Design out of complexity workshop report

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This paper is a report from a one-day workshop with the title 'Design out of complexity' that was held in London on July 2nd 2005. The workshop was organized as part of the activities of the EPSRC/AHRC funded research cluster Embracing Complexity in Design (ECiD) and with the occasion of the Computers in Urban Planning and Urban Management Conference (CUPUM05) organized by CASA in UCL. The ECiD cluster is one among 21 diverse interdisciplinary groups, which were awarded funding for a year to work towards identifying research priorities for design in the 21st century. CUPUM on the other hand is an international conference which showcases contemporary advances in computer technologies and methodologies in the area of urban planning and management. The synergy developed between the two for the purpose of the workshop produced some very interesting insights.

The general purpose of the workshop was to explore and propose a future research agenda on the relation between complexity and design. There was an open call for papers with the following suggestion:

> 'In a traditional view of complexity, the fundamental issue of interest is the emergence of global patterns out of the non-linear interaction of simple elements. Cities, organizations, policy networks, economic systems, or human-computer networks, all encompass the interaction of relatively simple (or not that simple!) components that at some level of abstraction might appear to have some order. The impact of abstractions like CA, multi-agent systems, networks, or co-evolution, in understanding and modelling reality and supporting decisions in complex worlds is overwhelming. However, it can be argued that patterns that emerge in cities, economies, or organizational structures, are not purely random (or self-organised) phenomena, because elements or agents of the system are taking deliberate decisions in anticipation of such patterns. The workshop wishes to explore epistemological and methodological issues addressing the problem of how complexity may produce order that has been designed to emerge or likewise how the emergence of such patterns might acquire a design value.'

The driving force for the organization of the workshop was to establish the idea that design is a fundamental issue in complexity research and discuss the particular hypothesis that design is a general capacity derived from the complexity and organization of a system.

Let us explain what this hypothesis implies for us. At the beginning of the workshop, the participants were invited to take part in a 'game'. The venue had been left without a particular arrangement (layout of chairs) apart from a projection screen which was placed at one end of the long side of the rectangular room. The chairs were assembled at the perimeter. The participants were asked to take a chair and place it as they wished to create a layout. In no time at all a configuration of chairs (of an approximate horseshoe shape) emerged.

Apparently, the resulting configuration of chairs had emerged with no central controller or top-down designer. Each participant acted as an individual agent

spontaneously or according to their individual goals, memories and expectations. For an external observer, the system constitutes a typical instance of a complex adaptive system. However, two further observations about the task can be made:

First, the whole chair-placing process led to the construction and social recognition of a functional artefact. The resulting configuration of chairs had a clear effect: it reduced the complexity of the environment and, more importantly, it was then used to structure the communication between the participants. The constructed configuration had an (intended) function.

Second, this capacity to construct and recognize a design artefact was by and large distributed; the configuration was a collective realization and to a great extent independent of the design abilities of the individuals involved. This can lead us to assume that design can be considered as a capacity derived by the organization (and complexity) of the system.

These observations are relevant to cities, design teams, political systems, organizations, ant colonies and social systems in general (human or animal) and the 'game' posed the motivating hypothesis for the workshop explicitly to the participants. A lot of the subsequent discussions touched in many ways on this central theme and the spawning questions around function, intentionality, social construction, the role of individual action, or intervention, as well as the role of observation and meaning-giving.

To structure the conversations, the participants were invited to explore two fundamental questions throughout the workshop:

Q1. What can complexity offer to design practice and research?
This question has two dimensions. The one is to do with how complexity can be of practical use in design professions, from policy design, to urban to software to architectural design. How can it influence the way we do design; what methodologies does it have to offer; and when (for what purpose) is it best to use them. The second dimension has more to do with understanding design, as process or as product. What can we learn from complexity about the way we do – or could do – design? What things can we understand about design that we couldn't understand before? These two dimensions are closely linked together. Using complexity as a theory and method that transforms design processes and products and their understanding, leads to questions about the relation between designed and complex objects. What is the difference between complex systems and designed systems? Can we embed complexity into design objects? Is it possible to design complex systems and how can we achieve this?

Q2. What is the role and meaning of design in complexity theory and methods?
There are generally two different, very widespread, views of design. We will make a crude generalization here just for the argument. The one view sees design as something that is imposed from above (top-down), something rigid, unimaginative or unsuccessful in the sense that it tries to impose order where it is not possible to do so. It is seen as the antithesis of complexity, which is all about self-organization, creativity, adaptability – and as it is the underlining principle of our universe – very successful. One the other hand, there are many designers that would forcefully disagree. Design is creative, innovative, amazing and resourceful; it is about the beauty of finding neat solutions, and one of the most important things for our society. Complexity is what makes things uncontrollable and unpredictable and whereas design is about creation, complexity is about destruction. This is a crude generalization but it is the core of why there are many conflicts and

misunderstandings between complexity scientists and design practitioners. The question is therefore, how these two views can be reconciled for mutual benefit.

