AIDED DESIGN STRATEGY UNDER THE PROFESSIONAL KNOWLEDGE-ORIENTATION

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Abstract. Professional knowledge is a key component of the decision making process, as well as a major part of the thinking process. This research uses a strategy oriented by professional knowledge to assist the analysis of strategies in the design process, and to incite different design thinking under the operation models of media; through the basis of the design process, analyse the utilization of professional knowledge by designers in the design process and the different knowledge understanding methods under different media utilizations.

1. Introduction

The development of computer-aided design in construction has moved from the early stage representation of shapes to the present animated-simulation process, paying ever more attention to the design process and thinking of the designers. Systematically-organized complete databases of the professional knowledge required can now be made available through computers (Maher et al, 1995), and these allow designers to take appropriate design decisions, leaving them to spend more time on creative thinking. In the design process, designers may choose from many solutions available to solve a particular problem, and they may have a particular leaning or a particular area of consideration, ie a "design approaching strategy". Common "design approaching" strategies that can be found in the design process are form-oriented and function-oriented strategies. Gero(1996) pointed out that the design process can be seen as the designer using the professional skills in "micro strategies" to tackle design issues, and use "macro strategies" to consider the present situation, and the process in which the solutions are obtained is also a decision process. Schmitt(1994) believes that the main origins for a design with creativity are the differences in learning abilities and the way to utilize knowledge. By "utilize knowledge", the amount of knowledge in precedents utilized is considered paramount. Oxman(1994) asserted a design thinking based on design precedents, and search for

inspirations through studying precedents - such innovative ideas gleaned from precedents usually represents unexpected new ideas. Chen and Lee (2001) advocated a professional strategy oriented towards the "media", with changes in the media influencing the design strategy and thinking models of the designer, and the orientation of the media changing the design strategy of the professionals. Therefore, the design knowledge rooted in the sketching drawn by the designers becomes the key towards the decisions made in the entire project. At the moment, there has been no research into a strategy oriented towards professional knowledge and its relationship with design thinking; media and thinking are key factors influencing the early-stage conceptual development in architectural design, and professional knowledge is a key factor influencing decisions, and hence a key factor in influencing thinking. The more areas considered by professional knowledge, whether more changes in media can assist the presentation of professional knowledge; different design strategies under different media, changes in the media changing design strategies; whether professional knowledge can change thinking methods resulting in different strategies; therefore this research's questions are: under different design media environments, what are the differences in the effects of professional knowledge on the thinking and decisions of designers? Can orientation by professional knowledge assist the effective development thinking of designers? What type of professional knowledge and skills are required in using sketching? What are the relationships between media and sketching under different design strategies? This research uses a strategy oriented by professional knowledge to assist the analysis of strategies in the design process, and to incite different design thinking under the operation models of media; through the basis of the design process, analyse the utilization of professional knowledge by designers in the design process and the different knowledge understanding methods under different media utilizations.

2. The cognitive orientation to Design Media

The traditional design process has a complete, functional and formal structure: analysis, systems, assessment and appearance. The computerized design process does not possess such a functional structure. Hanna and Barber(2001) demonstrated through statistical analysis that, in sketching, design creativity and computer-aided design, using computer media design in the design process results in statistically-significant differences. According to the research of Bentley(1999), newly-developed CAD tools can inspire the creativity of designers, using dynamic changes to solve present issues and overcome the limits of traditional design tools. Suwa and Tversky divide the areas that designers see and pay attention to into four areas: depicted areas and their relationship with their sensitivities, specialties and spatial patterns, functional thought and knowledge. The former two categories supply with us tangible

information, while the latter two provide intangible information. However, functional thought and knowledge are the two key areas that orientate the spatial relationship (Kavakli and Gero, 2002). Sketches have another important characteristic. They do not give something tangible to the designer when the work starts; rather, it is something that is created at the first stage of the design process. Through writing down their thoughts and inspecting them, or through comparisons on the windows on the computers, designers can improve or build on their thinking and generate new characteristics or new links, and to continuously improve the sketches. Apart from sketches, Oxman (2000) stated that methods of presentation of knowledge are also important, and should be clearly communicated to the designer. In the described work, we experiment with the design media becoming a general representation that is operable in a special design environment. These general representations are usually formed on the basis of theoretical assumptions, and related to such assumptions is the psychological representation created by designers from their inner thoughts, and the strategy through which they externalize and operate on such representations.

