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THE INVESTIGATION ON THE EFFECTS OF PRIOR EXPERIENCE ON THE PRODUCT DESIGNERS' CREATIVITY

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Abstract: As a creative problem solving process, product design involves designers' prior experience. This study investigates the effects of prior experience on the product designers' creativity as well as notes the differences in their design process. The sketches from a design task performed by senior and graduate students in product design department are examined via Zaltman Metaphor Elicitation Technique. The mental map revealed the difference of their design process according to the different degree of prior experience. Furthermore, the sketches are rated by four expert designers by Creative Assessment Technique. We found that product designers with higher prior experience can produce more creative outcomes. Theoretical and practical implications of these finding are discussed.

Keywords: *prior experience, sketch, creativity, Zaltman Metaphor Elicitation Technique (ZMET), Consensual Assessment Technique (CAT),*

1. Introduction

Creativity has been defined as the ability to restructure old ideas to produce singular inventions (Heap, 1989) and to apply original thinking (Coyne, 1997). The creativity process involves combining existing ideas and resources into something new and useful (Baughman & Mumford, 1995; Mobley, Doares, & Mumford, 1992; Hofstadter, 1985). In product design domain, mostly, to be creative is not about creating an entity out of thin air (Campbell, 1960; Simonton, 1999), designers use prior experience to explore new ideas and design alternatives. This paper investigates the effect that the prior experience performs in the product design, including the product design process and the creativity of the design concepts.

During the early conceptual stage, it is typical for designers to express their ideas as simple free hand sketch done rapidly and without much detail (Purcell and Gero, 1998). Many researchers have been

done to reveal the creativity involves in the sketch. However, the investigation of prior experience factor in the conceptual stage of design – sketch- is relatively rare. On the other hand, the relation of prior experience and creative performance has been studied widely (Amabile 1983; Martinsen, 1993; Chua & Iyengar, 2008). But the theoretical finding has not been evaluated in a specified domain, such as product design.

Based on the previous work, we argue that the prior experience can affect the product designers' design creativity as well as their design process. Through the analysis the results of a design task, we evaluated the conceptual works of product designers with different prior experience.

2. Related works

2.1. Prior experience in product design

Research in creativity has suggested prior experience in a given task domain to be an important predictor of creative performance (Martinsen, 1993; Chua & Iyengar, 2008). Amabile (1983) argued that possession of domain relevant skills is an important component of individual creativity. Furthermore, the degree of domain relevant skills one possesses depends on formal and informal education, and on the individual's experience in the given domain (Amabile, 2001).

Chua and Iyengar(2008) investigates the effects of prior experience, task instruction, and choice on creative performance. And they found that only individuals with high prior experience in the task domain and given explicit instruction to be creative produced more creative outcomes when given more choice.

2.2. Assessing the creativity in product design

Since 1950 researchers have developed an array of formal methods for measuring creativity. The widely used assessing methods are: through determination of personality traits using the Torrance Tests of Creative Thinking or the Myers-Briggs Type Indicator; through outside rating of a product or through thinking tests (Amabile, 1982; Hocevar 1981).

Moreover, creativity has also been assessed in a number of ways in art and design domain: uncover the sketch process by which an individual creates through various types of observations (Goldschmidt, 1991); analyze the imagery created, and quantified the sketches with coding schemes in an attempt to uncover the cognitive processes performed during the sketching as thinking process (Goel, 1995; Kavalki & Gero 2001); "think-aloud" protocol analysis combined with content analysis of the product (Menezes & Lawson, 2006; Goldschmidt & Weil, 1998, Suwa & Tversky, 1996) to document the thinking process as the individual sketches.

2.2.1. Sketch

Sketch allows quick exploration of ideas at a high level of abstraction, avoids early commitment to a particular solution, allowing many alternatives to be explored (Fish and Scrivener 1990; Ullman, Wood et al. 1990). Drawing remains the focus of design activity in domains such as product design and architectural design where the product is a physical object; the drawing is typically the single representation that the designer uses throughout the design process, from initial rough sketch to final fabrication drawing (Gero, 2004). Hence, sketch has been studied for understanding the designers' creativity.

Ayiran (2008) explicated the role of sketches in terms of creativity in design. Reviewing the generated concepts and the physical evidence of cognitive processes may illuminate a link between sketching and a final creative product (Ryan, 2008). And we believe that designers' sketches are suitable materials for examining whether or not the designers' prior experience affected their design creativity.

