THE DIGITAL DESIGN PROCESS:

Reflections on architectural design positions on complexity and CAAD

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Abstract. These instructions are intended to guide contributors to the Second Architecture is presently engaged in an impatient search for solutions to critical questions about the nature and the identity of the discipline, and digital technology is a key agent for prevailing innovations in architectural design. The problem of complexity underlies all design problems. With the advent of CAD however, Architect’s ability to truly represent complexity has increased considerably. Another source that provides information about dealing with complexity is architectural theory. As Rowe (1987) states, architectural theory constitutes “a corpus of principles that are agreed upon and therefore worthy of emulation”. Architectural theory often is a mixed reflection on the nature of architectural design, design processes, made in descriptive and prescriptive terms (see Kruft 1985). Complexity is obviously not a new issue in architectural theory. Since it is an inherent characteristic of design problems, it has been dealt with in many different ways throughout history.

Contemporary architects incorporate the computer in their design process. They produce architecture that is generated by the use of particle systems, simulation software, animation software, but also the more standard modelling tools. The architects reflect on the impact of the computer in their theories, and display changes in style by using information modelling techniques that have become versatile enough to encompass the complexity of information in the architectural design process. In this way, architectural style and theory can provide directions to further develop CAD. Most notable is the acceptance of complexity as a given fact, not as a phenomenon to oppose in systems of organization, but as a structuring principle to begin with. No matter what information modelling paradigm is used, complex and huge amounts of information need to be processed by designers. A key aspect in the combination of CAD, complexity, and architectural design is the role of the design representation. The way the design is
presented and perceived during the design process is instrumental to understanding the design task. More architects are trying to reformulate this working of the representation.

The intention of this paper is to present and discuss the current state of the art in architectural design positions on complexity and CAAD, and to reflect in particular on the role of digital design representations in this discussion. We also try to investigate how complexity can be dealt with, by looking at architects, in particular their styles and theories. The way architects use digital media and graphic representations can be informative how units of information can be formed and used in the design process. A case study is a concrete architect’s design processes such as Peter Eisenman Rem Koolhaas, van Berkel, Lynn, and Franke gehry, who embrace complexity and make it a focus point in their design, Rather than viewing it as problematic issue, by using computer as an indispensable instrument in their approaches.

1. Introduction

Design methods have been at the core of researcher’s attention since the early sixties. Many of the early approaches (Jones, 1996; Habraken 1976) were inspired by the paradigms of systems theory and rational problem solving (Simon, 1969). Innovative work was done on the systematic description of the design process, structure of design problems, study of designers and their methods, and reflection on the nature of design.

Cross (1984) provides an overview of the changing understanding of design problems. In broad lines, the field started with a systems theoretical view which stressed the systematic approach to charting and solving design problems (period 1962-1967). This research yielded insight in the complexity and large scope of design problems.

The focus changed from encompassing methods towards inquiries into the structure of design problems in the period 1966-1973. This work showed how various structures play a role in structuring processes and solution types. In the following period, 1972-1980, attention shifted to the study of designers and their every-day working procedures. Work done in this period highlighted the importance of understanding designers in action.

In 1980-1982, the work to that moment prompted many researchers to rethink their basic stance to design research. Cross (1984) notes a renewed interest in the basic assumptions that found research in design.

From the 1980’ies onward, computation has become a substantial part in research on design, in the cognitive research approach, the field of Artificial Intelligence, and information modelling techniques.

Throughout the development of the field, the complexity of design became more and more apparent. In the early eighties there was dissatisfaction when it gradually appeared that design methodology did not
live up to its expectations (Cross, 1984). Design methods were conceived as rigid, inflexible, and with limited application. The research field expanded into design research: a broad range of investigations into the nature of design, design thinking and cognition, organization, management, and other aspects. Much of design research today happens in laboratory-settings (Hamel, 1990; Cross et al. 1996), or takes its research data from everyday practice (Valkenburg, 200; Lawson, 1994). Design methods did not fall out of the research scope altogether (Rozenburg and Eekels, 1994; Cross, 2000) and currently there is increasing attention to the distinction between the rational problem solving paradigm and the reflective practice paradigm (Valkenburg 2000; Schön, 1983; Dorst, 1997).

