Using Patterns of Rules in the Design Process

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Abstract

In the past three decades computational processes were introduced and were widely applied in the field of architecture. This fact imposed questions about the types of strategies that architects apply during the early phase of the design process. The answer to this question became crucial as computational processes, based on algorithms, use explicit rules while in traditional ways the role of rule during the creative phase of design remains unidentified. If we want to effectively introduce computational processes into design then the role of rule in design should be identified. In this paper, I present an experiment where I examine the patterns of rules that architects use during the exploration of a design idea, from the formation of the design problem towards the design solution. Furthermore, I investigate the role that constraints play in the formulation of these design patterns of rules.

1. Introduction

The most challenging and enjoyable aspect of architectural design occurs during the early phase of design, when the architect is still free to play with concepts and shapes while exploring different ideas to solve a design problem. During this process, a variety of tools and procedures can be used to actualize architectural objects as possible solutions to the design problem. The goal is to develop a representation that can most accurately illustrate the designer's thoughts, while at the same time leaving enough space for further investigation and exploration. In Schon's words "creative fields are characterized by the generation and manufacture of objects for reflection and evaluation."[1] The generation and manufacture of an object, however, is not actualized in the same way in all creative fields. On the contrary, as Robin Evans notes, there exists a "peculiar disadvantage under which architects labor, never working directly with the object of their thought, always working at it through some intervening medium, while painters and sculptors, who might spend some time in preliminary sketches and maquettes, all end up working on the thing itself."[2] Throughout the whole design process, architects model an object that is not yet realized, using different kinds of processes and representations in order to illustrate its form and understand its structure. The object comes to life through the model, and the interaction between model and object leads to a constant exchange of information between the two, until the culmination of the design process in the realization of the object.

In the above context, architectural design can be perceived as a conversation between the designer's thoughts and the object under construction. This conversation is conducted with the aid of a design medium. Two are the important features that determine the outcome of this conversation: the design process and the object itself. The design process refers to the steps that the designer follows from the initial idea through its exploration to the final result. The object, on the other hand, consists the vehicle for the exploration as it reflects the strategies employed by the designer. The object, in other words, is considered as part of the architectural design process that enhance design development.

The focus of the present paper is on the early phase of the architectural design process: this of exploration and creativity. The scope of the study is to examine the patterns of actions that architects form around constraints during the creative phase

in order to both address a design problem and work towards its solution. In that framework I first pose some questions regarding the strategies that architects employ while designing. I then set up an experiment to examine these questions. Three basic features that characterize the structure of the experiment are then introduced and analyzed: the design problem, the design process and the feedback relationship. Finally, I analyze and discuss the results of the experiment.

The early phase of design describes designer's actions from the introduction to the design problem, through the exploration of the possible solution alternatives and their transformations to the crystallization of a first satisfying design result. A basic feature of the architectural design process at this stage is its undefined and unclear character: designers seem to proceed in design solutions in a rather *ad hoc* way[3] that makes difficult the establishment of systematic methods of approaching the design problems.

This undefined character of the design process is proved problematic especially today, where the introduction of new design tools in the field of architecture challenge the traditional ways of designing. While traditional tools and processes are based on designer's intuition and support the use of implicit actions, the new computational tools are based on very explicit processes and rules. Different design tools impose different design processes, so If we want to use, improve or even invent tools to effectively address the design process then we need to have a better insight on how designers form their actions and what patterns of actions they follow during the design process. As a first step to this research the following questions are addressed:

How do designers formulate the information contained within a design problem?
How do designers organize their actions towards a design solution?
How do designers move between different solutions?
Do they use rules or patterns of rules in these processes? And if so, what kind of rules or patterns of rules do they use?

To answer these questions I need to introduce first the design problem, the design process and the feedback relationship.

