

A study to the influence of applying analogy method in concept development

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Abstract: A reason for using the design method is to facilitate the production of ideas within a certain period. Given many studies of design methods only focus on general introductions about the steps of conduction, the limits of the method, and the applying field of a method, the subtle value of a design method remains ambiguous, increasing the actual usability of a design method uncertain. In this article, we postulate that this might be due to the inappropriate approach in previous studies of design method. In this article, we argue that neither assessing the design outcome produced with the assistance of a method nor the comparing method to the design outcome can reveal the value of a design method clearly. Alternatively, this study will identify the value of a design method by exploring the influences of a design method – analogy, to the quality of design idea, and to the designers' interaction. Two design groups, each containing five members, were employed in a design trial, in which only one group is given analogy method. The primary analysis includes the evaluation of quality of design idea produced in each group by means of four criteria: creativity, feasibility, development and relevant; and a comparison analysis to the quality of the idea generating process between the two groups. Results suggest significant difference in the quality of outcomes (the ideas) between with and without using the method. The process analysis found the different communication mode and idea generation, and the different role of mediator between the two groups. We concluded that the use of this particular design method, by modifying the way of and facilitating the group members' thinking and interaction, could change the way of group collaboration and increase the thresholds of idea creation, resulting in the different quality of ideas.

Key words: Analogy Reasoning, Design Method, Concept Development

1. Introduction

According to Jones, the term 'design method' can be defined as a logical, systemic process in order to provide the information for problem-solving in design related concerns. Nowadays, the design problems are increasingly complex due to more complex products resulting in that different design methods are developed for different design problems, for different experts in different design mission and contexts [1]. During the design process, the stage of idea development is suggested to be relatively important to the success of design. Many methods particularly developed for idea development can be seen in literature, e.g. brainstorming and scenario [2].

However, the current studies about design method documented in literatures are found to focus mainly on the descriptions how to conduct these methods, for example, the steps or the rules. The others described the related pros and cons of the methods. A few explored the value and limits of the method by applying it to a design project [3][6]. It is not surprising to see that the impoverished conclusions merely reconfirming the usage of the methods were made in such studies due to the sparsity in detailed investigations about the reasons why the benefits of a

method can be gained or, what may affect the gains of the benefit or the effectiveness of the method. Obviously, it is important for the designers to understand what kind of factors would affect the conduction of a method in order to reduce the uncertainty when using it and to enrich the result. Given no consolidated information guideline to the effective conduction of the design method, the design methods could only give little benefit to the design problem in real-life project [4].

Given the above, the study described in this article aims to explore the influence of the analogy method to the quality of design outcomes, and why the influence is produced. The underlying assumption of the study is that the influence of the method to the idea development would reflect on the interaction between the participants' and the sessional process, making the qualitative difference of the ideas and the process between the groups with and without using the giving method.

2. Literature review

2.1 Design thinking

Design thinking can broadly be seen in literature. Briefly, the term “think” in design thinking means the interior situational logic and the decision making process of a designer when solving a problem. [5]. Design thinking can be understood as an attempt of applying problem-solving model into the process of design problem-solving. During the design process, what the designers conduct can be seen as a thinking activity consisting of the steps from thinking, selection, planning and creation [6]. In general, thinking is a reflection to the condition where person is facing difficulty or confusion. As a result, alternative approaches are used in order to uncover useful information, suggest the solution, and achieve the goal, where the thinking activity is then terminated.

The process of idea development can be seen as a process of design think, in which the designers consider the given design problem (e.g., design brief in usual) and look for the solution (e.g., ideas). How useful a method is for idea development could therefore be revealed by studying the method's effect to the thinking process. This prompts the study described in this article.

2.2 Analogy method

Analogy reasoning is based on the recognition to the similarity between two entities. Baxter defines the term “analogy” as that there are existed similar or identical part (s) between two different entities. Analogy reasoning is a particular thinking or ratiocinating manner, during which one entity is taken as the other one [2]. Goel studies the relation between creativity and analogy reasoning, suggesting that analogy method is useful for creative design work [7]. Wang argues that analogy reasoning is a particular ability of human being and emphasizes the usability of analogy reasoning to creativity [8]. Cross classified the analogy method into four types: direct analogy, symbolic analogy, personal analogy, and fantasy analogy [9].

