AHRB/EPSRC Designing for the 21st Century Research Cluster: Embracing Complexity in Design (ECiD)

Notes from Dialogue on Complexity and Design
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The first meeting of the ECiD cluster was an introductory dialogue on the possibilities and difficulties involved in establishing links between the sciences of complex systems and design. Eve Mitleton-Kelly presented key concepts for understanding and working with complexity inspired by research in physics, chemistry, biology and social science and with a particular emphasis on the defining characteristics of social systems. In particular, she proposed 10 principles for the definition and study of 'complex co-evolving systems': Self-organisation, Emergence, Connectivity, Interdependence, Feedback, Far from equilibrium, Exploration of the Space of possibilities, Co-evolution, Historicity and time and Path-dependence (for more information see original paper) .

The presentation (see presentation slides) was organised in 3 parts, each leading to 3 small break-out group discussions.

The first part was focussed on the issues of self-organisation, emergence, connectivity, interdependence and feedback. The small groups discussed the following questions:

- Is your understanding of self-organisation and emergence different from that discussed? In what way? How do you think about them?
- How do they relate to design? Can you identify examples of self-organisation and emergence in design?
- What was the role of feedback?

Some of the questions/research issues generated from these discussions were:

How is it possible to engineer emergent properties? Can we anticipate emergence?
Design problems involve the need to formulate structures whose emergent behaviours and functions are anticipated. Even though emergence has been discussed in design science in relation to different dimensions such as creative processes or thinking, product engineering, shape representation, and data definition, the discussion has focussed on the relations between emergence and design at a conceptual level. At this level design might appear as the opposite of emergence and self-organisation. While emergence refers to the formation of a new property (structure, behaviour or function) that cannot be derived by the description of the components of a system, design conceptually refers to the formation of components that satisfy an emergent property. In this framework, a key research problem has been tacitly identified: the need to conceptualise and devise explicit methods to anticipate emergent properties and model them at different levels of abstraction.
In one group, the discussion about engineering emergent behaviours and functions, at multiple scales of abstraction, has led to the issue of exaptation. The example discussed was taken by Eve's position paper: A garden table with a hole in the middle for an umbrella acquired a new function as a working table when the hole was used to pass the power leads and cables that connected the laptop to a mobile phone through, keeping the space tidy. New functions can be devised for the same structures and the same structure might carry a number of functions. However the question that remains is whether it is possible to model and anticipate all possible behaviours and functions of a structure. Is it possible to enumerate them? If it is possible to anticipate the possible functions, how is it possible to use this knowledge to generate alternatives?

What is the relation between self-organisation and design? Are they comparable or contradictory? What is the relation between self-organisation, design and innovation?
Self-organisation has been described as a process that leads from a state of disorder to a state of spontaneous order, without the use of any design or plan. So what looks like the opposite of design, in another sense also looks very similar to design, as it is a process of producing/creating 'something new'. So is design similar or opposite to self-organisation? To one group, this also brought up a question about novelty and innovation. Is novelty a necessary condition of self-organisation? Does the result of a self-organisation process need to be something we haven't encountered before? It can be argued that the same doesn't necessarily have to happen in design. But can self-organisation be seen as a tool for innovation in design?
One of the positions expressed was that complex socio-technical systems have many levels of operation and there exist consequently many levels of analysis or observation. A city like London is an example of such a system. While at a macro level the city looks it is undergoing an 'uncontrollable' growth process, when seen from the perspective of people or organisations who act within it, many elements of design come to light. However chaotic might be, doesn't the transportation system in a sense dictate some form of growth or change? It was similarly discussed that the recognition of processes of self-organisation and design do not only depend on the scale of observation but also on whether we look at the process or the product.

The three groups came together at the end of their discussion to exchange their identified questions and views. Two collective lists of ideas and characteristics related to the concepts of self-organisation and emergence were created [see Appendix].

The second part of the presentation was focussed on the issues of co-evolution, exaptation, exploration of the space of possibilities and adjacent possible. The small groups discussed the following questions:

- Can you identify examples of co-evolution, exploration of the space of possibilities, exaptation and the adjacent possible?
- How would they work as necessary conditions in the design process?
- How would you employ micro-strategies and use distributed intelligence?

