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A COMPARATIVE OBSERVATION ON APPLYING KNOWLEDGE BETWEEN INTUITIVE DESIGN AND THEORETICAL DESIGN

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Abstract. Akin provides the main idea of this paper, *"It is necessary to understand intuitive-design to predict the performance criteria useful in developing appropriate tools for machine-design or design-method."* This paper discussing the knowledge applied in design bases on previous studies and focuses on theoretical-design. Firstly, the relationship between theoretical design and other kind of design is addressed. Secondly, a cognitive model is proposed and to be the basis of discussion. Thirdly, two cognitive experiments are conducted, and then analysis including coding scheme is discussed.

1. Introduction

Design as a discipline is discussed widely in many fields (Oxman, 1995), but a design with a design method is confined to be merely a subject of research. This paper attempts to focus on the theoretical-design (Wang, 2000), a design method that is strongly guided by theory. From the comparative point of view we discuss the following two questions of the theoretical-design: is it different from the general formation of design used and discussed in applying knowledge? Furthermore, can the characteristic of theoretical design advance the future developing of Computer-Aid- Architecture Design (CAAD)? As the aspect "Difference in Similarity" proposed by Lloyd and Scott (1993), this paper assumes these two kinds of design have the similar process, but still some difference between them have to be identified.

"Intuitive-design" (Eastman, 1970) or "Design under the natural design mind" (Wang, 2000), what so-called "design" is a design behavior without any machine-made, design methods or any other un-natural supporting. However, design behavior doesn't always in intuition. According to the former studies, which focused on cognition behaviors of experts, it is apparently that the procedure of retrieving knowledge became more and more rapid and accurate after trainings (Anderson, 1990). To make more sense, the designer uses the "preassembled scripts" (Minsky, 1985) to simplify the procedure and to reach the goal state (Liu, 1998). Other researches also discovered that the experts are able to organize the

visual/symbolic knowledge in a more abstract level position, and to create a hierarchical knowledge system controlled by higher order knowledge (Akin, 1986, 1990). Some designers may take a parallel process within the visual/technical information (Hakkarainen and Hakkarainen, 2001). They tended to adopt a specific strategy to search information, to decompose problem (Ho, 2001), or to develop their own operating processes and shaping grammars (Stiny and Mitchell, 1978) so-called “style”. Architectural style is usually called “-ism”. It is usually used to constraint the problems imposed on the design and to reduce the alternations (Akin, 1986). Theoretical design and design style may be similar in some sense, but much different in the meaning. Theoretical design is based on “Open building” theory proposed by Habraken (1976, 1998). The theory is generated in order to manufacture space efficiently. The designer determines the most basic elements and rules through use and extension of theories. Space is thus created from this method it is not pieced together from fragments of memories. If design were a memory game (Liu, 1997, 1998), then theorized design would be a "concept design game"(Habraken, 1987). It’s meaning echoes the primal creation of space and exudes the art embodied within.

The major procedure for this research is twofold: first, a cognitive model conducted by reviewing the former studies in order to explain how the designer applies knowledge during the design task. Secondly, two cognitive experiments are proposed. The analysis including two coding schemes is proposed later. At the end of this paper, some phenomena of applying knowledge between both two sides as well as its implications will be revealed raised on the analysis of the empirical data.

2. Applying Knowledge in Design

Knowledge uses chunks as its storage units. The size of each chunk is based on the obscurity of the knowledge. In other words, obscure knowledge can only be expressed vaguely, though comparatively speaking, its application is found in more areas and subjects. (Dörner, 1999). An experienced designer is able to use the higher order knowledge effectively. This kind of operation usually relates to creativity directly (Liu, 1998). Knowledge involved in architectural design can be distinguished into two parts-- elements and rules. Elements can be subdivided into symbols and meanings. Symbols are immutable while meanings vary its formations with designers’ assignation, which hence might be "Function-Behavior-Structure"(Yan, 1993) or "issue-concept-form"(Oxman, 1994). When a specific meaning is assigned, symbols become elements, which can be operated by rules. Rule is a procedure that represents doing things in a specific way (Anderson, 1990;

Liu, 1998). Elements and rules form the "Semantic network" which is linked by "links" (Akin, 1993).

Two phases involve the manipulation of knowledge: "pattern-matching" and "rule-application" (Liu, 1996), while "pattern-matching" can be subdivided into "knowledge-retrieval" and "knowledge-refinement" (Yan, 1993). Designers retrieve relevant knowledge with "index" (Oxman, 1994; Liu, 1997, 1998) formed by episodic knowledge. The knowledge might be the specific knowledge for solving specific problems or general knowledge (Akin, 1986; Lloyd and Scott, 1993), and then applied in design after the operations, "adaptation" and "refinement" (Oxman, 1994).

According to the reasoning running ahead, a cognitive model of applying knowledge emerges (Fig.1). In order to formulate a design problem or an issue, the designer has to frame a problematic design situation by applying specific meaning to the symbol (Schön, 1988), e.g. any existent condition represent in the project. The information becomes the "index" provided to designer to retrieve the relevant knowledge and then modifies it. Finally, knowledge is applied in design. "Rule-application" is replaced by "operation" to make much sense.