To introduce the benefit of analogy method to design, many studies take an approach by giving the method to a design project. Liaw and Yen studied the applicability of analogy method in innovation design works, and concluded that this method could reduce the recognition difference between the designers and the users [3]. Chang explored the achievement of product function by using analogy method to conduct a biomorphic forming design work [10]. However, it is not surprising to see the predictable results from such a kind of studies due to no evaluation standard for the design outcomes. The nature of design featured the difficulty in comparing the design outcomes could even worsen this situation. In fact, given no understanding to the potential factors

causing the differences between the cases with and without the method, the method would not be conducted without increasing the uncertainty and reducing the effectiveness. Baxter argues that the analogy method is more useful in dealing with well-defined design problems, and suggests that unless carefully arrangement of the group members with balanced experience and personality, the method will not work appropriately [2].

The above discussion prompts us to take an alternative approach allows the researcher to uncover the causes making the progress of idea development different between with and without using analogy method.

3. The design trial

In order to pursue the interests described above, a design trial was conducted focusing on exploring the differences between two design groups carrying out an idea generation work, in which only one group use analogy method. The analysis will explore the influence of the analogy method to the quality of design outcome, and interaction of idea generation between the participants in a group.

3.1 Trial setting

This section will present the selection of the participants; the design subject for the trial, and the equipments used and the trial environment.

The participants

To minimize the influence of personal ability in design, only those without design background were chosen as the participants. Consequently, ten participants with similar age and background knowledge were recruited and divided equally into two groups – the experimental group (Group A) and the controlled group (Group B). Only Group A used the analogy method against Group B used no specific method. In each group, the one with more leading skill was chosen as the group leader to manage the design process. Table 1 shows the leaders' characteristics of the two groups.

Table.1 Characteristics of two leaders of the two groups

Group	Gender	The group leader's experience in leadership	Speciality
Experimental group (Group A)	Female	With lots experiences of leading activities of certain groups.	Communication and analyzing
Controlled group (Group B)	Male	Being the cadre member in many dynamic clubs.	Integrating and generalizing

Subject for the trial

The participants were asked to generate the idea about “a method of saving or reusing the bathroom water” within one hour duration. Such a subject is chosen due to the consideration that a daily life issue would be more suitable for the participants with no design background. Moreover, the participants' imagination can be various from different perspectives, such as a mechanical device, a training method, or a user behavior.

Equipments

Data in the trial can be formed in text or speech or visual information, e.g. drawings or gesture. Therefore, a video camera, a digital camera and an audio recorder were used. Standard-size paper boards (84*120 cm), blank papers, pens and information related to the design subject were provided, including the documents about the bathroom devices and the current approach of water-saving in bathroom, to assist the production of ideas.

3.2 The procedure

In order to improve the group leader's leadership for the conduction of analogy reasoning, the leader of the

experimental group was trained by the researchers to familiarize with this method. The researchers also introduced the analogy method to the Group A before commencing the trial. The whole trial consists of three parts: the pilot session, the warm-up session, and the formal session.

The pilot session

In this session, researchers could revise the trial planning, and other tasks included the environment setting, such as the video camera and voice recorder setup, ensuring the equipment work well and avoiding the possible interference to the recording equipment, such as the glare from the whiteboard.

The warm-up session

The warm-up session provides the opportunity for the participants to know each other and become a team work in form. The other function of this session is for the participants to undertake “brain exercise” before the formal session, making them adapt to the formal session sooner and more easily [10].

Several mathematical exercises were firstly given to the participants (Fig.1), in which the participants were requested to “think aloud” during the calculating period to make them be used to verbalize their thinking activities. The previous studies suggested that the participants, by taking such a kind of warm-up exercise, could present more accurate and useful information, and show more logical way of thinking.

In the second part of the warm-up session, the participants were asked to draw several specific objects, e.g., a square or flags (Fig.2). Similarly, “think aloud” was also required. The purpose of this exercise was to make the participants be used to think about. Once the participants are ready to commence the formal session, Group B could start by their own pace. The Group A, on the other hand, took the third warm-up exercise in which the researchers explained the principles of analogy reasoning and offered several analogy exercises for the participants to practice before the following formal session (Fig.3).

