The sketch in industrial design process

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Abstract: The behavior of sketching could be considered as a key factor in stimulating and developing design creativity. We were interested in finding out the process of design thinking by the analysis of sketches at the early design stage. This research aimed to confirm the importance of sketching at the conceptual design stage and to explore an appropriate method to improve the efficiency of ideation. To understand sketching at the conceptual stage, we conducted protocol analysis of designers in three sessions of designing a computer mouse. The results consisted of three elements in the experiment: the numbers of sketches generated by the two student designers, differed their transformation interaction (lateral thinking and vertical thinking) of sketches, and the complexity of two designers’ sketches, ranked in the middle complexity levels (levels 2-4) by Goel’s method. Generally speaking, the number of sketches produced and the complexity of sketches were found to be negatively correlated. In addition, the number of sketches and lateral thinking had a positive relationship. Finally, the findings suggest that the applied method is useful in understanding the interaction of lateral and vertical transformations in design sketches. With this information, we can track designers’ thinking modes and, hopefully, figure out how to increase the efficiency of sketching activity.

Keyword: design thinking, sketch, conceptual design

1. Introduction

Design sketch is a vital part of the conceptual stage of new product development (NPD) [Cross, 1999; Lawson, 1994; Pipes, 1990]. Designers largely use freehand sketching as the main way of communicating their ideas during the conceptual stages.

Conceptual sketches are quickly generated and are used to frame not only the designer’s early ideas, but also to try to define and understand the problem. Conceptual sketches of visual representation are very different from other types of drawings used in the final stages of design development, such as rendering and mechanical drawing for a formal presentation. Recent researches have attempted to discover the elements of sketching process by various methods and techniques.

1.1 Sketching in conceptual design

During the conceptual stages of design, sketch is used widely to express ideas and has been deemed as the medium of reflection-in-action. Sketches are representations that allow designers to try out new ideas on paper quickly and economically. In addition, the sketch possesses the potential to act as both facilitator and recorder of creative acts, presenting opportunities for improved evaluation and the restating of problems [Temple, 1994].

Ferguson identifies three kinds of sketch, namely the thinking sketch, the prescriptive sketch, and the talking sketch [Ferguson, 1992]. The thinking sketch is used to focus and guide non-verbal thinking. And the prescriptive
sketch is made by a designer to direct a draftsman in making a finished drawing. Finally, the talking sketch is produced through the exchanges between designers and engineers while clarifying complex and possibly confusing parts of a drawing. However, the ability of the sketch is to communicate design proposals with others.

1.2 Typology of transformation

Goel discovers and defines the act of sketching. He identifies two types of operation occurring between successive sketches at the conceptual stages of design, namely lateral transformation and vertical transformation as shown in Figure 1 [Goel, 1995]. In a lateral transformation, movement is from one idea to a slightly different idea. However, a vertical transformation is said to occur when there is a progression to a more developed and detailed sketch based on the original one.

![Figure 1 Lateral and vertical transformation examples](Goel, 1995)

Goel [1995] concludes that freehand sketches, by virtue of being syntactically and/or semantically dense and/or ambiguous, play an important role in the creative, explorative, open-ended phase of problem solving. He believes that the freehand sketch facilitate lateral transformations and prevent early fixations.

2. Method

In this study, two senior design students (A and B) were selected from a class of 30 industrial design majors. Having had more than three years of product design and experience, both designers were asked to ideate and sketch by themselves for designing a computer mouse. The study was conducted by experimental method and arrived at its conclusions through qualitative analysis. The workplace was set in a lab with a video camera connected to a CRT terminal hidden in a neighboring observation room. The researcher stayed in the observation room and recorded the whole design process with videotape in a fashion as described in Purcell and Gero [1998]. Both designers had over three years of product design experience and were good at presenting ideas by freehand sketching. The experiment was divided into three design sessions, one-hour each, with a ten-minute break in between. In the first session, the subjects were allowed to freely sketch by themselves. However, in the second and third sessions, they were given hints by texts and pictures respectively.
The conditions set in the first session were based on literature reviews and would be used as a reference for further studies. Here both designers were asked to design a computer mouse without any given hint. In the second session, the designers were provided with required specifications (such as wireless communication, with flash memory card, with scrolling ball) and necessary attributes (easy to use, attractive, and small in size). In the third session, the designers were furthermore given 10 pictures of existing computer mice with various forms and functions as a reference. Finally, the designers were asked to recall and report what they were thinking while drawing each part of the sketch in a reviewing session. They looked at their sketches and the videotape to recall their thoughts while designing.

