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COMPUTATIONAL SUPPORT FOR EARLY STAGE ARCHITECTURAL DESIGN

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ABSTRACT: The concepts underlying 'scenario-based' design are introduced. From the analysis of a number of structured interviews with practicing designers, key design scenarios are identified. These scenarios are then generalised and outline guidelines developed for structuring early stage design.

KEYWORDS: scenario, architectural design.

1 INTRODUCTION

Architects have, traditionally, made extensive use of sketching in early-stage design development. One of the key functions of hand drawing is to actively explore the translation of descriptive design ideas into depictive representations (and vice versa) as ideas and mental images are represented in different components of our working memory. Sketches act as a form of "aide memoir" or "holding structure" for design ideas and design images. Given that CAD systems lack the immediacy and quality of hand sketching in this context, there is a growing interest in "scenario" techniques as a way of providing computational support for this design exploration. This methodology simulates possible future environments and then concentrates on developing paths from the present situation towards various possible futures. In following the different paths the complexity of the design problem is explored and any inter-relationship between alternative outcomes discovered. In this way many of the same key mental processes engaged in sketching are utilised although the representation is radically different.

2 WHAT IS DESIGN?

Design may be defined as the activity of specifying an artefact, given requirements that indicate one or more functions to be fulfilled and/or objectives to be satisfied by that artefact. The activity of design consists of transforming representations, beginning with an initial outline representation and then developing more detailed representations. The initial representations can be very diverse - composed of elements at various levels, from different sources, made up of contradictory and/or incomplete constraints, or implying such elements. The final representation has to be very precise and detailed - composed of elements that are all at the same level of abstraction and sufficiently specific to enable the artefact to be constructed from that representation.

Schön (1988) was one of the first to question the then pervasive "Problem Solving" view of design, saying that, "in this paper, [he] will treat designing not primarily as a form of 'problem solving', 'information processing', or 'search', but as a kind of making. In this view, design knowledge and reasoning are expressed in designers' transactions with materials, artefacts made, conditions under which they are made, and manner of making". Designing is "a kind of making…. What designers make… are representations of things to be built" (ibid). Schön emphasises that "problem solving" is generally considered as handling problems as "given", whereas the process of "problem setting" is neglected. "Problems of choice or decision are solved through the selection, from available means, of the one best suited to established ends. But with this emphasis on problem solving, we ignore problem setting, the process by which we define the decision to be made, the ends to be achieved, and the means that may be chosen. In real-world practice, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain" (Schön, 1983).

It is now accepted that the "Rational Problem Solving" and "Reflective Practice" paradigms developed in the 1960's and 1970's do not adequately explain the design process. Current theories build upon the "situatedness" of the problem solving activity (Winograd and Flores 1986, Suchman 1987, Varela 1991). This has been comprehensively elaborated by Gero (1990) into his "situated function-behaviour-structure framework" (Gero 2004).

Designing is an activity during which the designers perform actions in order to change the environment. By observing and interpreting the results of their actions, they then decide on new actions to be executed on the environment. This means that the designers' concepts may change according to what they are "seeing", which itself is a function of what they have done. We may speak of a recursive process, an "interaction of making and seeing" (Schön and Wiggins 1992). This interaction between the designer and the environment strongly determines the course of designing. In experimental studies of designers, some phenomena related to the use of sketches, which support this idea, have been reported. Schön and Wiggins found that designers use their sketches not only as an external memory, but also as a means to reinterpret what they have drawn, thus leading the design in a new direction.

Adopting situated problem solving implies approaching design problems through the eyes of the designer in a particular design situation. This means confronting the vagueness and subjectivity that is involved in local design actions and decisions. However, inasmuch as a design project is a problem solving process for the outside world, it needs to be controlled and the design decisions justified to the stakeholders. In that case there is a need to objectify the goals and decisions in the design project, to effectively eliminate the implicitness and elements of "subjective interpretation" from the design activities. Any perception and problem interpretation must then be made explicit and becomes a subject of negotiation between the designer and the stakeholders. Through this process of negotiating, design becomes a more or less "objective" process, in which problem statements, programmes of requirements, ideas and design concepts are still made "subjectively" and implicitly, but in the end are presented explicitly and evaluated in order to settle them and thus make them real objects in the world. The "objectivity" of the steps in a design process and of the terms used to describe it can thus be considered an artificial construction by the designer(s) for special purposes. This may be achieved through the use of "scenario" techniques. This methodology simulates possible future environments and then concentrates on developing paths from the present situation towards various possible futures. In following the different paths the complexity of the design problem is explored and any inter-relationship between alternative outcomes discovered.

3 INDETERMINANCY IN DESIGN

The major cause of the indeterminancy is that design has no special subject matter of its own apart from what the designer conceives it to be. The subject matter of design is potentially universal in scope (design thinking may be applied to any area of human experience) but, in the process of application, the designer must discover or invent a particular subject out of the problems and issues of the specific circumstances.