2. Design Problem

Newell and Simon describe a problem as follows: "A person is confronted with a problem when he wants something and does not know immediately what series of actions he can perform to get it."[4] While this definition is true for all problems there are some characteristics of certain kind of problems that make the approach to their solution even harder. For example, problems that scientists or engineers deal with are definable and may have solutions that are findable. In these problems, usually the mission is clear such as finding the solution to an equation. Furthermore, an exhaustive formulation can be stated containing all the information the problem-solver needs for understanding and solving the problem, provided that he/she knows how to do it.

On the other hand, this is not the case for problems that are ill-defined, ill-structured, or wicked[5]. On the contrary, these problems have no clarifying traits, neither a single solution. Additionally, the necessary information about the design problem is not, or even cannot be, available to the problem solver. The design problem needs to be structured upon objective and subjective parameters, for

example the program for a building and the personal interpretation of the program respectively. An example that best illustrates this situation is that of a design competition. A plethora of totally different design solutions is proposed as an answer to the same program, the same site, the same time-frame and the same client. It is clear, therefore, that architectural design problems cannot be organized deterministically and also that they do not have a unique solution. What do designers tend to do, then, when they seek a solution?

Gross et al. supported that constraints play a significant role in design. They described design as an exploration of constraints and argued that constraints provide a knowledge representation that supports reasoning about designs and designing. In order to test their hypothesis they did not provide any empirical evidence, but they developed a computer software, “the constraint manager,” to describe design.

Based on the above considerations, about the characteristics of the design problem and the importance of constraints in designing, I created two design problems. The design problems had the same objective: the creation of a family house in a rectangular site. While the size of the site was the same in both cases, the site changed: in one case it was placed in a city and in the second case in the countryside. The creation of the house in the city had to follow a specific building code and also respond to the urban structure. The creation of the house in the country side, on the other hand, was not bounded on the same constraints. The site was surrounded by nature and the architects were free from strict building codes.

3. Design Process

As mentioned above the design problem is strongly related to the design process. Therefore, the ill-character of the design problem affects the design process, which cannot follow an explicit path to reach the final product and is characterized by the use of implicit rules. This fact is sustained by the solution-focused processes that designers use in contrast to the scientists’ problem-focused processes. Lawson’s studies on design behavior revealed that the architects learn about the problem by trying out solutions so as to achieve the desired result, whereas the scientists are more concerned on studying and analyzing the problem to discover the rule.

In this framework, throughout the experiment, I investigated if and how architects form and follow rules while designing. I specifically examined the formation of patterns of rules according to different constraint conditions. Furthermore, I explored the methods that architects applied in order to handle the feedback relationship while designing. The term feedback is used to describe the process of reinterpretation of design: the designer observes a new relation on the produced design, he/she evaluates it against the initial idea or hypothesis and then alters the design solution.

4. Feedback Relationship

Several studies based on protocol analysis have acknowledged the importance of reinterpretation in the early phase of design and tried to identify mechanisms and tools that support it. Studies have also examined the role of sketching in reinterpretation as well as discovered the kinds of interactions that architects have with their designs. In a series of papers, Goldschmidt has examined protocols of design involving novice and expert architectural designers. She proposed that the dialectic between arguments of “seeing as” and “seeing that” during the process of

sketching “allows the translation of the particulars of form into generic qualities and generic rules into specific appearances.”[6] In the same line, Schon and Wiggins suggested that sketching consists a visual representation that can potentially be perceived in different ways through a design process that develops along the schema see-move-see. Goel reversed the question and investigated the properties of sketch that allow for reinterpretation. He acknowledged the importance of “lateral transformations” and supported the hypothesis that because sketching constitutes a symbol system, which is characterized by syntactic and semantic denseness as well as ambiguity, it allows lateral transformations to occur. Symbol systems, however, that are non-dense and unambiguous will hamper the exploration and development of alternative solutions and force early crystallization of design development.