3. Overview of Design Cognitive Strategies

Designers frequently utilize design strategies in a subconscious manner. In the hospital design example mentioned by Foque and Lammineur(1995), user interactions and computer-aided design methods were used to solve these issues. It also pointed out that a systematic method would not prevent or restrict the creativity of the designers. Kolodner(1996) pointed out that the heuristic strategies of strategic control play an indispensable role in the activities of creative design, including problem reformulation, emergence of properties and constraints on the solution, and to generate feedback from the environment, experience and experiments, and to merge prior designs into the present design. Candy(1998) espoused the objectives and methods in the presentation of strategic knowledge in design, especially the utilization of strategic knowledge by designers and the development of logical structure. Design understanding and the learning of knowledge recognition parameters can become part of design education (Oxman, 1999). Investigations into the ideas behind design thinking, knowledge structure, and design knowledge obtained through strategy can be used to benefit design education. Oxman(1999) also put forth the idea that computers is a media for the construction and testing the knowledge recognition process. In terms of design strategy, von der Weth(1999) analysed "step-oriented" and "function-oriented" modes. The strategies between "function-oriented" and "step-oriented" modes are different, as when sub-issues are treated thoroughly in the order of importance, from the clarification of the work to placing the sketches. The result of continuous work on sub-functions means that the solutions for sub-functions under consideration must result in adjustments towards other sub-functions that have undergone detailed planning. Through

immediately cementing the sub-areas, the use of "function-oriented" methods in the design process can significantly save time. However, it may result in the optimization of a solutions project becoming more complex. Another similar change-improvement method demonstrated is that during the research, those experienced designers without systematic design training favor "function-oriented" strategies (von der Weth, 1999). Also, Boulanger(2001) pointed out in the psychology and education areas, strategy is described through learning styles and personality types, rather than being a decision-making behavior.

4. Methodology and steps

The basic assumptions of this research are on whether using professional knowledge as an orientation will assist the development of the design thinking of designers. The subjects of the experiment are chosen to have professional design training and solid practical experience. The experiments are conducted in three stages: the first stage involves giving the subjects base maps and environmental and base restrictions, but no information related to professional knowledge. The second stage gives the subjects professional knowledge requirements; in terms of professional knowledge supplied, construction knowledge (such as structural systems), functional knowledge, knowledge on the materials, the environment, equipment and measurements are supplied primarily. In the third stage, detailed interviews are conducted. In terms of methodologies, "think aloud" is used; warm-up experiments are conducted prior to the actual experiments, and the topic of experiment is to design a museum to store an art collection, and the design development time is restricted to ten hours. There are three experiment groups: conventional media (group 1), the combination of conventional and computer media (group 3) and computer media (group 2).

4.1. DESCRIPTION OF THE DESIGN PROCESS

The environmental information given to the three groups of subjects involve the situation regarding the construction location, display methods, design targets, and the details of the design. The construction base is located in a large park, with several 8m-wide access ways, and 10m tall trees are planted alongside the access ways. The size of the construction site is about 100m x 100m, with the north and east sides facing open rolling grasslands, the west side facing dense plantations of 10m tall trees, and the south side facing 8m-wide roads and a plot of land reserved for a car park. The development strategy of the first group is to extend horizontally the perspective of the space at first, and to consider the window, balcony and horizontal shades (figure 1). Owing to the design habits of the subjects in group 2 and the requirements of this experiment, designing in group 2 was divided into two stages, firstly to develop the sketches on paper,

