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The Role of Design Creativity in Computer Media

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This study discusses the use of design media and design creativity in design education. By combining cognitive studies with educational psychology, it analyzes the cognitive processes involved in the use of the computer by experts and novices, and compares the effects of the computer on the design process of both subjects. In doing so, it discusses computer design media as well as creative thinking.
Keywords: *Computer Media; Creativity; Expert and Novice; Creative Thinking*

Introduction

By the 1990's, the computer became established as a design tool, and began to affect the thought processes of the designer and various aspects of traditional design (Mitchell and Malcolm, 1995). Researchers began to explore the possibilities of further developing the role played by the computer in design, (Verstijinen et al., 1998; Manolya et al. 1998), especially how the computer could aid the process of design (Gross, 1996; Elsas & Vergeest, 1998). In this way, the computer assumed a more advanced role in the process and presentation of design, eventually leading to what is known today as "computer-mediated design. As the words "computer" and "digital" began to assume an ever-increasing importance in the vocabulary of architectural design, people were taken by surprise by the seeming inevitably of the process—a process that simply could not be ignored, and which involved re-defining an array of such fundamental architectural concepts as function, form, volume, and space (Liu, 2001). The focus of research had thus moved away from "computer-aided design", instead channeling its energies into a recently emerged phenomenon known as "computer-mediated design".

As computer media continued to develop, the impact of computer-aided design could be seen in the early stages of the design process. During the early design stages, both the use of sketches and the inter-relationship of representational media with the design itself had suddenly assumed a more important role in the thought processes of design than that of the purely mental processes of design. It had become common practice to use large numbers of sketches and drawings in the early stages of design (Purcell and Gero, 1998). The sketch allows the designer to think in a more concrete way (Suwa and Tversky, 1997). Furthermore, the sketch as a design tool can inspire the designer while increasing the creativity of the designer's work (Goldschmidt 1994). By introducing a means of stimulating the designer's thinking during the design process, new possibilities of creative expression become possible (Purcell and Gero, 1998), and the somewhat ambiguous and vaguely defined properties of the design sketch came to be recognized as a major influence on the creative process (Liu, 1998). If we consider this development in relation to the computer in the cognitive processes of design, we see that the computer began to exert a new influence on the creativity of design (Gero, 2000). It also initiated the development of speculative thought about how the computer aids the creative process; in particular, the possibility of the computer itself becoming a creative force in the design process. Thus, the computer, as a medium of digital design, was no longer seen only as a way to realize design concepts, but rather as a tool to create design work. Wong (2000)

Figure 1. Experts design development process

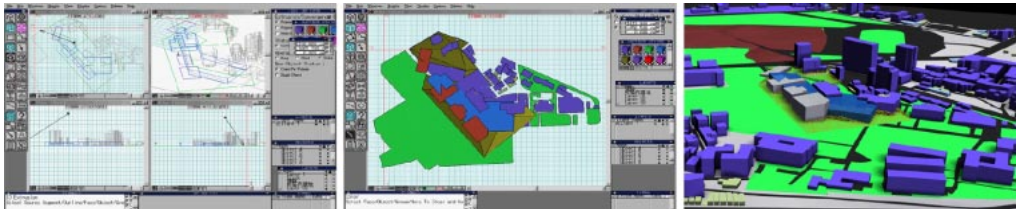
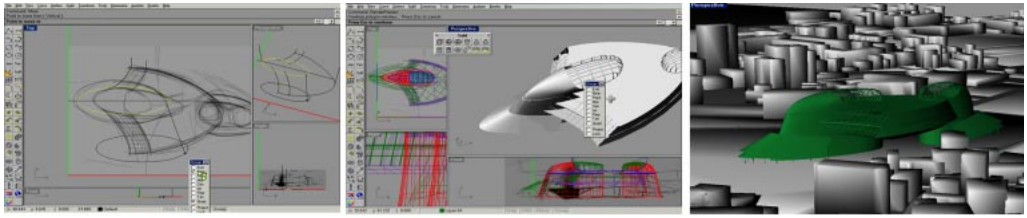


Figure 2. Novice design development process



raised the possibility of using the computer to aid the purely cognitive aspects of design work. Chen (2001) analyzed the ways in which experts as opposed to novices differed in respect to their perception of the uses of computer design, and discussed whether or not creative work could be elicited during the early stages of the design process. Akin (1990) raised a number of questions. For example, in cases where expertise and creative ability coexist, when the expert uses the computer to develop design concepts, what are the factors that will influence the creativity of this process? How will the novice designer use the computer to produce design concepts? Are there situations that exist for both the expert and the novice in which the computer is a pre-condition for creative design?

The purpose of this study is to discuss the topics raised in the above paragraph. It will examine the role played by the computer in the development of design concepts, and look at the ways in which experts and novices use the computer medium during the design process. It will attempt to understand the relationship between creativity and the cognitive processes. In analyzing the creative process, it will look for cognitive models that could help the novice designer become an expert designer.