The formal session

In this session, the participants start to conduct the idea generation. After the commencement of this session, the participants are encouraged to read the reference materials for about ten minutes. The end-time was decided by the leader of each group according to the condition of the participants’ fatigued. The actual duration of the trial was forty-five minutes for the Group A and thirty-four minutes for the Group B.

4. Analysis method

Data were separated into two parts: “video” and “texts”. The videotaped data shows the process of the

Q1. Mathematical exercise			
$\begin{array}{r} 513 \\ + 253 \\ \hline \end{array}$	$\begin{array}{r} 487 \\ - 132 \\ \hline \end{array}$	$\begin{array}{r} 426 \\ + 851 \\ \hline \end{array}$	$\begin{array}{r} 824 \\ + 135 \\ \hline \end{array}$

Fig.1 Mathematical exercises

Q2. Drawing the objects below		
1. a square	2. a national flag	3. a flag

Fig.2 Objects drawing exercises




Q3. Geometric ratio exercise					
2 : 4 = 4 : ___					
ocean : sky = water : ____					
Q4. Analogy of figures					
		=		:	___
1	2	3	4	5	

Fig.3 Analogical question exercises



Fig.4 The scene of the design trial

participants' thinking activities, enabling the researchers to explore the differences of design thinking between the two groups. On the other hand, "texts" includes all written materials, such as the texts represented the ideas and the annotation of these texts. The two data are used for exploring the characteristics of design behaviors of two groups and to support the observation approach in the formal session.

The analysis contained two parts: "design outcome" and "design interaction". The design outcome analysis was based on the qualitative concerns, including "creativity", "feasibility", "potentiality" and the "achievement". The creativity means the originality of the idea. The feasibility means an assessment of whether the idea can be supported by the available technology. The potentiality emphasizes the possibility of further development of the ideas. The achievement was determined by checking whether or not the ideas can fit into the design subject.

For the design interaction analysis, the "protocol analysis", a common research method in design thinking studying and behavior investigation was applied [11-13]. The research adapts the "time-axis" concept of protocol analysis to analyze the development of ideas. Meanwhile, the relationship among each design outcome and participants' interaction also play importantly to the analysis of the participants' interaction.

5. Analysis and the Results

All ideas outcome were recorded on paper boards (in traditional Chinese), Fig. 5. Group A used three columns to record the ideas from three aspects; what the function is, how to gain the function, and the ways to make "saving water" possible (cf. the left figure of Fig. 5).

5.1 Design outcome analysis

Comparing the quality of ideas between the two groups found that those from Group A' are developed according to three aspects, making a multi-threshold structure for idea generation, by which the participants could think more conceptual idea and therefore expand their ideas broadly. As a result, the longer of the design trial is, the varieties of idea development could be. Without using any method, Group B (see the right part of Fig. 5) only recorded the final idea development but no the thinking process. Consequently, the participants' imagination was difficult to expand because only the similar thinking to the earlier idea can easily be produced.

Three industrial designers were invited to evaluate the design outcomes according to the four criteria: creativity, feasibility, potentiality, and achievement. All ideas, regardless being produced by what group, were mixed together for the evaluation. Table 2 shows the results of the evaluation.

General speaking, Group A achieved better scores in creativity, feasibility, and achievement than Group B, particular in feasibility and potentiality. This might be due to that Group A members had read the reference materials before the design trial, making their ideas more feasibility and more achievable by the available technology than those from Group B. Due to Group A applied the analogy method, they could develop their idea step-by-step along the three aspects and need not proposal the final answer directly, making the ideas generated in