Design methodology, to conclude, has a rich and varied history. The translation of the research findings to concrete methods is not always obvious, Furthermore, The research group – SAR notes that the methodological reflection on design is not very popular, both with students and architects, he also notes from his experiences in architectural design methodology teaching and research, that there are five main reasons:

1. Comprehensive and systematic descriptions of design are productive for research purposes to provide a framework, but are too complex and cumbersome to effectively use in practice.
2. The architectural profession and the Building and Construction Industry did not undergo major changes, removing the immediate need for design methodological reflection.
3. Design methodologies age and have to be updated so that they tackle the relevant questions of current practice; this updating often did not take place and therefore design methods lost credibility.
4. Architects do not in general view a more transparent representation of the design process by means of methods favourably for fear that their own input will be conceived as trivial.
5. There has been a shift of attention from the design process to the design product; with an increasing emphasis on architecture theoretical positions rather than methodological positions.

At the same time we note that while using CAAD systems, architects and students are exploring new ways of designing with great enthusiasm, albeit seldom with design methodological underpinning. Architects have integrated CAAD in their everyday practice in various degrees. There are now a number of leading offices that use CAAD in innovative and creative ways, typically using a wider range of computer tools than the traditional CAAD software (such as animation and morphing software, e.g. Lynn,) or mixing it with various media (such as Gehry and Eisenman). New organizational forms of the design office appear, allowing for example round-the-clock
design teams world-wide and collaborative design. This innovative work invites methodological reflection on the design process.

2. Role of Design Drawing in Handling Complexity

Drawing plays an important role in design process. For example, design educator Lockard argues that the act of freehand drawing allows our mind to “see, comprehend and respond” to information (Lockard, 1973). Laseau in Graphic Thinking argues that conceptual drawings are drawn to present points of concern and to provoke further design decisions (Laseau, 1980). Designers use drawings to develop their designs. Designers often work by making sketches or transcribing drawings from their design team colleagues for further development (Graves, 1977). They use drawings to represent “movement, access, sound, view, function, and time” (Fraser and Henmi, 1994, p. 110). Lawson describes that the designers "find it hard to think without a pencil in their hand" (Lawson, 1994, p. 141). Herbert argues that drawings are “the designer's principal means of thinking” (Herbert, 1993, p. 1). He further argues that designer “must interact with the drawing” (p. 121). Designers use the terms of “diagrams”, “sketch” and “schematic drawing” Somewhat interchangeably. Here we use the term drawing and sketches to refer to the drawings designers make during early design process. Therefore a key aspect in the combination of CAD, complexity, and architectural design is the role of the design drawing. The way the design is presented and perceived during the design process is instrumental to understanding the design task. Lynn (1998) talks in this respect of “ambiguous yet rigorous shapes” (meaning that the design drawing can appear to be ambiguous, but is based on a precise and exact definition that can be constructed every time. More architects are trying to reformulate this working of the representation.

3. Protocol Analysis of Design

Protocol analysis studies have been used to study design problem solving. This research involved the collection of both verbal and visual data. In one of the first design process protocol studies, Eastman observed designers sketching to improve a bathroom layout to argue that designers' words and drawings correlate with the problems they find and solve (Eastman, 1968). Akin's Psychology of Design (Akin, 1986) followed Newell and Simon's information processing model (Newell and Simon, 1972). He studied architects sketching and recall analyzing the chunking of design actions and attention shifts. His study revealed several chunks: the wall and window segments, steps, and furniture of similar size that have close spatial relations.
a more recent chunking study done by Suwa and Tversky (1996) video taped architects designing an art museum. From the verbal post-design review protocols, they argued that seeing different types of information in sketches drives the refinement of design ideas. They further classified the information in the protocols into different categories such as spaces, things, views, lights and circulation. Akin and Lin designed a two-part experiment (Akin and Lin, 1995) that asked subjects to do two tasks: to reproduce a drawing from a printed transcript, and to predict verbal data from a video of the design drawing process with the sound track suppressed. They concluded that the verbal transcripts and drawings are complementary. Schön analyzed protocols of architects’ sketches in an attempt to infer their design reasoning (Schön, 1985; Schön and Wiggins, 1992). He described design sketching protocols to illustrate the idea of "reflection-in-action." He argued that designers first "see" then "move" the design objects. Goldschmidt's design protocol studies, like Akin, examined drawing as well as verbalization. She viewed sketching as an operation of design moves and arguments that results in the gradual transformation of images. Sketching, she argued, is a systematic dialectic between the "seeing as" and "seeing that" reasoning modalities. Her studies showed that the act of sketching is a vehicle for design thinking.