The workshop proceeded with keynote presentations by Robert Geyer and Tim Smithers, two parallel sessions with discussion and short presentations by Jeffrey Johnson, John Woodward, Chengling Gou, Mark D'Inverno, Marko Peterlin and Batel Dinur and a plenary session with discussion and presentations by Arnaldo Cecchini, Stephen Marshall, Ricardo Sosa and Richard Coyne. The submitted papers and presentations from the day can be found on the workshop website http://www.casa.ucl.ac.uk/cupumecid_site/.

Here is a brief summary:

Robert Geyer explained the history of the development of complexity in the social sciences and particularly policy making. He talked about the gradual shift from the Newtonian paradigm of order which assumed causality, reductionism, determinism and predictability, to a probabilistic understanding of phenomena inspired from fluid dynamics, to the paradigm of emergence which incorporated insights from the study of biological systems and the theory of evolution. He particularly talked about the understanding of complex systems and phenomena as such pertaining to an area between order and disorder and highlighted the special position of social systems amongst them. He gave some examples from policy development (from the areas of traffic and health management) where he discussed the importance of the context within which policies are developed and the influence of interpretation.

Tim Smithers gave a talk on the role of designing in complex adaptive systems. He first defined some fundamental terms and concepts such as closed and open systems, equilibrium and stability, and discussed the distinction between simple, complicated and complex systems. He also examined the difference between the concepts of dissipative structures and complex adaptive systems (CAS). He particularly looked at these two different notions in relation to the question of whether they are used as analogues or homologues in understanding and designing complex systems. He then considered some examples from cities and towns and suggested that CAS offer a better theory for understanding them. He finally concluded that CAS cannot be designed and proposed a way to see design as a process of changing the behaviour of CAS by focussing on individual components.

Jeffrey Johnson talked about design as the task of putting “things” together to produce emergent structures and stressed the need for a theory that can capture and represent the rich and heterogeneous relationships between design components. He presented his view on how relational mathematics can support a new theory of multilevel systems, in which levels are integrated through lattice hierarchies.

John Woodward focussed on the relation between complexity and design representation. He noted that for description methods that allow reuse of component parts, the complexity of the object remains invariant (i.e., it is independent from the primitives used in the description). He therefore suggested that concentrating on the construction of primitives helps framing a design problem at an appropriate level of abstraction.

Chengling Gou presented her work on mix-games where she investigated the effects of increasing individual performance versus increasing system efficiency. From her results she derived some recommendations for system design, particularly focussing on the role of payoff variety, memory capacity and group size.

Mark D'Inverno gave a short talk on behalf of another EPSRC/AHRB Designing for the 21st Century research cluster called "Designing Physical Artefacts from Computational Simulations and Building Computational Simulations from Physical Systems". He explained that the focus of the cluster is to explore the dual problem of how we can exploit simulation techniques in designing physical artefacts and how we design simulations and visualizations of complex systems. He talked about the various questions raised in this context and especially those relating to the complexity of collaborating across different disciplines as diverse as computer science and art.

Marko Peterlin introduced his view of how the paradigm of evolution can be used as an alternative theory and method to approach design. He framed the difference between design and evolution as the difference between hierarchies and networks or centralised and decentralised decision making, as well as the difference between (designing) phenotypes and genotypes. He concluded with proposing a view of design which is inspired from natural complex systems and focuses on processes rather than forms, or individual components, and incorporates adaptability and decentralised decision making.

Batel Dinur presented a theoretical perspective on how the study of ecology can be beneficial for architecture. She made a comparison between mechanisms and organisms drawing on descriptions of allopoietic and autopoietic systems and proposed the use of three ecological principles (fluctuations, stratification and interdependence) for the development of an ecological model of architecture. She further discussed how these principles can be potentially applied in architecture metaphorically, analogically or literally.

Arnaldo Cecchini discussed changes in planning theory and practice reflecting our understanding of complex systems, such as changes on the kinds of planning tools we use or our ability to forecast the impact of and plan our actions. He further unveiled some fundamental assumptions that lie at the heart of traditional theories and models and which can hamper the development of appropriate techniques and models, including for example the dogma of continuity, the hypothesis of rational behaviour and the fallacy of extrapolation.

Stephen Marshall demonstrated a program which uses simple rules to generate characteristic patterns of urban structure. He first explained the notion of characteristic structure which captures the quintessence of street pattern shape, and explained how this can be identified by measures of connectivity and complexity. He then demonstrated a generative system able to reproduce such characteristic structure. This was discussed as a point in support of the idea that the urban layout can be generated without overall or top-down design.

Ricardo Sosa presented his study on creativity and innovation in complex systems. He discussed how methodologies such as cellular automata and multi-agent systems can be used to simulate and explore social aspects of design such as the recognition and diffusion of innovation.

Richard Coyne focussed on the notion of network as a fundamental concept in complexity. He identified abstraction and universality as the two powerful characteristics of networks responsible for their extended use in understanding, analysing and representing complex systems. He then suggested using Deleuze and Guattari's concept of rhizome as an alternative metaphor – in contrast to the notion of tree – to convey a non-hierarchical or single-layered organisation.

