

MODELLING DESIGNING: Cognitive models of the design process using a semantic approach

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Abstract. This text is about research in design methods that the author hopes to undertake in the future. The objective of the research is to devise a cognitive model of designing, using empirical means of studying designers at work. The purpose of this proposal with respect to the research is to present it to an audience—preferably as a poster session, and examine possible strengths and weaknesses in the proposal. Apart from the obvious benefits that accompany any external scrutiny, there would be the advantage of presenting some independently incubated ideas to the rigours of an established realm of research.

During the course of the presentation, there is an examination of the Design Methods Movement of the 1970s, followed by an inquiry into its apparent failure. Subsequently, empirical studies in design research that have been undertaken are discussed—followed by a proposal to use verbal utterances in designing, and semantically map them with an ontology modeller like KAON.

Instead, the author proposes to use an ontology-instance modeller to record and disseminate verbal utterances, and thus form a cognitive model of designing. Words spoken during designing—and presenting design—can be coded, and used to form a cognitive model, using the parameters of concept, property and instance that KAON uses.

The author also presents a tentative methodology of empirically observing designers at work, and modelling designing using KAON.

In conclusion, it is established that such research would help develop a cognitive model of designing—more that one that is computational—but would nevertheless rely heavily on computational support. Moreover, such analysis would also need pro-active collaboration of the designers being studied.

1. Introduction

The scientific inquiry into design methods is largely known to be a post-World War II development. Increasingly complex design tasks led pioneers in the field like Christopher Alexander and J.C. Jones to seek improved ways of designing, as they felt the existing procedures to be inadequate. This early work sought to develop newer, better and more appropriate procedures, or design methods, and the field was appropriately called *design methodology* (Gedenryd, 1998). It was also popularly known by Cross as “the design methods movement”. These design methods, as their progenitors developed them, were schemes that described in detail a working procedure, the activities to perform, and the order in which to perform these activities. They were usually very specific in instruction, and the designers were expected to follow them meticulously in order to achieve the desired result. They also generally covered the design process from beginning to end. Interestingly, all design methods developed at that time had a similar visual characteristic. They were all box-and-arrow diagrams. It was the labels on the boxes and the connections between them that distinguished one method from another (Jones, 1970).

2. The Failure of Design Methods

In spite of all the good intention associated with design methods, their failure in general is a widely recognized fact (Gedenryd, 1998). Henrik Gedenryd, in his recent thesis in 1998 at the University of Lund recognizes a number of circumstances that bear testimony to this. Firstly, it was the original advocates of the design methods movement, rather than critics from outside, who proceeded to document its failures, and abandon them. Moreover, the exceptional haste at which this reversal came is significant. Alexander’s original description of his methods was published in 1964. When interviewed in 1971, he proceeded to dismiss design methods completely:

Until those people who talk about design methods are actually engaged in the problem of creating buildings and actually trying to create buildings, I wouldn’t give a penny for their efforts...In short, my feeling about methodology is that there are certain mundane problems which it has solved—and I mean incredibly mundane. (Alexander, 1971)

Broadbent went on to state:

Yet asked to catalogue its achievements, in terms of buildings built, cities designed, and so on, most of its advocates find themselves in difficulties. (Broadbent, 1979)

3. Prescription vs. Description

A possible cause of the failure of design methods was that it was prescriptive in nature. The objective of the design methods movement was to devise a methodology for designers to follow. However, the broadness of design-activity, and the inherent complexity within the simplest of design-tasks make designing difficult to formalize. John Gero writes:

More recently, it has been suggested that designing in its fullest sense maps well onto abductive processes, which helps explain why it is so difficult to formalize it. In addition to its abductive nature designing is situated: i.e. designing cannot be predicted since decisions to be taken depend on where the designer is at any particular time and what the designer perceives the situation to be when (s)he is where (s)he is. (Gero, 1999)

On the other hand, the single largest achievement of the design methods movement was to effectively begin articulating the design process. The same boxes-and-arrows that signified proposed design methods can be used to describe the design-process *subsequent* to the act of designing. The complexity within design tasks which are difficult to predict, because of the very nature of design, can be mapped easier in *retrospective*, i.e. when the activity of design is deemed to be over, and one can retrace the path the designer undertook to arrive at the design solution. Certain steps in this direction are already being taken in contemporary design research, in the form of protocol analyses and empirical studies of human design activity.