2.1 Definitions

2.1.1 Identifying sketches in sketching episodes

The approach adopted in this study required the researcher to identify each sketch in terms of complexity. The observer first went through all the sketches and identified separate sketching episodes. Utilizing a method similar to that used by Goel [1995] the researchers identified the drawings according to their generation sequence. (Figure 2)

![Individuated sketches from student designer A’s project](image)

2.1.2 Complexity level

Although Goel’s [1995] work recognized that transformation had taken place, no measure of the degree of transformation was proposed. Such measurement would be helpful to track the design process and rank the development of design. It may also help to measure the extent of lateral transformation, whether it is a small change or a complete conceptual shift. To measure degree of transformation in the sketching process, a practical and straightforward complexity scale was developed during this study. Typically, the two designers’ sketches were rated from one to five. The simplest sketches were rated as complexity level one. And the most complex ones rated as five. A more detailed definition of the complexity rating is outlined in Figure 3.
3. Results and discussion

This section presents the results of the two student designers’ sketching activities. The results consist of three elements in this experiment. Firstly, we found that the numbers of sketches produced by designers A and B across the three sessions differed. Secondly, we identified the occurrence of transformation interaction (lateral thinking and vertical thinking) in the sketches produced. Thirdly, the complexities of the designers’ sketches were both ranked in the middle complexity levels (levels 2-4) by Goel’s method. Finally, we analyzed the relationships between these three elements of the designers.

3.1 The number of sketches

As part of the study, the number of sketches produced by each designer in each session was counted. The result showed that the numbers of designer A’s sketches decreased gradually across the three sessions. To be exact, he produced 15, 9, and 5 sketches in the first, second, and third session respectively (Figure 4). However, it was worth noticing that as the quantity decreased, the detail and complexity of designer A’s sketches increased. In the later sessions, the content of the drawings gradually included annotations, multi-angle descriptions and the outline of scenario images.

Designer B’s number of sketches illustrated a different trend. Designer B’s sketches, though also decreasing in the second session, increased in the third session and almost reached up to the amount as in the first session (Figure 5).
3.2 Transformation activity - lateral and vertical thinking

As part of the study, each designer’s successive sketches were classified as employing a lateral or vertical transformation. Session by session, the ratios in percentage of each designer’s sketching activity in terms of adapting lateral and vertical transformations over the observation period was calculated. Figures 6 and 7 showed the respective results of designers A’s and B’s transformation strategies. Through the figures, it could easily be seen how designers adopt lateral or vertical transformation in their design. Referred to Figures 4 and 5 for the numbers of sketches produced in each session by the designers.

Figure 6 showed that designer A started with lateral activity in the first session. Moreover, there was a good balance between lateral and vertical transformations (i.e. 69:31%) in the second session. The number of sketches produced (i.e. nine) was also appropriate for this session of the project. Designer A’s work is typified by a fairly balanced approach overall. Even when there was a notable bias existing towards one type of thinking, designer A showed a dominant tendency towards lateral activity.

In Figure 7, designer B produced a good number of sketches during the three sessions. He displayed an initial tendency to produce lateral work. During sessions 2 and 3, the sketching activity showed a brief vertically-biased episode followed by a laterally-dominant session. Overall, designer B’s work displayed a predominantly lateral start with alternate switching between lateral and vertical modes thereafter.

The overall result may be more helpful in analyzing both designers’ thinking process. Overall, the total figures illustrated that designer A displayed a dominate lateral bias (71.9:28.1%) while designer B was almost 50:50% between lateral and vertical transformations. These findings corresponded well with the findings from a recent study of architects [Suwa & Tversky, 1997].
3.3 The complexity of sketches

The study analyzed the complexity of sketches by Goel’s scale method [Goel, 1995]. Generally speaking, the complexity of each designer’s sketching activities was ranked at the middle complexity rating (levels 2-4). But the designer A’s sketches illustrated increasingly complex sketches (Figure 8). In contrast, the complexity of designer B’s sketches was with a higher rating in the second session that started to decline again in the third session (Figure 9). Additionally, this study also found that designer A’s sketches contained little details and annotations (low complexity) in the first session. In the second and third sessions, however, his sketches contained phrases to describe the content of his sketches. Comparatively, designer B’s sketches in the second session utilized details and annotations. These details were absent in the first and third sessions.

Fig.8 Student Designer A’s sketch complexity activity  Fig.9 Student Designer B’s sketch complexity activity

Based on the results of the sketch numbers and the complexity of the designers’ sketches, it showed a negative relationship between these two elements. Also, the number of sketches and lateral thinking had a positive relationship.

4. Concluding remarks

At first, this study has confirmed that freehand sketching is prevalent in the conceptual phase of designing. Secondly, the sketching activity includes lateral and vertical transformations over time. Thirdly, sketches can provide insight into and trace the designer’s mode of thinking at any particular point in the design process. In addition, it is hoped that the method adopted in this study will provide effective metrics for design progress and development tracking during the conceptual design stage. More work is, of course, required to refine and validate such metrics.

Future research will extend this work to cover the use of sketches of experts and novices, and compare the difference between them. Accordingly, it may delve into the difference of traditional media and digital media at the conceptual stage. Also, the scope may be expanded to utilize a setting where greater amounts of noise and more information are incorporated.
Reference