Goel’s conclusion is similar to an observation made by Ivan Sutherland back in 1975. Sutherland comment concerns reinterpretation relatively to the structure of the design in different representational media. He argued that because pencil and paper have no inherent structure, they can be decomposed and manipulated in any manner of interest to the designer. An evolving design may thus have alternative descriptions that may change from time to time in unanticipated ways. The structure of the computer design, on the other hand, presents an obstacle to all of this, because it is fixed in specific design operations.

As discussed above, I conducted an experiment to investigate the design problem, the design process and the feedback relationship through the patterns of actions that architects form around different constraint conditions. In this way, constraints can be considered to be the driving force that organize the architects’ actions from the formulation of the problem towards the creation of a solution. The types of constraints vary: some are external and relate to the site or to the program, while others are personal or internal and express architects preferences. In most cases the combination of the two leads the architect to outline the solution. Constraints alone, however, are not enough to guide architects to the solution. It is also the various patterns of actions that architects form around the different types of constraint that lead the exploration and filter the alternative solutions. The way that these patterns are organized and the different groups that they form were under examination throughout the experiment.

5. The Experiment

The aim of the experiment was to investigate design actions in response to different design situations. The feature that defined the difference between these situations was the constraint condition: design problems were divided in less constrained versus more constrained ones. The patterns of action that architects formed so as to address the different constraint conditions were in the focus of the experiment. The method selected for it was a protocol analysis of retrospective reports of subject’s design thoughts. The think-aloud verbal reports method,[7] which is most typical one of analyzing subjects cognitive processes was not employed because previous work suggested that talking aloud may influence designer’s perception of their design actions.

The experiment was conducted with the participation of five proffesional architects and was consisted of three tasks: two design tasks and one report task. In each design task the participants were asked to solve a design problem in a one-hour session. They were provided with a simple diagram presenting the site in which they were asked to locate a family house. Participants were free to use whatever

representational medium they wanted as tool for design. They were not asked to describe their moves and actions while they were designing, nor were they interrupted during that time. In order to keep track of the process that each architect followed towards solving the design problem, a video camera was used to record the architects design decisions.

The two design tasks happened sequentially in two day time. One week after the design tasks were completed the report task followed. I met with each participant and together we reviewed the process he/she followed with the aid of the videotapes. More specifically, while watching the videotapes, I asked each participant to describe the moves and the decisions he/she took during the design process. They were asked to remember and report with as much detail as possible what they were thinking as they were designing. Participants were not interrupted with questions during the report, except when the participant skipped a design event without commenting on it, when I asked him/her to describe it. The whole session was audiotaped.

6. Protocol analysis

The analysis of the protocol followed the subsequent steps. First, the verbal protocol recorded from the design sessions was transcribed. The next step was the analysis of the designs based on the visual representation of the drawings and their verbal descriptions. Every design solution was divided into three segments regarding the formulation of the problem, the organization of the actions, as described on the design, and the construction of responsive mechanisms. In the last step the two design solutions that each participant produced in response to the two design problems were compared according to the above three segmentation categories.

In the formulation of the problem the focus was on how architects interpreted the design problem information and what kind of groups of actions they created according to it. In this phase a more diagrammatic analysis of the problem was attempted by the architects. In the more-constrained problem, the created diagrams were mostly related to functional features of the problem and different organizations of groups of spaces were proposed – for example spaces were organized in terms of private and public, of lighting or of adequate dimensions of different spaces. In the less-constrained problem, the fact that architects were more free to work towards the solution did not mean that they did not followed certain constraints. On the contrary, having as a point of reference the site, architects imposed their own personal constraints, which were not only functional but related for example to other characteristics such as the view. In both cases, however, the same process was observed: the analysis of the problem was based upon a selection of constraints. From the infinite area of the solution space a set of constraints was selected. In response to it a general pattern of actions was created that helped architects to develop their thoughts.