4. Describing Designing

The first formal protocol analysis study of design was conducted by Charles Eastman in 1969. Several designers were asked to design a bathroom under experimental conditions. Eastman's conclusion dwelled on the behaviour of designers—of what architects do when they designed—design representations, subjects' problem identification behavior and problem decomposition (Akin, 1998).

More recently, John Gero writes about two possible approaches to protocol analysis—the concurrent or 'think aloud' method and the retrospective method (Gero, 1999). In the former, the designers under study are asked to consciously 'think aloud' while designing. Simultaneously, their verbal utterances are recorded and transcribed, and used to develop a coding scheme. In the latter method, the designer is videotaped during designing, and shown the tape immediately after. The person is then simultaneously asked to think aloud about what he/she was thinking during the design activity, and the resulting transcriptions are subjected to a similar coding and analysis.

The objective of protocol analyses in all such cases has been to develop computational support tools to aid human designers. Eastman states:

...one of the strengths of the human problem-solver is his ability to use several representations— words numbers, flow diagrams, plans, sections, perspectives — to represent, compare, and manipulate information...that any man-machine system to aid the designer must recognize his reliance on multiple representations.(Eastman, 1969)

Gero writes:

The results of such studies provide grounded insight into the behavior of designers as they are designing. These insights can form the basis of the development of computational support tools for designers. (Gero, 1999)

Moreover, current methods of empirical protocol analysis restrict themselves to concentrated periods of design activity—referring to ‘instances’ of designing. However, designing often involves decision-making over elongated periods of time, with inputs of multiple persons in various forms. This is evident in both pedagogy and practice—in the designer–critic discourse in the studio, and the designer/s client interactions in the profession.

5. Talking Design

Currently, design is taught all over the world by means of the studio and the designer–critic interaction. During the task of engaging with a design problem, the student has multiple interactions with the studio critic/s, during the course of which the design develops. Though the designed product manifests itself in the form of drawings and models, the discussion is verbal in nature, where the student tends to *talk* about the design, and the critic responds in the same manner. Over subsequent such interactions, multiple design iterations are produced, until the last such solution tends to be satisfactory for all concerned.

In cases where multiple students are engaged in a group, communications within the group are largely verbal. While discussing an aspect of a problem, sketches/diagrams are indeed made, but the backbone of all activity is spoken argument and agreement. Such ‘thinking aloud’ goes on to produce designs—which are subjected to critical scrutiny—which in turn produce a lot more verbal output.

Even within the profession, where firms comprising of multiple individuals go about the task of constructing buildings, the presence of the spoken word is paramount. Designers, assistants and consultants alike talk about their work, in order to develop it, a lot more than they actually draw.

If examined, it is probable that the quantum of words spoken and exchanged

during designing far outweigh the quantum of physical work produced in the form of drawings. Therefore, it would be reasonable to say that an analysis of these verbal communications—which are made over long periods of time, and are generously spaced apart—would give an insight into the processes that result in a design being produced.

6. Working with words: the LSA

Among the current research in the study of designers—particularly those that rely on the examination of verbal utterances—Andrew Dong’s work at the University of Sydney is of particular significance. A computational linguistics tool, the Latent Semantic analyzer (LSA), has been used to analyze design communication in a conversation mode and measure the duration of coherent discussions in design teams. According to this research coherent thinking is understood as the alignment of thoughts that lead to the construction of a design task (Dong, 2004). A method such as this is an important tool in assessing design cognition in collaborative environments, and producing computational environments that aid designing. However, it does not produce, or even aim to develop a model of the design process.

Still, the use of the LSA is an important development in verbal protocol analysis, a widely adopted method for analyzing designers’ communicative acts to investigate design thinking (Ericsson and Simon, 1993; Cross et al., 1996).

7. Working with words: the possibilities of KAON

KAON is an ontology modelling tool that was started in August 2001 as an internal research project of the knowledge management groups of the Forschungszentrum Informatik (FZI) and the University of Karlsruhe (TH). The general goal of KAON is to retain scalability in reasoning with large ontologies and knowledge bases. Currently, KAON relied heavily on Semantic Middleware, i.e. the use of textual occurrences of words to map these ontologies. Typically using parameters of Concept, Property and Instance, the KAON workbench as depicted in Figure 1, produces box-and arrow diagrams, which are non-static, multi-dimensional entities that evolve and remodel constantly with each addition and evolution to an ontology or a knowledge base.

