity, but to define and create flexible methologies allowing practical application for design of new emerging theories, to transform the discovery of complexity into a method to handle complexity.

Further, keys concepts central to handling complexity may gain clarity when going with a cultural maturity that entails the designer responsibility (1997:116) and are revealed as familiar to designers: a complex thought integrating uncertainty while planning organization, linking, contextualizing, globalizing, recognizing both singular and general dimension. Using holistic visions then turns into a broader (entwined)

---

organisational practice using a complexity perspective. This perspective draws on insights into evolutionary theory emerging in the natural sciences, strands of social constructionist thought in the social sciences and various psychological understandings of the dynamics at work in networks of human relationships. The Complexity and Management Centre seeks new ways of working with these ideas. See the URL http://www.herts.ac.uk/business/centres/cmc.html.

The *Complexity Society* provides a focal point for people in the UK interested in complexity. It is a community that uses complexity science to rethink and reinterpret all aspects of the world in which we live and work. Peter Allen and Elizabeth McMillan from the Open University started the initiative in 2001. Founder members include business people, healthcare professionals, consultants and academics. Information are on line at http://www.complexity-society.com/

The *Manufacturing Complexity Network* is an international, inter-industry, inter-university, multi-disciplinary research network which addresses the issue of complexity in manufacturing organisations. It is coordinated by the Universities of Cambridge, Oxford, Durham. This Network was established in 1998 and was initially funded by UK's Engineering and Physical Council Research Council (EPSRC). Its site (http://www.ossu.co.uk/mcn/) is a mechanism for disseminating the activities and work of the Network.

The *Centre for Complexity and Change* (CCC) links the work of three disciplines in the Open University's Technology Faculty: Systems, Development policy and practice, Technology management. Members of the Centre share a commitment to interdisciplinary and systemic approaches to the study of complexity and change, especially in the management of technologies, organizations, the environment and sustainable development in all parts of the world. Their work is particularly concerned with the impact of technological activities, the development of new technologies, and the management of interventions, including forecasting and assessment, regulation and innovation. Their emphasis is on taking a holistic view of situations, by considering the changing use of technology within its social, economic, cultural and institutional context. See http://ccc.open.ac.uk/.

sense of reality, meaning rapid ability to adapt to changes, to be part of change itself, to take uncertainty as a chance (not only a risk or a limit), to relying on processes (rather than structures), to develop skills of organization, dis-organization and re-organization, inventing dynamic concepts (as well as their links).
Complexity, it is said, is in the eye of the observer. System theory teaches us that an observer is a person who makes measurements (observations) on a system to gain information about it. This information can be communicated to other people in the form of a description. The field of complex systems is interested in relationships. The observer and system are in a relationship. Thus a precise notion of an observer and the basic act of observation or measurement is a key concept in this context. As a more general definition (Bar-yam 1997) we could take that an observer is a system which, through interactions, retains a representation of another system (the observed system) within it.
The conventional view of an observer is of an objective observer and an objective observer is independent of both the system being observed and the rest of the environment. Implicitly there is an influence between the system and the observer. Thus, the act of observation must cause an influence of the observed system on the observer.
The designers as observer is then expected to manage the ability to apply holistic visions, attempting to create a balance between interdependent elements, disciplines, requirements, possibly sharing this ability with any professional seeking to participate in the design of future realities (Boutin and Davis 1997: 117).

Percorso n. 6: A concept map for competent navigation

It has been claimed that "*the demanding challenge for designers and managers of design is to understand the consistent drivers of complex, dynamic realities. Operating in these realities is based on the understanding that complexity can not be controlled, but requires competent navigation*" (McGrory 1997).
The tradition of complex thought provides a significant number of further key concepts that can draw a conceptual map to progressively connect design activity to complexity navigation: the notion of system itself, environment, network, emergence [8].
(i)
In this map, a system is a delineated part of the universe which is distinguished from the rest by an imaginary boundary. One of the basic concepts in the systems approach is that all systems interact with their environment. How can we then identify what a system is for design activity? Aren't we always making an artificial boundary? In order to perceive or know anything, we always make distinctions. The key idea of "system" is that once a system is identified and its boundary described then one may describe the properties of the system, the properties of the universe excluding the system which affect the system, and the interactions between them. Thus it is a task of the describer to identify the way in which the system is interdependent with the

[8] For most concept definition we are referring to the textbook for seminar/course on complex systems *Dynamics of Complex Systems* by Yaneer Bar-Yam (1997), exploring questions about the structure, dynamics, evolution, development and quantitative complexity that apply to all complex systems. The full text is also available on line at http://necsi.org/publications/dcs/index.html.