An architect begins with what might be called *quasi-subject matter* (Buchanan, 1992), tenuously existing within the problems and issues of specific circumstances. Out of the specific possibilities of a concrete situation, the architect must conceive a design that will lead to *this* or *that* particular building. A *quasi-subject matter* is not an undetermined subject waiting to be made determinate. It is an indeterminate subject waiting to be made specific and concrete. For example, a client's brief does not present a definition of the subject matter of a particular design. It presents a problem and a set of issues to be considered in resolving that problem.

This is where scenarios take on a special significance as tools of design thinking. They allow the architect to position and reposition the problems and issues at hand. Scenarios are the tools by which an architect intuitively or deliberately shapes a design situation, identifying the views of all participants, the issues which will concern them, and the intervention that will serve as a working hypothesis for exploration and development They are the *quasi-subject matter* of design thinking, from which the architect fashions a working hypothesis suited to particular circumstances.

This helps to explain how design functions as an integrative discipline. By using scenarios to discover or invent a working hypothesis, the architect establishes a *principle of relevance* for knowledge from both the arts and sciences, determining how such knowledge may be useful to design thinking in a particular circumstance without immediately reducing design to one or another of those disciplines. In effect, the working hypothesis that will lead to a particular design solution is the principle of relevance, guiding the efforts of the architect to gather all available knowledge bearing on how the building is finally planned.

But does the architect's working hypothesis or principle of relevance suggest that the building itself is a determinate subject matter? The answer involves a critical distinction between design thinking and the activity of production or making. Once a building is conceived, planned and built, it may, indeed, become an object for study by any of the arts and sciences, but in such studies, the activities of design are easily forgotten. The problem for designers is to conceive and plan what does not yet exist.

4 DESIGNERS APPROACHES

Scenarios, as a process, work in a similar way, moving the design team away from their existing schemas to explore new territory. The scenario process enables designers to visit and experience the future ahead of time and to create "memories" of the future. This is a form of experiential learning which develops purposeful learning skills (Kolb 1984).

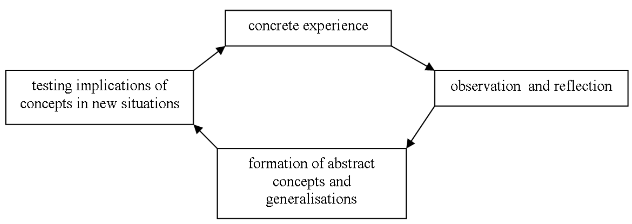

Figure 1. Experiential Knowledge (after Kolb (1984)).

To determine some of the characteristic processes, ten practicing architects were interviewed in a series of structured interviews which were recorded, subsequently transcribed and then analysed. The questions were open-ended in order to encourage discussion without leading to (or implying) particular answers. The discussion was structured as a mixture of general and specific questions, beginning by asking how the designers go about the conceptual design of a new project. For example, do they use generic volumetric forms or do they develop specific forms from, say, site influences. They are then asked about design constraints – are they self-imposed or derived from regulatory frameworks; do they support or limit the design development? How do they decide to adopt one particular idea in preference to another - for example, from previous experience, design precedents, or site/regulatory constraints. Is the approach the same for different building types or large or small scale projects? In conclusion they are asked to illustrate their approach by reference to one of their design projects.

The preliminary findings show a number of distinct approaches:

- A01 and A06 begin with technological issues and develop particular design details which then lead to specific forms
- A02, A07 and A08 use pure forms to develop a 'geometry' in response to the site. A09 works in a similar way but with physical models
- A03 tries to distil the essence of the site, taking inspiration from artefacts found on the site
- A04 relates client requirements to specific functional architectural standards
- A05 derives visual axes from the site
- A10 works from design precedents

These general approaches are summarised in Table 1.

Table 1. General Design Approaches.

Designer	Brief	Function	Client	Site	Context	Scale	Material	Form	Feelings
A01	●			●	●	●	●		
A02				●	●			●	
A03				●				●	●
A04		●	●				●		
A05				●	●			●	
A06	●	●	●						
A07				●	●			●	
A08				●				●	
A09				●	●	●		●	
A10				●				●	

Further generalizing the detailed findings, two pairs of key axes emerged which structure the sample architects' approach to early stage design. One was on a 'structural – spatial' approach to layout and the other on a site – building typology/technology approach to constraints.