Considering that Modelling Designing can be seen as ontology—an effort to provide a systematic account of the design process—KAON is a potentially valuable tool to do so. Whether KAON is used in its present form is used, or customized for modeling designing, or a new ontology modeller be developed—is subject to a more thorough study of the workings of KAON. Moreover, the decision whether the Concept-Property-Instance parameters inherent in the OI Modeler be used, or

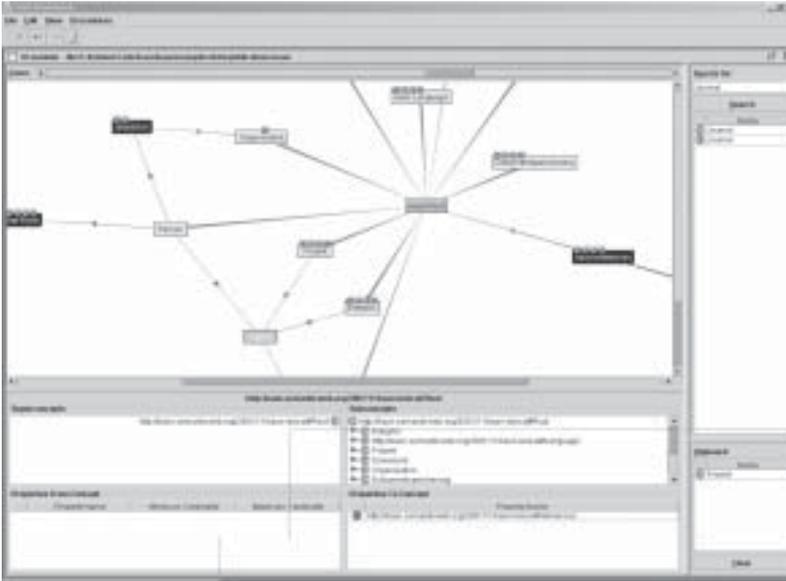


Figure 1. A Typical KAON workbench screenshot.

substituted by Objective-Constraint-Priority parameters that are more descriptive of designing—is also a matter of detailed methodology. However, what is important to observe at this stage is the remarkable similarity between the output of the KAON Workbench, as seen in the diagram, and the early box-and-arrow diagrams produced during the Design Methods Movement of the sixties.

8. OI modelling and Designing—Proposed Methodology

At this early stage of this research, it is not possible to chalk out a detailed methodology without more thorough background research on the subject. What is particularly important is an examination of the Ontology Modelling capabilities and limitations of a program such as KAON. Furthermore, it would be pertinent to assess whether there is more prior work done in using semantic utterances to record Designing—like Andrew Dong’s use of the LSA. However, a tentative roadmap that this research can take is:

- Take up a design task as a prototype and observe and record it from start to finish.
- During this process, record all verbal utterances that occur—between members of the design team, between designers and critics/clients, and between designers and production teams. In concise, all verbal communication between all stakeholders in the design process.
- Extract *keywords* from this repository of words that are shaping the process.

- Put these keywords in the OI Modeller, and establish relationships between them.

What this method would probably produce is a detailed breakdown of processes and sub-processes in the design task, and the evolutions and iterations that the action has gone through from start to finish. A series of resulting diagrams that would emerge from the Modeller would be similar to a map of the design process.

However, this methodology might need extensive hand-coding, unless more effective methods of recording verbal utterances are developed. Moreover, the model of designing produced would be more cognitive in nature—than computational—though it would rely heavily on computation in its development. Furthermore, there would be a need for pro-active collaboration and support of the designers being studied.

9. Conclusion

In conclusion, it can be ascertained that modelling the design process using an ontology modeller has tremendous potential, provided it is taken to its logical conclusion. Such a model would be a valuable tool in the assessment of designing. Since the ingredients—and also the by-products of the semantic ontology modeller would be words, it would aid in the description of designed products, the articulation of individual designers' strengths and weaknesses, and in the designer-critic discourse. Moreover, if detailed studies are made of various designers engaged in multiple kinds of problem-solving, it might even yield articulated typologies of designing.

However, at this stage, this research is higher on promise than on delivery. Until a prototypical model is developed, and its fundamental feasibility tested, it would be unfair to make any claims to its prowess. Furthermore, for this end, this research would need institutional support, and cannot continue out of private individual initiative, as it has done till date. The objective of this text has been to bring forth these conjectures for review among established researchers in the field, and also to serve as a research proposal, on the basis of which institutional support may be garnered.

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