environment.
(ii) The environment - in complex thought - is the context in which the system we are interested in is found. Strictly speaking, it is whatever is not included in the definition of the system. In developing a systems perspective a system is descibed in relationship to its environment, and how changes in the environment affect the system. The response of a system is how it changes when the environment changes in a particular way. Completely describing the state of the environment is, in principle, a much more difficult task than describing the state of the system. However, it is generally possible to restrict the aspects of the environment that are described to those forces which are most directly relevant to the system.
(iii) Then, a network is a description of the connections that allow interactions and influences between parts of a complex system. It is also used to refer to the parts along with the connections, i.e. the system as a whole, when considering the effects of these connections. There are several types of networks: transportation networks, communication networks, utility networks, supply networks, but also networks of molecular reactions, networks of cells, networks of computers and social networks. All networks can be thought of as influence networks: the state of the parts that are connected by the network affect each other through the network. Many of the most commonly studied networks assume that they are connecting essentially similar parts, with connections that are in some sense similar. However, more generally, real networks connect dissimilar parts in dissimilar ways. As part of the study of complex systems, the general understanding that we gain of how networks behave can be transferred between various kinds of systems, whether they are physical, biological, social or engineered. It is useful to think about behaviors that are common to different kinds of networks and behaviors that are different.
(iv) Emergence is what parts of a system do together that they would not do by themselves: collective behaviour, and also what a system does by virtue of its relationship to its environment that it would not do by itself: e.g. its function; and further, the act or process of becoming an emergent system. More generally, it refers to how behavior at a larger scale of the system arises from the detailed structure, behavior and relationships on a finer scale. In the extreme, it is about how macroscopic behavior arises from microscopic behavior.
To see in both these views we have to be able to see details, but also ignore details. The trick is to know which of the many details we see in parts are important to know when we see the whole.
In conventional views the observer considers either the parts or the whole. Those who consider the parts consider the details to be essential and do not see the patterns that arise when considering parts in the context of the whole. Those who consider the whole do not see the parts. When one can shift back and forth between seeing the parts and the whole one also sees which aspects of the parts are relevant to the description of the whole. Understanding this relationship in general is the study of emergence. Emergence refers to all the properties that we assign to a system that are really properties of the relationship between a system and its environment.
Jonas (1999) started arguing that systems thinking, especially sociological systems theory, provides some useful tools to describe design as a highly complex multilevel system, thus making the meta-discourse more efficient and purpose-oriented. He has proposed identifiable levels of the social communicative system/process: individual, team, organization, social subsystem/disciplinary system, and society as a

whole; levels of reality (Jonas 1998): events/objects, patterns of behaviour, structures and visions; and levels of observation, necessary for dealing with the blind spots of the lower levels: the meta-level of epistemology and the manner how theories and methods evolve in time ("strong theories"); the level of operative theory/ "small theories" ("weak theories")/methods; and the operative level of making.

By introducing the hypothesis to conceptualize design in a wider sense as a social subsystem of this kind, Jonas (1994) has also introduced design as the network of future-shaping disciplines (i.e. futures studies of design acting as sensor; management of meaning in design as cultural industry or strategic design; product design for material or immaterial objects; service design to design invisible structures and stimulating behaviours).

The meta-theoretical difference *system/environment* is re-introduced into the system as leading differentiator[9]. Design-problems may be treated as system/environment fits throughout and the concept of organised complexity may provide the essential tools for either *systemic modeling and projective thinking.*

Path n. 7: Designing within complexity

As we see it, the designer is mainly faced with cognitive difficulties.

A crucial aspect of learning regards most often *cognition*, that is the process by which decision makers form and modify representations in order to make some sense of a reality which is generally too complex and uncertain to be fully understood (Dosi et al. 1996:10). The systematic gap between the agents cognitive abilities and “reality can take at least two often interrelated forms: a *knowledge gap*, involving incomplete or wrong representations of the environment and a *problem-solving* gap between the complexity of the tasks agents face and their capabilities on accomplishing them.

In general, knowledge gaps arise from the lack of isomorphism between the environment and the agent’s model of it. This is what is called call in Dosi and Egidi (1991), paraphrasing Simon, *substantive uncertainty.* In turn, one may further distinguish between *weak* uncertainty (i.e. probabilisable risk) and *strong* uncertainty, involving genuine ignorance and intrinsic inadequacy of the mental models of the agents to fully capture the structure of the environment. Conversely, problem-solving gaps entail different degrees of *procedural uncertainty*, with or without substantive uncertainty.