and secondly to develop the sketches on computers (figure 2). The subjects in group three started straight from computer media, and began with an analysis of the site and the horizontal extension of the construction (figure 3). An ellipsoid construction was designed to connect the three stories and the vertical dynamic lines, and the placement of escalators was used to consider the horizontal lines. Professional knowledge was also given for reference; when working on the restaurant, the needs of having a view and having "service" were considered, and it was decided for the service desk to be located in between the lift and the restaurant. The restaurant was placed next to areas with a better outside view, in order for guests to enjoy the views. Because the display area had plenty of walls, it was more closed to the outside world and as a result was placed in the northwest corner.
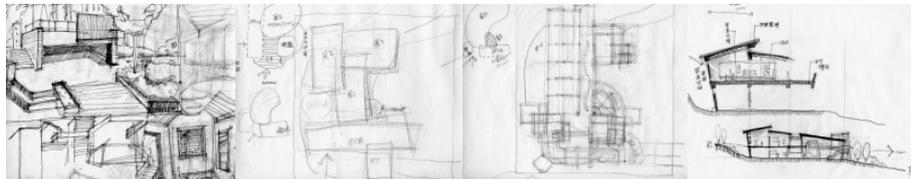

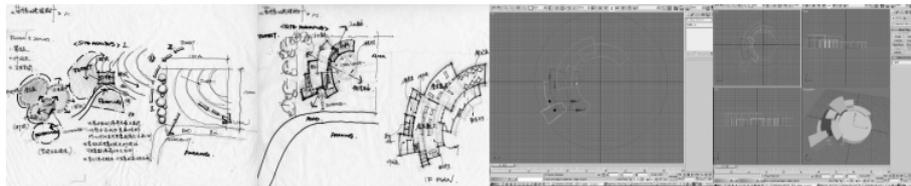*Figure 1*. Design sketches using pen and paper as media.

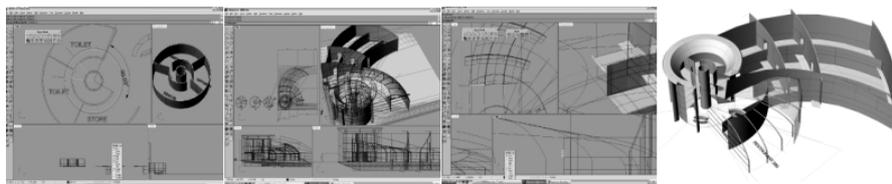*Figure 2*. Idea sketches using traditional and computer media.
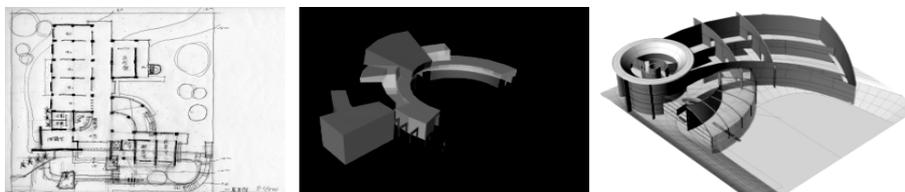

Figure 3. Idea sketches using computer media.

Figure 4. Idea sketches from the three groups of subjects; groups 1, 2 and 3.

4.2. PRESENTATION OF THE EXPERIMENTS' RESULTS

From presentations resulting from the three groups of subjects, the first group placed most emphasis on the floor plans of the floors, with the spatial placement and clarity in movement lines being paramount. Group 2 subjects eventually used computer models for presentation, to seek the relation between the space and the construction. Group 3 subjects, through computer models, demanded more presentation in the structure and the functionalities. (figure 4).