5 FRAMEWORKS FOR UNDERSTANDING CONCEPTUAL DESIGN

Macmillan et al. (2001), argue that conceptual design is too disorganized, with the result that collaboration suffers as team members become frustrated. As a remedy, they propose a "generic model" for supporting conceptual design that would be expressed as a series of steps for interaction to give all participants a road map. Their research approaches design as a profession, and reports on observations of nine case studies of team interactions during the early phase of design. From these observations, they note several problem areas common to all the projects: confusion regarding direction or progress, team members rushing ahead of one another, expectations that all requirements can be equally satisfied, little user involvement during conceptual design, and wrong people involved in the initial briefing sessions (Macmillan et al., 2001). To address these problems, they propose a series of twelve sequential steps to enhance collaboration between members. The authors make clear the framework is meant as a toolkit to enhance collaboration, not a prescription for how to make buildings. Continuing with their focus on practicing architects, they fine-tuned their model based on verification meetings with each of the teams to make sure the model reflected their experience.

Table 2. Framework for conceptual design (after Macmillan et al, 2001).

Conceptual Design Framework Tasks
Specify the need
Assess the requirements
Identify essential problems
Develop the requirements
Set key requirements
Determine project characteristics
Search for solutions
Transform and combine solutions
Select suitable combinations
Firm into concept variants
Evaluate and develop a choice of alternatives
Improve details and cost options

6 SCENARIO DEVELOPMENT

Scenarios provide a powerful technique for analysing, communicating and organising requirements. Following Macmillan et al one of its main strengths is in communicating key ideas so that stakeholders share a sufficiently broad view to avoid missing vital aspects of the process. Scenarios are based on the idea of a sequence of actions carried out by intelligent agents. In the architectural design context this intelligent agent may be the human designer or some computing support. It provides the focus for all modelling, design and communication, making use of narrative, sequence of events over time and for guessing and reasoning about alternative outcomes.

Three main techniques are used:

- Prototypes: these provide an interactive artefact that clients and design team members can react to.
- Scenarios: the designed artefact is situated in a context.
- Design rationale: the designers' reasoning is exposed to the rest of the team and the clients, thus encouraging participation in the design development.

The main objective of scenario building is to determine possible, probable or preferable futures (or futures to be avoided). Process of designing attempts to reduce uncertainty at different levels: individual/organisational/social. The methodology shifts the focus from the design object to the process of communication and interaction. Design decisions define possibilities; eliminate alternatives; absorb uncertainty; create novelty.

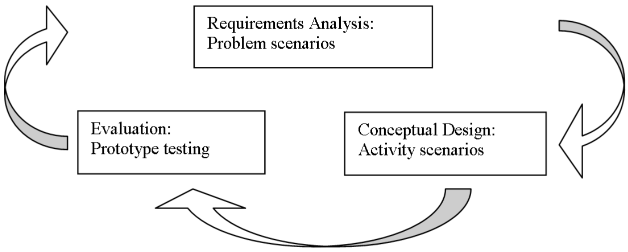

Figure 2. Cycle of analyse, propose and test.

The key stages of scenario development are summarised in Table 3 and Figure 3.

Table 3. Stages in scenario development.

Task Analysis - Identify Design Problems - User situations/evaluation structures - Review present situation; define goals; discuss strategies - Analyse strengths and weaknesses of alternatives - Incorporate into scenario descriptions
Influence Analysis and Problem Description - Define problem domain and identify key elements - Context in which project is set - Decompose complex situations into chunks - Structure chunks - Represent interconnections as aspect models - Network relationships between influence areas - Recognise trade-offs and dependencies
Future prediction - Work out and justify alternative paths towards possible design goals as a way of dealing with uncertainties
Concept generation - Determine which alternatives are a good match for the desired future and evaluate compatibility between alternatives

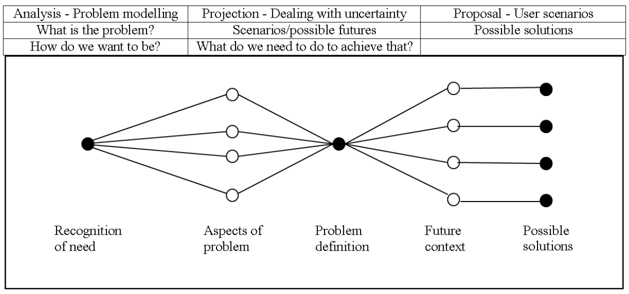

Figure 3. Scenario Development.

Scenarios need evaluation mechanisms. It is necessary to test potential solutions. In the past design evaluation tended to be summative – positioning a solution relative to other alternatives on various scales (cost, energy use). More usefully, scenario evaluation attempts to be formative – seeking to identify aspects of the design which might be improved. Feedback cycles are one way of achieving this, utilising theory (backward feedback) and practice (forward looking).

7. CONCLUSION

Scenarios provide a realistic new approach to constructing early-stage design support systems. Our application of these ideas at Strathclyde is in two areas. The main focus is on agent-based design evaluation. The second is pedagogical: if experienced designers' scenarios can be defined then, we believe, these could become valuable mechanisms in the teaching of design.

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