Here we argue that the designer is still part of an operative dimension where both a *substantive uncertainty* (in Dosi e Egidi 1991) and a *procedural uncertainty* are present. Consequently it may be recognized that the emergent horizon of action of the designer will be dependent on the ability for improved understanding of a

---

[9] Jonas (1998) articulated a functional definition of design as:

- *use-oriented (with quality of life as criterion, without claiming to know what this is),*
- *illustrative (creating wholes, contexts, narratives, aiming at agency),*
- *anticipative (looking ahead, in different directions and time scales),*
- *generative (aiming at the synthesis of structures, patterns of behaviour and artifacts),*
- *integrative (neglecting disciplinary boundaries, moderating perspectives, including its own),*
- *context-sensitive (being aware of and using social, cultural, technological interdependencies*).

complex reality and improved skills to face that reality.
Jonas (1999) has started to describe design theory as a dynamic network of "chunks of ideas", with *self-similarity of design models* on the different levels of the process: not only design problems consist of largely contingent, purpose-oriented networks of variables but design meta-theory is a largely contingent network of theoretical elements, ideologies, preferences. "*Complexity on the problem side (how to describe the situation) corresponds to contingency on the solution side (how to change the situation into a preferred one). Organized complexity means the end of linear causal chains and creates feedback mechanisms. Design as a complexity-reducing medium of constructing the world is exploring the space of possible alternative futures."* (Jonas 1999).

Path n. 8: Designing complexity
The scale of intervention of the designer may face ranges from the level of *evolving artifacts* to that of *large technological systems*[10], where the systemic dimension is tangible[11].
It has been argued (Friedman 1999) that acting within complexity involve either substantive challenges to design (increasingly ambiguous boundaries between artifact, structure, and process; increasingly large-scale social, economic, and industrial frames; an increasingly complex environment of needs, requirements, and constraints; information content that often exceeds the value of physical substance) and contextual challenges (a complex environment in which many projects or products cross the boundaries of several organizations, stakeholder, producer, and user groups; projects or products that must meet the expectations of many organizations, stakeholders, producers, and users; demands at every level of production, distribution, reception, and control).
These challenges require a qualitatively different approach to professional practice: analytic and synthetic planning skills that can't be attained through practice alone, advanced knowledge that is not a higher level of professional practice but a qualitatively different form of professional practice. If complex systems operate at the edge of chaos, designing at this edge at this edge requires behaviorally adaptive skills (Friedman 1999).

But, can complexity be designed?[12] Or is it simply not designable?

---

[10] See T.P. Hughes, *The Evolution of Large Technological Systems*, in W.E. Bijker, T.P. Hughes, T. Pinch, *The Social Construction of Technological Systems*, The MIT Press, Cambridge, Mass., 1989, pp. 51-82.
[11] In T.P. Hughes (1989, 51): : "*Technological systems contain messy, complex, problem-solving components. They are both socially constructed and society shaping. Among the components in technological systems are physical artifacts, (...) organizations, (...) components usually labelled scientific, (...) legislative artifacts, (...) natural resources, (...). An artifact - either physical or non physical - functioning as a component in a systems interacts with other artifacts, all of which contribute directly or through other components to the common system goal; if a component is removed from a system or if its characteristics change, the other artifacts in the system will alter characteristics accordingly*".
[12] Keith Billings introduced a series of thoughts towards a learning designing method

It has been argued (Le Moigne 1985, 84) that a complexity that may be designed (or represented, invented, understood) is something complicated (or overcomplicated), not complex.
Let's go back to the designer paradox as in Morin.
When facing the phenomenology of design, even in the simplest evidence, it can not be ignored any longer that any design action has to be connected to a framework of events, which in turn generate multiple maps of actions, and that any design solution is not the ultimate one but just a possible one.
It is such a tension between design as the action to reduce the complexity of reality into forms of order, and design as the thought questioning the nature and substance of reality (so to progressively approach its inherent complexity), that here is re-proposed as the energy fostering a deep, rich transformation in the design approach. Recalling the ideas of Edgar Morin, designers and design researchers are asked to generate a form of action and knowledge allowing them multiple points of views and driving them to move from one perspective to another. They could also be required to refer to conceptual tools that - instead of isolating entities - allow complete freedom and circulation of ideas[13]. Furthermore, they are required to think about the specific identity of single artifacts - in any acception - as well as about the systemic dimension where artifacts are immersed. And finally they can learn to conceive and articulate a *meta-point of view* on multiple points of view, including their own as observers within a system.
Some authors (Findeli and de Coninck) have already proposed at least four design study articulations[14] to approach complexity, applied into the advanced education program aimed at developing complex intelligence in design researchers. Two articulations are considered inherent the design process, and two are peripheral. They are methodological complexity, inherent to the design process itself; the complexity of products; the complexity of design problems; and the complexity of (design) impacts. These articulations have started to represent significative paths to design research and study.

