Scenario-based Design

Integrating Design Computing with Design Studio

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The concepts underlying "scenario-based" design are introduced and put forward as a computationally-supportable alternative to sketching in early-stage design. 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, making use of TRIZ methodologies.

Keywords: *Scenario; TRIZ; architectural design.*

The need for an alternative to sketching

Cognitive science suggests a link between the embodied act of drawing and the perceptual experience of space. But what happens during problem solving, remembering, perceiving, and other psychological processes in the transition from pencils and pens to keyboards and mice? This proposition raises a basic question – should the established methodologies of hand drawing even be expected to transfer to CAD? There is one crucial difference between the two mediums. In hand-drawing, traditional design representations utilise an acquired skill the designer has learned and developed throughout their design education and practice: the particular representations used and their perceived usefulness are unique to the individual designer. In direct contrast, designers using CAD systems are presented with a pre-determined set of representations (and manipulation tools) with properties and influences over which the designer has no control.

There are two distinct responses to this problem. One approach is to "individualise" CAD systems. CAD literate designers are increasingly representing design ideas in the form of computer code. This code will then generate design propositions that can be manipulated by the designer in ways decided by that designer. Well-known examples include "smart geometry" which represents dimensional constraints in a parametric form enabling designer interaction and "bio-mimetic" design where computer algorithms "grow" buildings according to defined rules. An alternative approach is to consider the issues being explored in sketching and see if those objectives might be achieved in a different way. 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. It is also the case that our mental resources for visual invention are better adapted for acting in the present rather than for imagining hypothetical futures. Given that designing falls into the category of planning for the future some form of external aid is obviously beneficial. Given that CAD systems lack the immediacy and quality of hand sketching in this context, there is a need for an alternative. One possibility is 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. The possible futures may be generated as described above or could be derived from selected "design precedents". In this way many of the same key mental processes engaged in sketching are utilised although the representation is radically different.

Given that this methodology makes "design process" relatively explicit, it was realised that the technique could equally well be applied in traditional design studios. To test this hypothesis, structured interviews were conducted with studio teaching staff (mainly practicing architects with part-time teaching contracts) in order to determine their approach to design (in effect their personal design scenarios). Our conjecture was that if the tutors' approach to designing was made explicit then the students might more clearly understand the rationale behind the studio and thus perform better

Design activities

It is now accepted that the "Rational Problem Solving" and the "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 as introduced by Winograd and Flores (1986) and Suchman (1987). This has been comprehensively elaborated by Gero into his "situated function-behaviour-structure framework" (Gero, 2004).

In the design process, and especially in "non routine" activities, designers have to create an innovative product as well as to satisfy certain specifications. The structured interviews (supported by the literature) showed the importance of precedents in this process. Schematically, in order to solve the problem at hand (the "specific" problem), the designer would refer to a similar problem or situation, for which a solution already exists (the "generic" solution) and would then transfer certain features of this solution in order to develop the solution (the "specific" solution) for the problem at hand.

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. Memory, as an overall term, must be seen as a process rather than a fixed state. The significance of the idea of constructive memory in designing has been demonstrated by Gero. Situatedness and constructive memory thus provide the conceptual basis for grounding the knowledge of an agent in the situation being constructed by its interactions with the environment. Situatedness in designing can be modelled as the interaction of three worlds (figure 1).

The external world is the world that is composed of representations outside the designer or design

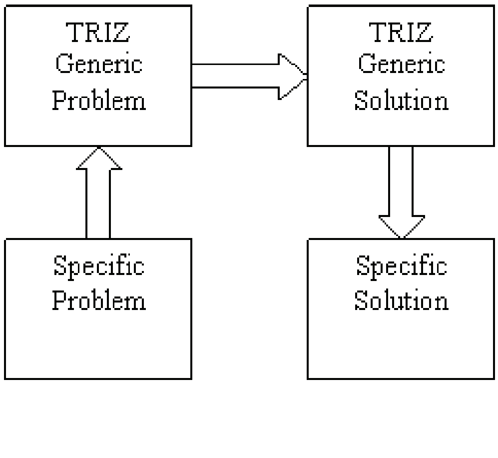

Figure 1.
Situatedness modelled as the interaction of three worlds (after Gero, 2002)

Table 1. 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

agent. The interpreted world is the world that is built up inside the designer or design agent in terms of sensory experiences, percepts and concepts. It is the internal representation of that part of the external world that the designer interacts with. The expected world is the world imagined actions will produce. It is the environment in which the effects of actions are predicted according to current goals and interpretations of the current state of the world (Gero, 2002).

Frameworks for understanding conceptual design

Scenarios provide a powerful technique for analysing, communicating and organising requirements. 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 key stages of scenario development are summarised in Table 1.