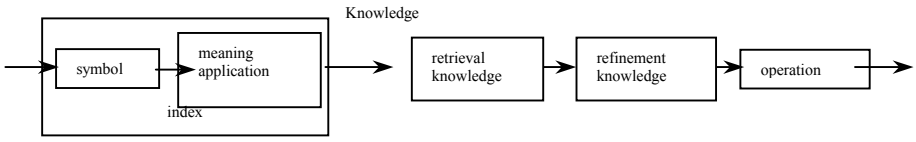


Figure 1. A cognitive model of applying knowledge.

3. The Experimental Framework

This paper employs protocol analysis as the major methodology and takes an architectural project to study the knowledge used by intuitive-design and theoretical-design. In the first one, a designer as participant A was asked to generate an "Intuitive-design", while the participant B in the second one performs the same task as participant A but generated a "Theoretical-design". The participants were asked to thinking-aloud during the design task. One camera was used to record their sketches and verbal data at the same time. This research treats the segments as "episodes"(Someren et al., 1994; Visser, 1995; Gero and McNeill, 1998) to obtain the information of the use of knowledge in design procedure.

Two participants involve the experiments. Both of them are graduate students with four-five years academic architectural design training. Besides the participant B have already developed a "section theory", she is regarded as the theoretical-design designer.

The design task in this study was an architectural design project regarding "A Community Library". The participants have to develop a proposal, before proceeding the task. The experiments sustained forty minutes and the participants could use any media she wanted.

Two coding schemes "Levels of abstraction"(Gero, 1998; Ho, 2001) and "Applying knowledge model" are used in this study. "Levels of abstraction" are denoted by the numerals 0 to 3 to represent the range from system level down to the detail level, which is to examine the level of the knowledge hierarchy. "Applying knowledge model" is identified above, and an additional item "seeing" is used to indicate the designer reviewing the design.

4. Cognitive Phenomena of Applying Knowledge

Fig. 2, 3 represent the relation between the coding result and the segments of the participants during the design task. Participant A generated 63 segments, and participant B had 27 segments. All of the segments are addressed on the figures.

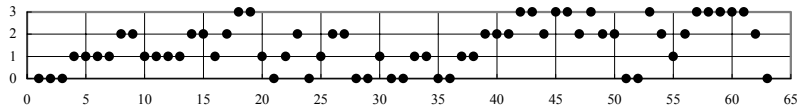


Figure 2a. "Level of abstraction" result vs. segments of participant A

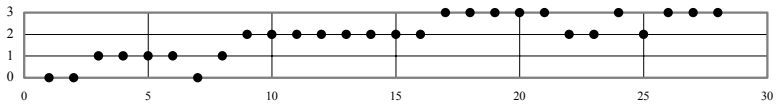


Figure 2b. "Level of abstraction" result vs. segments of participant B

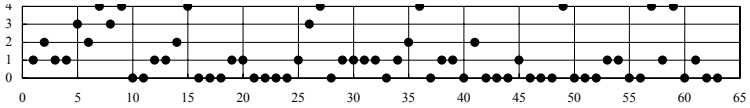
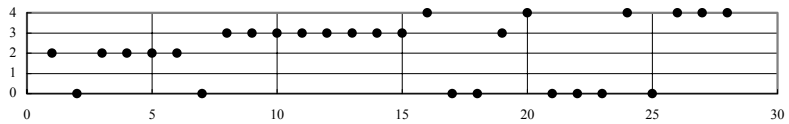


Figure 3a. "Applying knowledge model" result vs. segments of participant A



0-seeing, 1-index, 2-retrieveal knowledge, 3-refinement knowledge, 4-operation

Figure 3b. "Applying knowledge model" result vs. segments of participant B

The result reveals Phenomena that: 1. The procedure of theoretical design is much more stable than intuitive design. 2. Participant A's attention spread equally in each level of abstraction, while participant B progressed step by step from the aspect of whole system to the aspect of detail. 3. Participant A spent lots of time to look around the design and searched indexes, but participant B focused on retrieving/ refining knowledge and operation. 4. Participant B didn't frame any problem.

5. Conclusion

The results of this study indicate the difference between intuitive-design and theoretical-design. It may be caused by the characteristics of theoretical-design: 1. The elements and rules are well defined in the system. 2. The architectural space and form can be generated directly by applying rules not by designer's memory. 3. The design retrieves knowledge from his/her "theory-base" rather than the "knowledge-base".

The characteristic that the search space and the mechanism of moving between states cannot be well defined, it is deeply influences the capacity of CAAD system to simulate the real design behavior. However, it is based on intuitive design. If we can replace the designer's natural design mind to theoretical design mind, the search space and the mechanism of moving between states may be well defined. And the CAAD system can be a specifically expert assistant in design process.

This paper is a preliminary study in theoretical design. There are some issues to be the further studies: 1. How a designer forms a theoretical design mind. 2. A computer simulation study to examine the theoretical design. 3. How and when the creativity appear in theoretical design task.

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