5. Discussion and analysis

5.1. COMPUTATIONAL SUPPORT FOR DECISION-MAKING

In all three groups, it is clear that the orientation of professional knowledge in design is intertwined with functionalities. By the second stage, after the designers obtained more information on the professional knowledge, it was filtered and selectively applied in the design process. Perspectives from experience played an important role. If the analysis and evaluation in the solutions process was incomplete and the conceptualization was not material enough, errors in the functions or common problems will appear at a later stage. Also, assessments tend to rely on areas chosen on a subjective basis, and cannot determine the overall requirements, similar to the issues described in Pahl and Frankenberger et al (1999). The ideas stage is where principles appropriate in the solutions are developed or identified, and the design is developed later. Through the three groups of experiments, the use of computer media to develop sketches allow, through accurate visualizations, effective concept decisions to be made, resulting in fewer post-decision changes on the concept compared to pen and paper sketches. Any changes are likely to be modifications as a result of conflicts between the structure and the modelling.
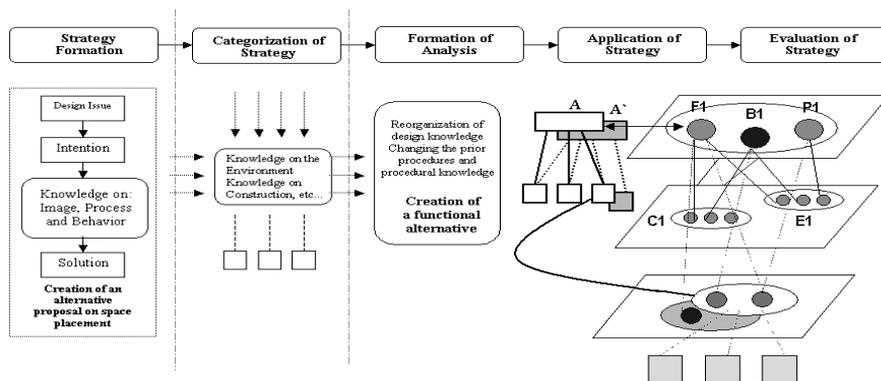

Figure 5. Flow Chart of Professional Knowledge and Design Strategy

5.2. PROFESSIONAL KNOWLEDGE-ORIENTATION AS A COGNITIVE MECHANISM IN DECISION -MAKING

Design thinking is the interactive process where design knowledge is used to resolve issues in design. Design knowledge can be divided into explicit and implicit knowledge: explicit knowledge includes knowledge on imaging, construction, functionality, materials, behaviour, etc.; implicit knowledge is similar to procedural knowledge, i.e., how to effectively utilize knowledge. In terms of the spatial design abilities, the utilization of professional knowledge and good interactions in design thinking can produce designs that suit the construction design requirements better; therefore, the analysis of the formation of strategy allows us to clearly understand the necessity of having prior training in order to run a design project: not only to improve the design to meet the design requirements, but also to improve the knowledge of designers and allow more accumulation of experience (figure 5).

5.3. DESIGN MEDIA FOR A COGNITIVELY BASED APPROACH

Design knowledge derived through experiments and observation is a major factor in the development of cognitive-based tools that can improve understanding and assist design (Oxman, 2000). Analysing the experiment shows that computer-aided design tools similar to traditional hand-drawings and sketches can assist in deeper thinking for designers. Various characteristics inspired by different media are like a strategy that subtly influences design thinking, understanding and decision-making.

6. Conclusion and future work

In terms of decision-making in design thinking, professional knowledge inspires strategies that change the design methods, and allow complex design issues to be clarified, while producing alternatives with more structure and functionality. A strategy oriented towards aiding professional knowledge can effectively assist designers to solve more sub-issues, and provide greater analysis into behaviour, process and imaging knowledge. In this research, the design strategy is the utilization of process knowledge, intertwined with construction and environmental knowledge. This research offers a staged guidance on the strategies of professional construction knowledge in architectural education, assisting designers' development in the design process and in the grooming of an architect, as well as inspiring the multi-dimensional considerations of the designer in the conceptualization and development stage. Given the huge amounts of experimental information, taking only one concept for analysis is the restriction placed on this research, and it has not been considered in this research whether a strategy based on an orientation of professional knowledge can inspire creativity, and whether it can emphasize the individuality of the exterior design -

issues that are appropriate for future continuing research.

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