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).

Other techniques may be embedded within the scenario. One of the most promising, which has received relatively little attention, is the Theory of Inventive Problem Solving (or TRIZ). TRIZ is a Russian acronym (**Т**еория **Р**ешения **И**зобретателбских **З**адач) for the theory, which was developed by Genrich Altshuller (Altshuller, 1984). The theory originated from an extensive study of patents, from which Altshuller was able to derive a number of generic problem-solving methodologies. The core findings of TRIZ research on the global patent database are that there are only 40 Inventive Principles and that technology evolution trends are predictable. Essentially, TRIZ researchers have encapsulated the principles of good inventive practice and set them into a generic problem-solving framework. The task of problem definers and problem solvers using the large majority of the TRIZ tools thus becomes one in which they have to map their specific problems to and select solutions from this generic framework. Mann and Ó Catháin (2001) give a general introduction related to architectural design and Lee and Deng (2006) show its relationship to case-based design.

The fundamental basis of TRIZ is using a database of generic solutions to identify a potential solution and then adapting that tentative solution to the specific circumstances. This is known as the "Prism of TRIZ" and is shown diagrammatically in figure 2.

Innovation is introduced by the "Four Pillars of TRIZ". These are essentially paradigm shifts, looking at Contradiction, Ideality, Functionality, and Use of Resources

The methods and tools are embodied in a five-step process, the Ideation Process, which consists of the following:

1. Problem documentation and preliminary analysis
2. Problem formulation
3. Prioritization of "Directions for Innovation"
4. Development of concepts
5. Evaluation of results

Modelling a problem is a process of converting a mass of mental data relating to the project into an ordered collection of sequential "knowledge units," and of determining the relationships between these units. Once the problem has been formulated, design development may begin, typically by making use of a Structured Knowledge Base. As each idea resolves a different aspect of the problem, the ideas must be combined into new, innovative concepts. An analysis of the ideas that have been generated supports classification of ideas based on certain "combination criteria" of which there are two options:

1. Combining ideas that perform the same function in different ways
2. Combining known systems
   a. Combine systems having the same functions
   b. Combine systems having opposite functions
   c. Create a system from homogeneous elements

The approach of combining ideas that perform the same function in different ways assumes that each idea has its own advantages and disadvantages. As a result of this combining, the new idea should have all of these advantages and no disadvantages. Achieving this entails the following steps:

- Select two ideas that resolve the same problem in different ways.
- Compare these ideas; each has its own advantages.
- Consider the idea that has better functional features as the "source of resources"; the other idea is the "recipient of resources."
- Determine the elements that provide better functionality of the source idea.
- Apply these elements to the recipient.
- Consider if some elements of the recipient can perform functions of the newly-applied elements, and simplify the system.
- As the best result, the new system should consist of elements of the recipient and have features of the source.

When combining ideas, functions, and systems the result is often an increasingly complex (sometimes monstrous) design concept. The next natural step is to go through a process of simplification and refinement.

The evaluation of results is the culmination of the five-step process. This step is designed to ensure that the concept(s) have been thoroughly thought out and is implementable. There are three stages to this process:

1. Meet criteria for evaluating concepts
2. Reveal and prevent potential failures
3. Plan the implementation

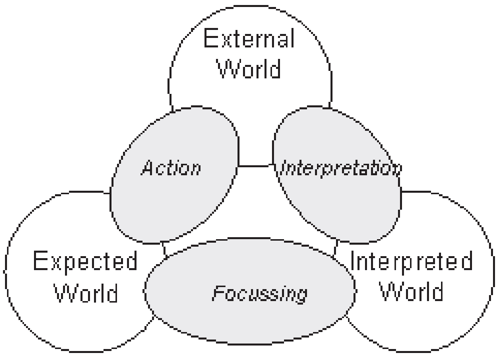

Figure 2. The Basic TRIZ Problem Solving Process

Real designers

Having determined elements of a theory it was necessary to see if any of these characteristic processes could be found in practicing designers. Ten architects (referred to below as A01 to A10) 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

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. These were adopted as the key scenarios for experimental use in the design studio.

Conclusion

Scenarios, supported by TRIZ, provide a realistic new approach to constructing early-stage design support systems. Our research work continues in developing agent-based design evaluation based on these theories. Meanwhile, the explicit methodologies were tested (without extensive computing) in a second year design studio. All of the students involved felt that the structured approach was valuable at that stage of learning to design. The main comment was that the scenarios provided a "route" to follow which they felt could be personalised as they gained more experience in designing. We now believe we have sufficient evidence to continue this pedagogical research as an important contribution to the teaching of architectural design.

Acknowledgement

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