Some of the questions/research issues generated from these discussions were:

How can we define co-evolution in design and how central is it? Is it a ubiquitous process, or is it a special condition?
The groups identified some examples of co-evolution:

- The mobile phone market
- The Metro newspaper as an example of the adjacent possible from marketing. A target market of ABC1 commuters trapped on the underground for 40 mins each every morning should have been tapped earlier !
- The co-evolution of reading and producing news over the internet [an evolving media ecosystem as defined in 'WeMedia': http://www.hypergene.net/wemedia/weblog.php]
- In a product development process there is co-evolution between the user, the designer and the product: The designer proposes something, the user agrees or disagrees with aspects of the specification and re-defines it, so the designer re-designs the product and so on.
- At an abstract/conceptual level, the design problem co-evolves with the design solution, the framing of a design problem continuously changes as the solution to this problem is further elaborated.

One of the points identified through this discussion was that for co-evolution to happen there must be two or more systems that mutually adapt to each other. This opened a discussion as to whether a system such as a building, which cannot change structurally, can be considered to be part of a co-evolutionary process. Although changes are produced within buildings by the inhabitants, these changes are external, non-autonomous adaptations and should not be considered as part of a co-evolutionary process. The argument brought forward as an answer to this dilemma, was that seen as a whole, the user-building system is a co-evolving system, since the one is adapted to another, independently from who produced the changes at a micro scale. A more widely accepted view expressed was that co-evolution in this case should refer to the process of building design rather than the process of user-building interaction; to the way for instance the structural and architectural design processes evolve together. Another argument expressed was that although buildings are not (yet?) capable of autonomously re-configuring themselves, there are artificial systems that could potentially achieve this (such as robots, autonomous software agents, etc).

The third part of the presentation was focussed on the issues of far-from-equilibrium, dissipative structures, bifurcation, path dependence and the concept of enabling infrastructures. The three groups discussed collectively the following questions:

- What does 'design' mean from a complexity perspective?
- What difference does it make to our thinking about the design process
- Is it possible to 'design' an organisation? How?

In this discussion, the following research issues were identified:

What are the effects of design: reduction or increase of complexity?
Here the discussion revolved predominantly around the relation between design and complexity and the scope of adopting a complex systems 'thinking' in design. One of the main questions was whether we should think that the goal of design is that of increasing complexity, and hence adopt methodologies and strategies so as to widen the scope of exploration, or whether we should think that the goal of design is that of decreasing complexity and hence use complexity methods and tools to better manage or control multi-level processes. The particular point of discussion was that in organisations there has been a switch of emphasis from control to enabling infrastructures. This sparked a discussion on whether or not designing control processes for/in complex systems is a desirable paradigm. In response to this question many dimensions have been discussed. From an organisational point of view control is conventionally interpreted as top-down supervision which fails to account for complex bottom-up processes. However, in social, physical, biological and engineering sciences, control has been identified as a mechanism that reduces the variety (and complexity) of a system and as such it can play an important role for the design of any system. Additionally, one of the arguments put forward was that we do not necessarily need to think of control as a rigid, top-down process; the science of control systems itself has already incorporated in the design of control mechanisms concepts and paradigms coming from complex systems sciences (see distributed control or evolutionary control mechanisms).

Such and other questions delineate some of the opportunities and difficulties in attempting to establish connections between the two domains of complex systems sciences and design. The meeting offered the opportunity to initiate the discussion with the hope we can establish some key research directions. As a summary, we consider - and this is of course only a partial view- that the main outcome was the need to understand, define and engineer emergence/self-organisation/co-evolution in design not only as functions that support and characterise aspects of design, but also as conceptual bases for defining design phenomena. We feel that much of the misunderstandings, questions, and ambiguities that were produced during the course of the meeting were nevertheless creative and informative. At different points the need for a common language or framework that would enable us to communicate common problems was discussed; and this is potentially another question we are faced with. All cluster members are invited to contribute to the above discussion and raise the issues they consider more crucial.

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Appendix
Flipchart notes from group discussion 1: emergence and self-organisation

Notes from individual group discussions

Group1:

1. Can one design for emergence? (I hope so). If so, how?

2. Do we have to know the components to describe

3. Interactions/feedback

4. Structure
   Behaviour } interaction
   Function

Group2:

Self-organisation = design?
e.g cities, products

Collective group discussion: lists of ideas and characteristics related to the concepts of emergence and self-organisation

Emergence:

Surprise (is it still emergence)

Novelty

Unsurprising

Info flow & continuity

Stable state of the system

Built in property v anticipated

Pattern/result

Not necessarily anticipated

Undesired side-effect

Aha!

Desired function

Whole v sum of parts

Origination

Self-organisation:

Type of emergence

Equilibrium – disequilibrium – far from equilibrium

Bottom-up

Intelligence

Attractor

Feedback process

Observer dependent

Novelty?

Innovation

Agent

Autonomous

Automaticity

Co-ordination

Reaction to environment

Anticipated pattern

Generation of new structure

Predict new functions?

Description level

Perspective