After the first analysis of the problem, the architects organized their actions by imposing their thoughts on paper and constructing the first synthesis of forms. Spatial relationships determined the solution space and formed the actions that articulated the spaces. In both solution cases, more and less constrained, geometry played a significant role in the organization of patterns of actions. Grids that organized the provided space, relationships to the boundaries and occupied area (figure 1) are some of the geometrical rules that determined architects' actions. In this segment category various applications of each constraint were examined

through spatial patterns of actions within the limits of the design solution. This fact resulted either in the abandonment of solutions that did not satisfy the constraints or in further refinement of the ones that did. In this second phase the solution space was limited.

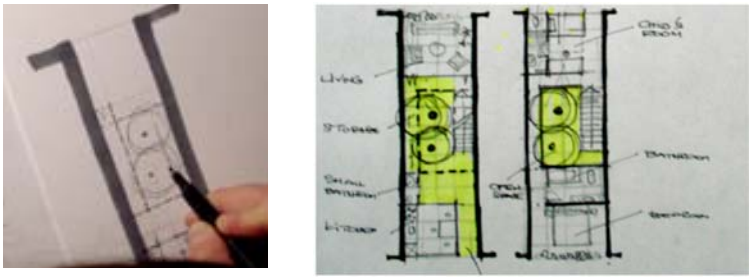

Figure 1: Geometrical constraints

The final segmentation relates to the responsive mechanism that architects formed so as to evaluate their actions and work towards the solution. This mechanism described the feedback relationship. The mechanism involved a continuous examination of various constraint applications in different solutions, the abandonment or maintenance of which led to a gradual shrinking of the design solution space. Architects were creating patterns of action according to the facet of the constraint they wanted to examine. They were then evaluating the design solution against them. In cases where the patterns of actions were conscious, for example imposing a grid and allocate spaces according to it, the architects, were able to better handle the part of the solution which was under examination, understand its limits and potentials.

7. Conclusions

In the present paper I attempted to cast some light in the vague field of the architectural design process. In order to do so, I examined the design patterns of action that professional architects employ while exploring a design problem. My main goal was to investigate how these patterns of action facilitate the design process. I discovered that architects often build their patterns of action around the foundation provided by the constraints inherent to the design problem. The selection of constraints and the associated patterns of action that were created were examined in three phases: the formation of the problem, the organization of the action as reflected on paper and the responsive mechanism. The experiment provided evidence that architects develop patterns of action in relation to the problem constraints, which therefore guide the design exploration. More specifically, architects arrive to a final solution by examining intermediate solutions in terms of how well initial constraints are fulfilled; subsequent solutions are then reached by making the necessary adjustments so as to satisfy pending constraints. In other words, given an infinite solution space, the architect finds an optimal solution by gradually eliminating ‘penalty’ regions: areas of the solution space that do not satisfy the constraints.

Future work will focus on identifying types of constraints, as well as patterns of actions that architects use while designing. It is hoped that this process will open new avenues in the field of computation, since it will make possible new design tools that can better address architects’ needs. Only when the design processes that architects use become more clear, can computers really contribute in the exploration and creative phase of the design process.

[1] Donald Schon, *Educating the Reflective Practitioner* (New York, NY: Jossey-Bass, 1990).

[2] Evans Robin, *Translations from Drawing to Building,* (London: Architectural Association Publication, 1997).

[3] Nigel Cross, *Designerly Ways of Knowing*, (London: Springer, 2006).

[4] Newell, Allen and Simon, Herbert. Human Problem Solving. Prentice Hall, 1972.

[5] Horst Rittel and Melvin Webber, "Dilemmas in a general theory of planning," Policy Sciences vol.4(1973): 160.

[6] Gabriela Goldsmichidt, "The dialectics of sketching," Creativity Research Journal vol.4 no 2 (1991): 128.

[7] Herbert Simon and Anders Ericsson, *Protocol analysis: verbal reports as data*, (MIT Press: Cambridge, 1993).

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