2.2.2 Zaltman Metaphor Elicitation Technique

Zaltman Metaphor Elicitation Technique (ZMET), developed by Zaltman in 1994, is a qualitative technique that elicits both conscious and especially unconscious thoughts by exploring people's non-literal or metaphoric expressions. Originally, ZMET is a developed to understanding costumers'' need as a market research tool. As Zaltman described "A lot goes on in our minds that we're not aware of. Most of what influences what we say and do occurs below the level of awareness. That's why we need new techniques: to get at hidden knowledge-to get at what people don't know they know." (Pink, 1998). The technique has been used by academic researchers and for marketing purposes to study a variety of topics related to both marketing and the social sciences. Zaltman argued that humans think in images – often in the form of visual images – rather than in words (Shocker and Zaltman, 1977; Zaltman, 1991). The goal of the ZMET interviews and analysis is to uncover the relevant fundamental structures that guide people's thinking about a topic.Therefore, we believe that ZMET is a reasonable method which can be used to reveal the design thinking and design process through the only explicit presentation in the conceptual stage of design –sketches.

2.2.3 Consensual Assessment Technique

The Consensual Assessment Technique (CAT), developed by Hennessy and Amabile in 1999, was selected for this study to assess the evidence of creativity in free-hand sketch because of its reliable use in previous examinations of creative assessment of a product (Carson, Peterson & Higgins, 2005; Chen et al, 2000; Dollinger, Clancy Dollinger, & Centeno. 2005).

3. Methodology

We chose an experimental approach to find out the influence of designers' prior experience on product design. Experts were invited to assess the creativity of the students work via the modified Consensual Assessment Technique. The design experiment aimed to investigate the following research questions:

- Does the designers' prior experience affect their design creativity?
- Are there different patterns among the designers' design process and idea generation with and without prior experience?
- Can any relationship be identified between the prior experience of designers and their design creativity?

It was hypothesised that the higher the prior experience one possesses, the higher creative design concept he/she can generate in the product design task. To answer these research questions, forth year undergraduate product design students and second year master students with different educational background (bachelor of biology, product design and space design) in the product design department in a national university in Taiwan were recruited for the study. This ensured that the participants have the necessary experience to be able to take part in the study meaningfully as well as enough mature design education to fulfil the design task.

3.1. Experiment

3.1.1. Participants

In order to compare the different effect of prior experience, the experiments were conducted in three different groups. Group A contains seven students, and all of them have the experience of keeping pets for at least one year, we define this group as informal education prior experience group. Group B is formal education prior experience group, contains two students who have a bachelor degree of biology. The number of participant is relatively few because the students with the interdisciplinary background are limited. Group C includes seven members who have neither keeping pet experiences nor biological educational background. The demographic characteristics of the participants are summarized in Table 1.

Table 1. Participant attributes

Participant		Gender	Age	Education background	Major
Group A (Informal education group)	P1	Female	21	senior	Product design
	P2	Male	25	Master student	Product design
	P3	male	23	senior	Product design
	P4	female	28	Master student	Product design
	P5	Female	25	Master student	Space design
	P6	Female	26	Master student	Space design
	P7	male	21	senior	Product design
Group B (Formal education group)	P8	Male	30	Master student	Product design + biology
	P9	Female	28	Master student	Product design + biology
Group C (Non-prior experience group)	P10	male	22	senior	Product design
	P11	Male	27	Master student	Product design
	P12	Male	28	Master student	Product design
	P13	Female	20	senior	Product design
	P14	Female	28	Master student	Space design
	P15	Female	19	senior	Product design
	P16	Female	24	Master student	Space design

3.1.2. Environment setting

Group A participate the experiment in a standard classroom. Free-hand sketching tools are provided.

The experiment of Group B and Group C is conducted in the observation lab in the product design department. The room is divided into two parts. The experimental subjects stay in the inner room, where needed facilities to fulfil the design task, such as desktop computer, drawing and writing tools, are provided. A video is set up at the front of the table to shoot the drawing process in a close distance, and the whole process of the experiment is recorded by the video equipments at the four corners of the

ceiling. The observers stay at the outer room, where they can observe all of the participants' movement through a one-way version glass.

3.1.3. Task and procedures

Three groups with different prior experience are asked to perform the similar design task- design a product based on your own experience about biology. The biology-related experiment was selected because the biology knowledge is shared universally. Hence, we can achieve the general conclusion according to the study.

However, we narrowed down the scope of biology. Group A performed the design exercise based on their own experience of keeping pets within 1 hour. Group B and C did that after 12 minutes video documentation about 7 kinds of crabs was shown to them. And then they sketched and generated design ideas within 1 hour. During the 1 hour, they can review the segment video or pictures of each kind of crab by the computer provided.

On one hand, the same stimulation ensured that the experiment result revealed the pure relationship between the designers' prior experience and their design idea generation; on the other hand, we can build an assessment standard to analyze the design outcome efficiently and systematically.