Methodology and Steps

The aim of this study was to utilize audio/video protocols to provide an in-depth exploration of the subject. The first part studied the cognitive processes of experts and novices who used the computer to develop design conceptions. In the second part, the information was collated and analyzed.

Design cognition experiment

Before conducting the actual experiment a warm-experiment was first held in which no time limit in respect to the development of design conceptions was imposed. Novices and experts developed three design ideas, and were later asked their opinion on who produced the most creative design. The theme of the design was a digital arts center. In classifying test subjects, those subjects designated as “experts” were architects with a high-degree of knowledge and expertise, and a minimum of fifteen years design experience. “Novices” were defined as “beginner students of design lacking knowledge and experience.” The novice designers were considered to be students with two years of architectural design experience. In the experiment, both expert (Figure 1) and novice(Figure 2) selected one design that they

considered the most creative out of all the designs produced, and then analyzed it, with the results below:

The encoding system

With the advent of discoveries made by cognitive psychologists and physiologists in respect to the differentiated functioning of the right and left hand sides of the brain, the 1960's witnessed the development of the concepts of "lateral thinking" and "procedural problem solving methods". These concepts can be said to refer to the respective means by which inductive reason and creativity generate ideas and techniques, and it also describes the relationship between inductive reasoning and design in respect to ideas and techniques. When the nature of a problem and the aims that are desired in respect to that problem are ambiguous or unclear, then the appropriate approach to the problem is one creative in nature. In other words, creative thinking does not generate standard answers, and, moreover, the creative approach often demands answers that lie outside conventional modes of thought. Thus lateral thinking and non-linear thinking both come under the category of "creativity".

Creativity is another way to solve problems and an end-result of problem solving. Thus, creativity can be used to solve a problem, and if the solution to the problem is original and/or elaborate, this shows that a degree of flexibility and fluency were used to deduce it. The three qualities of fluency, flexibility, and originality are the most important for arriving at a creative solution. Therefore, these three qualities will be selected to assess degrees of creativity. Torrence (1966,1989) used an additional quality-elaboration-as a means of assessment. In this study, two different coding schemes were used. The first is Chen's (2001) four models: Conception(C), Operation(O), Perception(P), and Evaluation(E). The second used Torrance's four measurement criteria in his "Test of Creative Thinking:" Fluency (F), Flexibility (Fl), Originality (Or) and Elaboration (El). For the process of encoding, Gero and McNeill's two-stage encoding process (1998) was used.

Analysis and Discussions

Novices had to consult many images of different angles to obtain a sense of actual space. After drawing the sketch, they assessed the first image before working on the next. If they produced a model of the contours of an object, this encouraged them to produce further design based on a purely visual sense of the object, and used a predictive means of induction (Figure 3).

When faced with the problem of simulating the various relationships defining the spaces, the experts induced a range of possible functions from a single image. After looking at the image once, the experts were then able to proceed, relying entirely on memory to record design data. In respect to conceptual sketches, out of the total factors, recording played a more important role than cognition. During the schematic phase, because these experts had already acquired a degree of knowledge through problem solving, they were better able to make use of memory as a means of aiding cognition (Figure 4).

Because of the nature of the computer design medium, designers had to key in precise numbers to operate programs; thus, at times, discrepancies between the design conception and the actual design

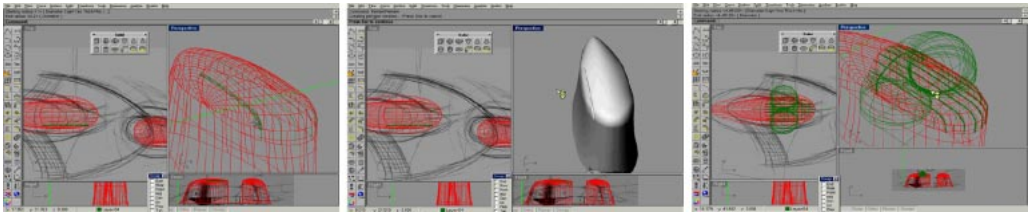


Figure 3. Novice detailed design stage.

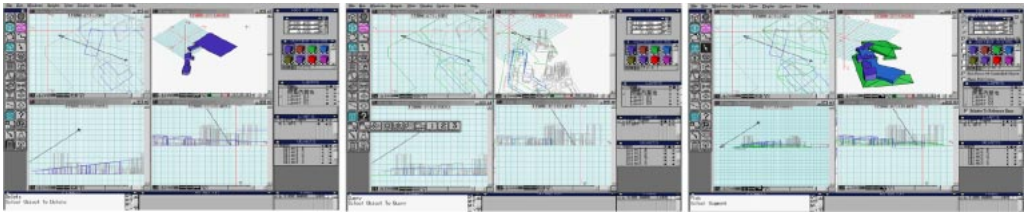


Figure 4. Conceptual leaps made by experts in development of space

Figure 5. Expert creative output often occurred within the circulation elements: conception, evaluation and operation, the computer command mode helped to inspire creativity.