All the above studies described the association of thinking, verbal protocols with design drawing.

In this Paper we propose to construct design methods of particular architects on the basis of written material about their work. This leaves out the study of design methods based on observation and/or interview. The main reason for this approach lies in the aim to provide students with a working method that allows them to assess architects who use computer in the early stages of their design process. Students usually only have access to written documents for this purpose. Rather than trying to construct ‘strong’ design methods that have wide applicability in multiple domains of design (thus having weak implications for the design outcome itself), we aim to construct methods that are narrowly focused on a specific architect – and thus have strong implications for the design outcome. We have to emphasise therefore that the results of the analysis have limited applicability to design in general, and that the expected ‘life-span’ of the design methods will be brief due to changes in style and working method of the architects in question. The design studio is titled Architectural and Urban Design with CAD, and is an advanced CAD and design course. It consists of lectures combined with an exercise. The goal of the course is to give a sophisticated understanding of the relationship between the use of computers, working methods in design, and the products of this process.

Two architects are discussed with respect to their use of CAAD in design: Peter Eisenman and Frank Gerry; the author has gathered the information on
these architects beforehand. By studying and emulating the methods of these architects, students must be able to define their own insights and attitudes towards the use of CAAD.

The architects are discussed in the light of the general theoretical focus areas mentioned above. In the course, these become more specified in the following aspects.

3.1 THE POSITION OF THE ARCHITECT (ONTOLOGY)

Which elements/concepts does the architect distinguish in his theoretical position?

3.2 DESIGN METHOD

How does the architect organize his process; where and how does he use CAAD?

3.3 RESULT

How do ontology and method influence the result of the design process?

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4. Architects Dealing With Complexity

The problem of complexity underlies all design problems. With the advent of CAD however, Architect’s ability to truly represent complexity has increased considerably. Besides being systems for achieving aesthetically pleasing results, architectural styles also provide means to tackle complexity in design. They point to a hierarchy of issues that have to be dealt with first in order to get a successful design. These issues not only concern organization, structure, relation diagrams, but also elements, composition, and order (see for example Broadbent 1990 for an overview of approaches in this area).

Another source that provides information about dealing with complexity is architectural theory. As Rowe (1987) states, architectural theory constitutes “a corpus of principles that are agreed upon and therefore worthy of emulation”. Architectural theory often is a mixed reflection on the nature of architectural design, design processes, made in descriptive and prescriptive terms (see Kruft 1985). Complexity is obviously not a new issue in architectural theory. Since it is an inherent characteristic of design problems, it has been dealt with in many different ways throughout history.

Contemporary architects incorporate the computer in their design process. They produce architecture that is generated by the use of particle
systems, simulation software, blobs, animation software, but also the more standard modelling tools. The architects reflect on the impact of the computer in their theories, and display changes in style through using it. In this way, architectural style and theory can provide directions to further develop CAD. Most notable is the acceptance of complexity as a given fact, not as a phenomenon to oppose in systems of organization, but as a structuring principle to begin with. In this paper, we will be interested in precisely this aspect.

Complexity is obviously not a new issue in architectural theory. Since it is an inherent characteristic of design problems, it has been dealt with in many different ways throughout history. Complexity has been picked up explicitly by for example Venturi (1966) and more recently by Koolhaas and Mau (1995). Architects who incorporate CAD in their design process, such as Franke Gehry Peter Eisenman, and Lynn, van Berkel (UN Studio), etc. utilize complexity in their work and also formulate new positions in architectural theory and style.