The experiments of all the three groups comprised two consecutive tasks: the first is a session for generate design concepts via free-hand sketches, and the second is to complete an in-depth interview exclusively related to the concepts. The in-depth interview is aimed to further the outcome of the students' design process, specifically, inquiring into their design inspiration and the referring prior experience.

After the design task, the idea sketches are analyzed by four expert designers, two are product designers with 9 and 11 years design experience in company, and the others two are associate professors in product design department with 8 and 11 years education experience. The four expert designers graded the design concept based on the modified Consensual Assessment Technique and also their own experience.

3.2 Analyzing the design process via ZMET

Once we got the sketches from the participants, we can investigate the stages of design process and the main elements in each stage with the ZMET. Zaltman defined 10 ZEMT interview steps: storytelling, missing issues and images, sorting task, metaphor elicitation, representative image, opposite image, sensory images, mental map, the summary image, the vignette; and these steps can be adjusted slightly for different topics (Zaltman and Coulter, 1995; Zaltman, 1996). Considering about the research focus, we executed the first to eighth steps, the detail are described below.

1. Storytelling : The participants recalled and described the main process and content of their design thinking in the in-depth interview. This is named Metaphor Elaboration by Zaltman, According to the external result of the design thinking- sketch and text; the participants explained the effect of their prior experience on their design thinking, via the semi-structure interview. This retrospective protocol will be the main content for the analysis.

2. Missed Images: the participants can reveal any information what they did not concern but is meaningful. For example, P9 said when he saw the climbing crab, the building cleaners' movements appeared in his mind, so he decided to design an electric vacuum cleaner in crab's shape. In this example, the missed image is the building cleaner, which is revealed in the interview. Without the missed images, the design process will not be interpreted completely.

3. Sorting: the interviewee categorized the participants' design thinking and activity in order to extract the construct of design thinking in the next step.

4. Construct Elicitation: Based on Kelly Grid and Ladder, three layers of design thinking are defined: originator construct; connector construct and destination construct. In this study, the originator construct means the stimulation: animal's metabolism, animal's body colour, animal's shape, animal's organs, animal's movements, and animal's living environment. The connector construct means the design thinking: association, attraction, curiosity, analogy. The destination construct means the design outcome- product design.

5. Most Representative Picture: the interviewer point out the most representative pictures among which inspired his/her design thinking.

6. Opposite Images: the interviewer finds the most contrast images with their design concept, which is helpful to understand their design thinking.

7. Sensory Images: The participants can describe the other perception, including touching, tasting, smelling, listening and emotion, which inspired them in the design process.

8. The Mental Map: The interviewee confirmed each participant' design process and represent it via the mental map.

3.3. Assessing the design creativity via CAT

The measure of creativity was implemented through use of the Consensual Assessment Technique (CAT). We modified the CAT related more directly to a product to address the specific of our research. The CAT method assesses separately between the areas of creativity, aesthetics and technical quality. The creativity score was derived from the raters' personal definition of creativity; includes the degree to which the idea was novel or unusual, and the consistency of the concept throughout the design process. The aesthetic score consists of overall aesthetic appeal, the pleasing product composition. Technical quality was assessed by the degree to which the concept considers the technical requirements, how well is the problem solved.

Four expert designers as raters were given verbal instructions, definitions, and standardized review forms. Raters were instructed to look at all the sketches prior to starting the review, and to grade the sketches in a random order. Eight items were assessed on a seven-point Likert scale, indicating agreement descriptions such as "low" or "high", "not at all" or "is apparent" depending on each item. Assessment entailed using a Likert scale survey rating for creativity, technical quality and aesthetics. Raters worked independently, and ranked the sketches based on their personal interpretation of creativity. The final score of each participant is the mean of the grade given by the four raters.

4. Discussion

The sketches of the participants are shown below.

Most of the members in Group A fulfilled the design task in a very detailed way (Figure 1). The characteristics of pets are introduced, and the problems they met are solved by new design. Each sketch contains abundant textual information and design process cue like arrows or text.