References

---

which instructs about complexity by using "changeability" as prime constituent. In 1997 he wrote that future designers have to design with change in mind (Billings 1997: 79). "*All designers should be able to identify the types and degree of change likely to influence the proposed design project (...) Change should be viewed as the basic condition (...)* (1997:90).

[13] E. Morin, 1977, op.cit., p. 179.

[14] At the École de design industriel, Faculté de l'aménagement, Université de Montréal, a new option was introduced within the Master's in Environmental Design Program devoted to design research. The Master's Degree in Environmental Design "Design and Complexity Option", under the supervision of Pierre de Coninck and Alain Findeli, is the equivalent of a master's level degree in research with an essay requirement. The program aims to develop a "complex intelligence" in candidates, the capacity to grasp, through a research process, the growing complexity of design problems, wherever this complexity is manifested (methodology, technology, assessment, problem-solving process). The chosen research method is the research project, as the reconciliation of the practical and theoretical dimensions of design.

Aida, S. et al. 1985. *The Science and Praxis of Complexity*. Tokyo: United Nations University.

Ashby, W. R. 1956. *An Introduction to Cybernetics*. London: Chapman & Hall.

Bar-Yam , Y. 1997. *Dynamics of Complex Systems (Studies in Nonlinearity*). Westview Press.

Bechtel, W., and R. C. Richardson. 1993. *Discovering Complexity*. Princeton: Princeton University Press.

Billings, K. 1997. Learning to Design for Change: moving from intuition to reasoning when managing complexity. In P. McGrory, ed., *The Challenge of Complexity*, 79-95. Helsinki: University of Art and Design Helsinki UIAH.

Bijker, W. E., T. P. Hughes, T. Pinch. 1989. *The Social Construction of Technological Systems*. Cambridge, Mass: The MIT Press.

Bocchi, G. e M. Ceruti, a cura di. 1985. *La sfida della complessità*. Milano: Feltrinelli.

Bocchi, G. e M. Ceruti. 1988. La riscoperta della Physis per una storia naturale delle possibilità. In M. Ceruti e E. Laszlo, eds, *Physis: abitare la terra*, 15-37. Milano: Feltrinelli.

Boutin, A. M. and L. Davis. 1997. Design as a creative approach to handling complexity. In P. McGrory, ed. , *The Challenge of Complexity*, 114-118. Helsinki: University of Art and Design Helsinki UIAH.

Ceruti, M. e E. Laszlo, eds. 1988. *Physis: abitare la terra*. Milano: Feltrinelli.

Dosi, G. and M. Egidi . 1991. Substantive and procedural uncertainty. An exploration on economic behaviours in changing environments. *Journal of Evolutionary Economics* 1:145-168.

Dosi, G., L. Marengo and G. Fagiolo. 1996. *Learning in evolutionary environments*. Papers. University of Trento: Computable and Experimental Economics Laboratory.

Edmonds, B. 1996. What is Complexity? The philosophy of complexity *per se* with application to some examples in evolution. In F. Heylighen & D. Aerts, eds., *The Evolution of Complexity*. Dordrecht: Kluwer.

Findeli, A. and P. de Coninck, *Fondements épistémologiques d'une formation de recherche universitaire en "Design et Complexité*", manuscript delivered by the authors.

Friedman, K. 1997. Design Science and Design Education. In P. McGrory, ed., *The Challenge of Complexity*, 54-72. Helsinki: University of Art and Design Helsinki UIAH.

Friedman, Ken. 1999. Philosophies of design. In A. Ekholm, ed*., Ämneskonferens projekteringsmetodik*. Lund: Datorstödd projektering (CAAD), Lunds Tekniska Högskolan. Ämneskonferens projekteringsmetodik, NorFA research symposium on design methodology, LTH - Lund Technical Institute, Lund University, 25-26 November, 1999.

Friedman, K. 2000. Form and Structure of the Doctorate in Design: Prelude to a Multilogue. In D. Durling and K. Friedman, eds*. Doctoral Education in Design. Foundations for the Future*. Proceedings of the La Clusaz Conference, July 8-12, 2000. 369-376. Staffordshire: Staffordshire University Press.