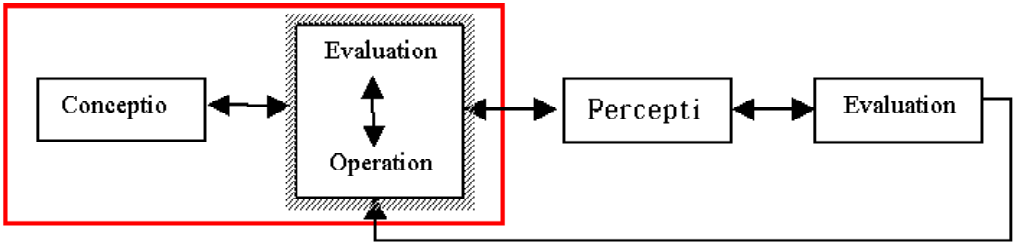


Figure 6 . Experts creative output in relation to the three circulating systems of assessment. The boxed categories show factors leading to creative breakthroughs: conception, assessment, intuition, operation.

on paper appeared. As a result, the designer tried to correct these discrepancies by keying in the correct figures. However, in this kind of situation, the designer can view images created by these past miscalculations, and then devise a new design concept. While operating the computer, experts benefited from this situation by creating new design conceptions. (Figure 5), and their creative output related to the three circulating systems of assessment. The boxed categories show factors leading to creative breakthroughs (Figure 6).

After the novices keyed in commands, they became more visually familiar with the design objective though comparisons with several windows, and then began to develop design conceptions (figure 7). Novices tended to use the computer and evaluate the visual images after developing design conceptions, and tended more often to locate themselves within the operation, intuition, and evaluation system of circulation (figure 8).

In the case of both experts and novices, when the subject used a computer to develop a sketch of the design conception and then considered the four different means of assessment, the subject was able to integrate the four factors. Novice originality and flexibility became more apparent, whereas expert fluency of cognition and originality, as well as workmanship, became more apparent. The experts' experience enabled their cognitive fluency, originality and workmanship to increase constantly throughout the experiment. However, the computer medium did little to enhance cognitive flexibility. Originality of

Figure7. Showing the inter-relationship between operation of the computer and intuition for novices, showing how inter-reaction with computer could produce creative breakthroughs.

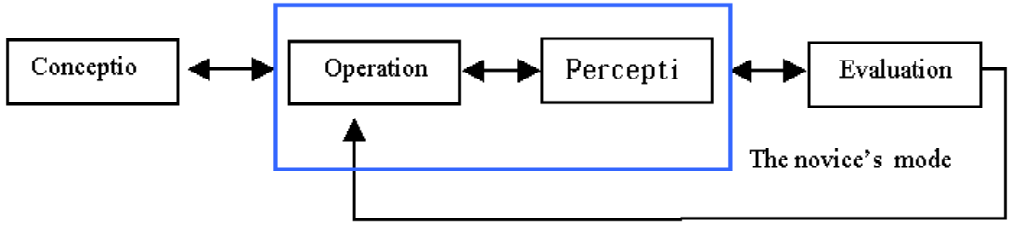


Figure 8. Cognition model of the way in which novices made use of computer. The boxed categories show factors leading to creative breakthroughs.

thought, flexibility, lateral thinking, fluency of cognition, workmanship, and vertical thought were factors that played a more influential role. Computer-generated two-dimensional images helped improve vertical thinking. Lateral thinking also improved because of the computer's digital system of commands. These commands also led to the inadvertent creation of new images. Novices performed quite well in respect to vertical thinking, for the computer primarily served as a means of recording data and aiding thought, and allowed novices to revise initial presentations. For experts, the main role of the computer was to create an alternative space while offering opportunities for design that conventional design media could not supply.

Conclusions

This study concludes that in the problem solving stages of design, experienced designers are able to use a number of set perimeters, produce many variations in potential structures, correctly define the design problem, and arrive at a correct solution. However, novices did not display this ability. Experts demonstrate an ability to produce more coherent and unique designs than those made by novices, but novices are better able to fine tune different types of design than the experts. This is partly explained by the experts' superior skills in fluency and originality. Novice superiority in terms of flexibility and workmanship skills is expressed in their greater willingness to stop working to examine in detail completed work. The computer is a tool that can enhance the creative potential of the designer. The design drawing used in conventional design provides information that is already known. But data fed into a computer can supply the designer with information and images unseen before - sometimes with astonishing results. Moreover, previously unknown information and images often provide the user with creative solutions to a design problem; or in cases where creativity is insufficient, provide a starting point for further design explorations.

Limitations and Future Studies

The computer expresses design concepts in a minimum amount of time and enhances the creativity of the designer through special characteristics, such as the use of numerical inputs to show likely outcomes. Thus, the computer's impact on design behavior and design problem solving is significantly greater than that exerted by conventional design media, especially because it provides a more tangible and lifelike design

image. This study provides important knowledge to architectural students of design, namely, how to develop novice design skills into expert skills, the best way to achieve this transformation, and the best way for experts to further develop their creativity. This paper's research is only a first and tentative step. There is room for further research on how the computer system of commands—as well as the input/output interfaces-influence creativity. Further research could also be conducted on the role played by the computer system of commands.

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