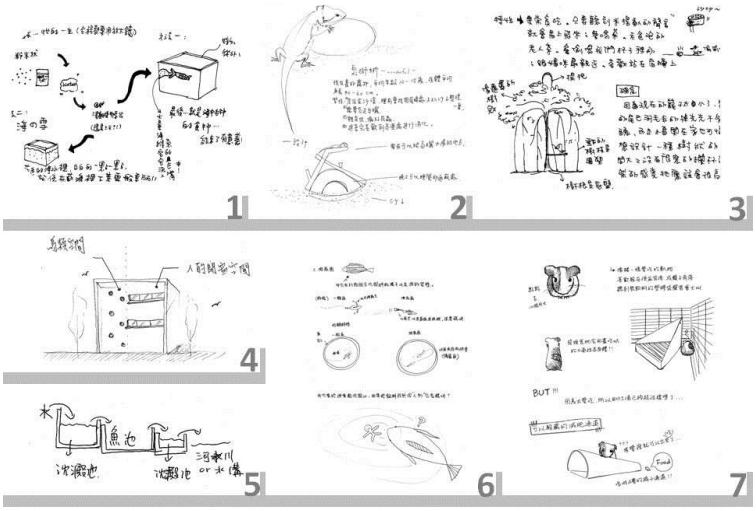

Figure 1. Sketches generated by Group A

Comparatively, the sketches generated by Group C are mainly roughly pictures without textual information and design process cues. Three examples are shown in Figure 2.Their sketches look like isolated segments of the videos, we cannot find the significant continuity of design thinking.

Figure 2. Examples of sketches of Group C

4.1 Mental maps of design process

In this study, we generated the mental maps of all 16 participants. And we summarized them into three styles: administrative levels style (Figure 3), explosive style (Figure 4), and rigorous style (Figure 5).

Figure 3. Administrative levels style mental map (O: originator construct; C: connector construct; D: destination construct)

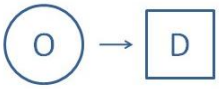

Figure 4. Explosive style mental map

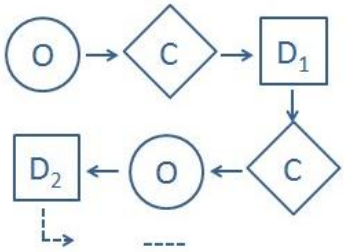

Figure 5. Rigorous style mental map

We found that most designers with higher prior experience (P1, P2, P3, P4, P5, P7 in Group A and P8, P9 in Group B) fulfilled the design process in administrative levels style, which means they performed the design in a standard and complete way according the three construct of ZMET: originator construct, connector construct, destination construct.

However, the mental maps of the designers without prior experience (P11, P12, P13, P15, and P16 in Group C) presented an explosive style. Their design concepts were inspired by the video, hence their design concepts generated in a short time and design thinking lacked continuity. Furthermore, three participants (P6, P10 and P14) were thoughtful, and their mental maps were iterative and strict. We believe that this is partly caused by individual personality.

4.2. CAT score of design concept

On a scale of 0-7, the Group C got the lowest mean score4.7 even there are some individual high score, such as P11's aesthetic score (5.2) and P16's creative score (5.4). The score of CAT is tabulated in Table 2. No significant difference between the Group A and Group B. The influence of formal educational prior experience and informal educational prior experience on the product design needs more precise investigation in the future work.

Table 2. CAT score in all categories

Participant		CAT creative score	CAT aesthetic score	CAT technical score	CAT overall score
Group A (Informal education group)	P1	5.2	5.0	5.2	5.2
	P2	5.0	4.9	5.3	5.0
	P3	4.9	5.1	4.8	5.0
	P4	5.2	5.2	5.0	5.3
	P5	5.4	5.5	5.1	5.2
	P6	5.2	5.2	5.1	5.4
	P7	5.4	5.2	4.9	5.0
	Mean	5.2	5.2	5.0	5.2
Group B (Formal education group)	P8	5.3	5.5	5.4	5.1
	P9	5.1	5.2	5.0	5.2
	Mean	5.2	5.3	5.2	5.1
Group C (Non-prior experience group)	P10	4.2	4.6	4.2	4.3
	P11	4.7	5.2	4.6	4.8
	P12	4.8	5.0	5.0	5.0
	P13	4.9	4.8	4.5	4.6
	P14	4.5	4.2	4.8	4.4
	P15	4.4	4.7	4.5	4.5
	P16	5.4	4.6	4.8	5.0
	Mean	4.7	4.7	4.6	4.6

In addition, another interesting result is also revealed in the experiment. Designers were believed to be attracted and affected by the appearance/form of the creature. However, among the nine participants inspired by the video of crab, there are eight times that designers said they were inspired by the movement of crabs. Comparatively, it is surprised that the appearances of crabs illuminate them five times.

4. Conclusion

Prior experience plays influential roles over almost every aspect of human aspects and product designers are not exempt from the effects. In this paper we analyzed the differences in the way design concepts are generated, which we found to be caused by the difference degree of prior experience. The experimental study involving participants with different prior experience revealed significant contrast in the way design concepts were created. Furthermore, the CAT score rated by expert designers demonstrated that the higher prior experience can enhance the product designers' creativity, which supported our hypothesis.

It is important to recognize the prior experience contains not only the domain knowledge, what kind of structure of prior experience can benefit the product designers best will be studied in the future work.

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