Friedman, K. 2002*. Problem and Paradox in Foundations of Design*. Available at URL http://www.expandinvestment.de/verhaag/basicparadox/

Heylighen, F. and D. Aerts, eds. 1996. *The Evolution of Complexity*. Dordrecht: Kluwer.

Heylighen, F. 1996a. What is complexity? [online]. In *Principia Cibernetica Web* [cited 9 December 1996]. World Wide Web: http://pespmc1.vub.ac.be/COMPLEXI.html.

Hughes, T. P. 1989. The Evolution of Large Technological Systems. In W. E. Bijker, T. P. Hughes, T. Pinch, eds, *The Social Construction of Technological Systems*, 51-2. Cambridge, Mass.: The MIT Press.

Jonas, W. 1994*. Design - System - Theorie. Überlegungen zu einem systemtheoretischen Modell von Designtheorie*. Essen: Die Blaue Eule.

Jonas, W. 1998. Viable Structures and Generative Tools: an approach towards "designing designing". In *Contextual design: design in contexts*, 23 - 25 April 1997. Stockholm: the European Academy of Design

Jonas, W. 1999. On the Foundations of a 'Science of the Artificial'. Useful and Critical. In P. Korvenmaa, ed. , *Useful and Critical: Conference on Design* , Helsinki: University of Art and Design.

Jonas, W. 2000. The Paradox Endeavor to Design a Foundation for a Groundless Field. In C. Swann and E. Young, eds.*, Re-inventing design education in the university*, 44-50. Perth, Australia: Curtin University of Technology.

Jonas, W. ed. 2001. The basic PARADOX - foundations for a groundless discipline. URL: http://home.snafu.de/jonasw/PARADOX0.html Date accessed: 2001 December 26.

Jonas, W. 2001a. *The Paradox Endeavor to Design a Foundation for a Groundless Field*. URL: http://home.snafu.de/jonasw/JONAS4-54.html Date accessed: 2001 December 26.

Jonas, Wolfgang. 2001b. On the Foundations of a "Science of the Artificial." URL: http://home.snafu.de/jonasw/JONAS4-49.html Date accessed: 2001 December 26.

Kampis, G. 1991. *Self-modifying Systems in Biology and Cognitive Sciences: a New Framework for Dynamics, Information and Complexity*. Oxford: Pergamon Press.

Kauffman, S. A. 1993. *The Origins of Order: Self-Organization and Selection in Evolution*. New York: Oxford University Press..

Laszlo, E. (1985). L'evoluzione della complessità e l'ordine mondiale contemporaneo. In M. Ceruti e G. Bocchi, eds. *La sfida della complessità*, 362-400. Milano: Feltrinelli.

Laszlo, E. 1986. *Evoluzione*. Milano: Feltrinelli.

Laszlo, E. 1988. Evoluzione: il nuovo paradigma. In M. Ceruti e E. Laszlo, a cura di , *Physis: abitare la terra*. Milano: Feltrinelli..

Le Moigne, J.-L. 1985. Progettazione della complessità e complessità della progettazione. In G. Bocchi e M. Ceruti, a cura di, *La sfida della complessità*, 84-102. Milano: Feltrinelli.

McGrory, P., ed. 1997. *The Challenge of Complexity*. Helsinki: University of Art and Design Helsinki UIAH.

Morin, E. 1977. *La Méthode. I. La nature de la nature*. Paris: Le Seuil.

Morin, E. 1984. On the Definition of Complexity. In S. Aida et al., eds., *The Science and Praxis of Complexity*, 62-68. Tokyo: United Nations University.

Morin, E. 1985. Le vie della complessità. In G. Bocchi e M. Ceruti, a cura di, *La sfida della complessità*, 49-60. Milano: Feltrinelli.

Prigogine, I. and I. Stengers. 1979. *La Nouvelle Alliance. Métamorphose de la Science*. Paris: Gallimard.

Symposium, 1995. The Evolution of Complexity, Evolutionary and cybernetic foundations for transdisciplinary integration as part of the conference *Einstein meets Magritte: An interdisciplinary reflection on science, nature, human action and society*, May 29 /June 3, 1995 at the Free University of Brussels, Belgium. Available on line at http://pespmc1.vub.ac.be/Einmagsy.HTML.

Stengers, I. 1985. Perchè non può esserci un paradigma della complessità. In G. Bocchi e M. Ceruti, a cura di, *La sfida della complessità*, 61-83. Milano: Feltrinelli.

Waldrop, M. M. 1992. *Complexity: The Emerging Science at the Edge of Order and Chaos*. New York: Simon & Schuster.

Weawer, W. 1948. Science and complexity. *American Scientist* 36: 536-544.