4.1 PETER EISENMAN’S WORKING METHOD

Peter Eisenman’s working method, as described in Galofaro (1999), relies on a simultaneous production of drawings, scale models, and computer models. The technique of superposition is used to combine historical readings of the site into material that forms the basis of a design (this is very well documented in Bédard, 1994). In this way, Eisenman is looking for complexity in material related to the history of the site (he regards the site as a ‘palimpsest’ – an old parchment with traces of previous texts). In a later phase, this already complex superposition gets an additional layer by means of a diagrammatic model: an image that is associated with the project (e.g. the image of the structure of a liquid crystal display as related to the design task of the headquarters of a software firm). This image is used to distort the current design by making the design follow lines and directions present in the diagrammatic model. This is done either in two dimensions, on the plan level, or in three dimensions, in a computer model.

Eisenman’s method progresses through the following stages.

4.1.1.2 Phase 1: Reading the site (Figures 1-4)

a. Eisenman finds as much (historical) maps of the site as possible.
b. Eisenman categorizes the material with keywords about the content.
c. He finds relations between objects of the maps and the design brief.
He uses the trace technique to find relevant forms in the map material. For Eisenman form has meaning.
He looks for important lines in the site (references to shapes, objects, places)?
He uses scale, rotate, and move to reinterpret objects relative to each other.

d- Eisenman superimposes the maps and selected objects on the site.

Eisenman tries to read the site not as a Tubule Rasa, but as an area with history, information, and influence on the design. He refers to the Palimpsest metaphor.
He tries to find connections between the maps/objects and the site.
He looks for special places that emerge from this superposition.

4.1.1.3. Phase 2: Deformation strategy (Figures 7-12)
e- Eisenman Finds a diagrammatic model that is relevant for the design.
A diagrammatic model is an image that depicts some kind of structure, organization, or working of forces.
A diagrammatic model may not be derived from the discipline of architecture.

f- He Studies the properties of the diagrammatic model.
He superimposes the diagrammatic model on the design.
He finds an interpretation of the structure that he can use for deforming the current design.

g- He translates the properties to deformations of the design.
He uses for example densities in the diagrammatic model for contracting or expanding the design.
He changes the geometry of the model along for example the lines of the diagrammatic model.

4.1.1.4. Phase 3: Reflections about the design (Figures 13-21)
h- Eisenman’s method is very analytical and needs a lot of referential material.
i- Reflections on how the superimpositions influence form and location of objects on the site.
j- Reflections on how the deformation strategy influences the design.

The diagrammatic (Figures 5 and 6) model is an image of an organizational structure that is related to the core issue in the design task. It
forms a metaphor for thinking about the design, and in which direction it should progress. In their work, the development of the building design and how it relates to the diagram is an important aspect. The diagram provides a handle on complexity as it hints to directions in which the solution can be developed.

*Figures 1-4. Phase 1: Reading the site: Eisenman tries to read the site not as a Tubule Rasa, but as an area with history, information, and influence on the design. He refers to the Palimpsest metaphor. He superimposes the maps and selected objects on the site. He tries to find connections between the maps/objects and the site. He looks for special places that emerge from this superposition. He uses Superposition techniques: CAD: layers & objects, Layers: AutoCAD / Photoshop- Objects: CorelDraw Operations: Scale, rotate, translate, retrace (source: Galofaro (1999), Bédard (1994), Eisenman (2001)).*
Figure 5-6. The diagrammatic model is an image of an organizational structure (source: Galofaro (1999), Bédard (1994), Eisenman (2001)).

Figure 7-12. Phase 2: Deformation Strategies: Eisenman finds a diagrammatic model that is relevant for the design. A diagrammatic model is an image that depicts some kind of structure, organization, or working of forces. A diagrammatic model may not be derived from the discipline of architecture. He studies the properties of the diagrammatic model. Superimposes the diagrammatic model on the design. Finds an interpretation of the structure that he can use for deforming the current design. He translates the properties to deformations of the design. He uses for example densities in the diagrammatic model for contracting or expanding the design. Changes the geometry of the model along for example the lines of the...