It is impossible to reconstruct all the discussions, or recollect all the issues and ideas expressed following these presentations, but some key discussion issues can be identified which fall into the general questions described above:

1. Defining design

Throughout the workshop various examples of design were invoked and discussed. In these examples a multitude of definitions or views of design were revealed (at times complementary or contradictory) which underlined different approaches to the problem of complexity in design. For instance when design is seen as a process, the focus of research might be on identifying how complexity supports or hinders the capacity to design, whereas when design is seen as a product (artefact), the focus might be on the complexity of component analysis or object representation. Other views include seeing design as a social activity and focussing on identifying complex structures behind the creation and 'institutionalization' of designs, or seeing design as theory/epistemology and therefore focussing on the nature of design problems and their distinction from problems in other domains. Despite the multiplicity of views and foci, design has emerged as an important issue in understanding complex systems (such as cities, traffic systems, political systems etc) and a fundamental instrument for conceiving, creating or steering future worlds. The general question of defining design is closely linked to all the other issues that were formed in the course of the discussion.

2. Complexity thinking in design

One of the objectives of the workshop was to investigate and propose concepts and methodologies coming from complexity science that can be of theoretical, methodological and practical use in design. Among the predominant concepts brought forward in the workshop were those of evolution, networks, autopoiesis and self-organisation. Such characteristic concepts were in many ways contrasted to design, yet invariably proposed as useful 'models' of and for design. These theories and methods were considered as vehicles for gaining better understanding of natural and social systems which (and within which) we design. This implies a better understanding of what and how we (can) design, and therefore adduces changes in the form and object of design, as well as the perspective of the designers. One of the main arguments about the application of complexity thinking in design was focused on the exploitation of simulation as a way to generate, explore, visualise and test hypotheses about the nature of complex systems and the outcomes of design actions. Complexity therefore can be seen not only as a source of concepts, methodologies and tools, but also as an epistemology.

3. Philosophy of complexity science

In relation to the above, many discussions were focussed on the nature of scientific statements and concepts generated within the complexity paradigm. An important issue highlighted was that complexity relates to assignment of meaning and that the observers/designers are part of the systems they wish to understand and synthesise. For example, it was discussed that networks are widely used not only because they facilitate the study of complex relations between components in different systems, but also because they offer a meaningful visual representation of these relations. Other examples of concepts such as fields, catastrophes or multi-level systems were also mentioned to support the argument that some concepts hold more authority than others because they can afford meaningful interpretations and help focus on appropriate levels of analysis.

4. Design in complex systems

Adopting a complex systems thinking in design alters our overall perception of design as an activity that aims to produce changes; if we design in an unpredictable world,

how do we know our design will succeed? If complex systems cannot or should not be controlled by a central designer, how is it possible to harness them to our benefit? One example that was repeatedly mentioned as a case in point was that of urban traffic systems. The creation of traffic jams is a dynamic, emergent phenomenon which is hard to predict and control: so how do we design policies that will help avoid traffic congestion and reduce the negative effects to the environment? Would the imposition of an overarching law work, or is it more effective to focus on local actions that will cumulatively produce the desired effect? Instances of both approaches were presented and no consensus was achieved, but there was a near agreement in seeing design more as steering rather than controlling. The various ideas presented included the introduction of the notion of design as strategy, the dismissal of goals (or at least top-down goals), and the crucial dependency of design (and its success) on its context. These ideas were also escorted with different approaches to what constitutes the object of design: artefacts or processes, strategies, behaviours, genotypes and so on. Undoubtedly these are questions that lie at the heart of every attempt to 'reconcile' design with complexity.

Before closing this report it is interesting to return briefly to the argument that motivated the workshop. The general focus and belief on using complexity concepts to re-assess the definition, form and object of design, reinforces the initial hypothesis that design can be studied by looking at the organisation of systems. Apparently the main problem in accepting the hypothesis that design is an essential capacity *derived by* the complexity and organisation of a system is that design is (predominantly) associated with the existence of a top-down-acting 'global' designer. Irrespective of whether top-down design is useful or successful, what is essential to point out here is that from the moment one accepts the transfer of complexity concepts in design (with a view of 'substituting' design with complexity), immediately the possibility is exposed that complex systems themselves may have the capacity to design. This capacity does not come from some particular cognitive ability or expert competence but from the way the components and functions of these systems are related and organised. Although there was not enough time to discuss in detail this possibility, and the view that design can be used as an abstraction to study and understand complex systems, it is true to say that the idea sounded valid. And although at the beginning of the workshop the chair-placing game was not commonly considered to be an example of design, the resulting layout was ultimately accepted and used as a design both in practical terms and even as a prompt for the discussion. This of course is not a proof of the validity of the hypothesis but certainly a happy reassurance that the workshop was an interesting and positive enterprise. Thanks to the participants.