**Figure 12.** Diagrammatic mode: Eisenman studies properties of the schematic model. The schematic model is superimposed on the different superimposed layers. He defines the influence of the schematic model on the superposition according to its relation to the concept. He distorts the existing superposition on the basis of the schematic model. And he lets the drawing for example compress itself there where the schematic model shows a concentration of lines. Then he follows lines in the schematic model *(source: Galofaro (1999), Bédard (1994), Eisenman (2001)).*
Figures 13-21. Phase 3: Reflections about the design: Eisenman’s method is very analytical and needs a lot of referential material. It needs reflections on how the superimpositions influence form and location of objects on the site. And how the deformation strategy influences the design. The diagrammatic model is an image of an organizational structure that is related to the core issue in the design task. It forms a metaphor for thinking about the design, and in which direction it should progress. In his work, the development of the building design and how it relates to the diagram is an important aspect. The diagram provides a handle on complexity as it hints to directions in which the solution can be developed (source: Galofaro (1999), Bédard (1994), Eisenman (2001)).
4.2. FRANK GEHRY’S WORKING METHOD

Working method, as described in Friedman (1999), relies on experimentation with materials extends to process too. He works from a series of loose sketches and rough models that are scanned in 3-d and then developed as working drawings. The sketches and models are overlaid on the basic program requirements and Gehry sculpts the forms from there. The building is literally designed through the working models.

4.2.1 Case Study (Figures 23-26)

The National Nederland building, Prague (1992-1996), it is one of the more controversial buildings in Prague is the "Dancing Building" also known as "Fred and Ginger". Designed by the California architect Frank O. Gehry along with the Croatian architect living in Prague Viado Milunic. It seems
out of place at first. Prague is one of the few cities in Eastern Europe to have escaped World War II with minimal damage. So this modern building almost stands alone amid the many historical buildings in Prague. It is designed in the tradition of deconstructive architecture. The building is situated on a site where American bombs accidentally destroyed a building at the end of World War II. When first looking at the building the left side seems to have been crushed thus recreating an allusion to the effects of the violence from the bombs. And yet at the same time it appears to be whimsical and dancing. In early sketches, Gehry envisaged the building as a scrummage of boxy and pillow-like forms, to which Milunic added a geyser-shaped tower. Despite its undeniable panache and presence, the overall effect of Gehry's anthropomorphic collage is slightly disorientating (source: Fialova and Gehry (2003), Friedman and Gehry (1999)).

Figure 22. Sketch of the National Nederland building, Prague, 1992-19: Gehry works from a series of loose sketches and rough models that are scanned in 3-d and then developed as working drawings (source: Fialova and Gehry (2003), Friedman and Gehry (1999)).

Figure 23. Scale models: Start of the design process Gehry sculpts the forms from physical models (source: Fialova and Gehry (2003), Friedman and Gehry (1999)).
5- Conclusion.

The work presented here shows a particular approach to teach CAAD in the context of architectural theory and design methodology. The aspects of ontology, method, and product provide a structure to derive teaching
material from literature on architects. The analysis can be extended to other architects provided they have some body of theoretical work. The goal of the course is to make students aware of the varied ways to use computers in design, to understand the reciprocal relationship between CAAD and theory, and to formulate their own position in this respect. A theoretical basis in terms of architectural theory and design method seems to be in contrast with the perceived freedom of design. As Christopher Alexander stated: ‘If you call it, ‘it’s a Good Idea To Do’, I like it very much; if you call it a ‘Method’, I like it but I’m beginning to get turned off; if you call it a ‘methodology’, I just don’t want to talk about it’ (Taken from Cross, 1984). Design methods however, capture ‘good ideas’ and aim at a higher level of abstraction so that they can be more generally applicable. Design methods however, capture ‘good ideas’ and aim at a higher level of abstraction so that they can be more generally applicable. CAAD software now enables us to move freely through a number of design methods, and use them as a vehicle to question the design process, the design task, the design outcome, and the position of the architect.

However Many of these approaches rely on modelling geometry only, where the meaning still has to be inferred from the designer him- or herself. The research area of Information Modelling is aiming to tackle just this issue of semantics. The Design Systems group, at the Faculty of Architecture, Building, and Planning, Eindhoven University of Technology in Netherlands, is focusing on FBM as developed by van Leeuwen (1998) as the information structure. In order to link FBM with graphics representations, the group is aiming to describe so-called generic representations in terms of Features.

References