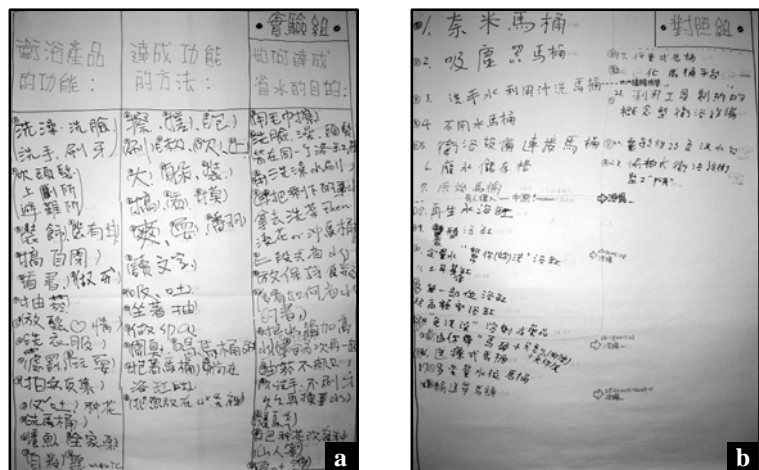


Fig. 5 Results of idea development written on standard-sized sheets

multiple thresholds. In contrast, Group B attempts to give a name to each concept, making the difficulty in developing new concept from the existed ideas. Concerning with the achievement of the design outcome, due to the Group A develop the ideas according to the steps of analogy method, ideas from Group A is likely to be achievable than those from Group B.

Table.2 The quality evaluation of the ideas

Item	Group A	Group B
Creativity	13.48	15.58
Feasibility	15.87	8.33
Potentiality	15.31	9.36
Achievement	14.67	12.22

5.2 Interaction of idea development analysis

Here, the analysis focuses on the relationship between the amount of outcomes (y-axis) and time (x-axis) during the trial and discussed the progress of idea development and differences between the two groups.

Analysis of Group A's thinking line

A continuous line could be seen in Group A's thinking line (Fig. 6), indicating that the design thinking could follow the required design problem. Group A members made design outcomes according to the steps of analogy method, and developed their ideas to the design trial problem. In Fig 6, we can see that although the amount of idea generation is at the peak in ten minutes after the commencement of the trial, the idea generation is continuously progressed over the session. Inspecting the videotape found that in Group A, the proposed design outcomes were not discussed or annotated by the leader, but directly recorded on the paper board. Consequently, the amount of the outcomes developed by Group A was larger and more originality than that of Group B.

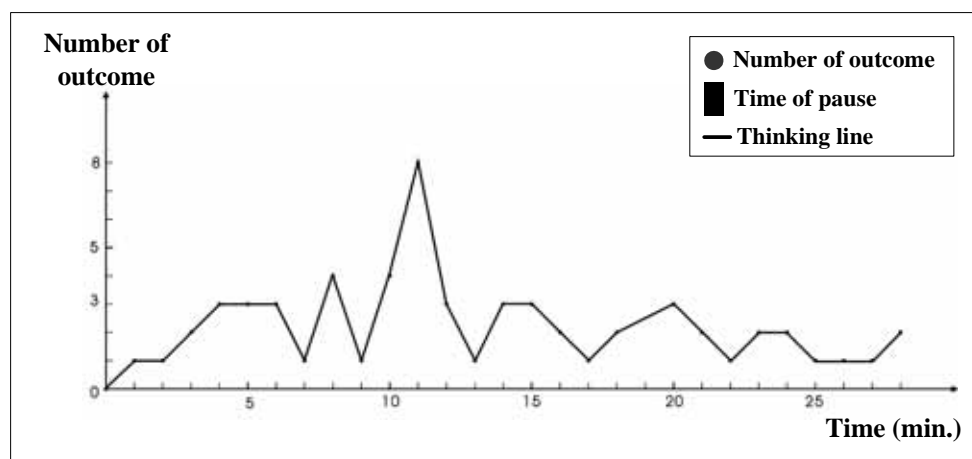


Fig. 6 The Group A's thinking line

Analysis of Group B's thinking line

Compared to Group A, the thinking line of Group B (Fig. 7) was non-continuous, and there were several intervals and pause inside. The related more enthusiastic members (called as core-member) would influence the group performance remarkably. Inspecting the videotape suggests that once the core-member showed less thinking reaction, the group would pause and even break off until the core-member recovered and contribute new outcomes. The frequency and periods of pause increase as the trial progressed. Moreover, compared to the interaction mode of Group A's members, we found that they would challenge and criticize each other's outcomes, forcing the

outcome contributor needed to explain it, which resulted in the pause time.

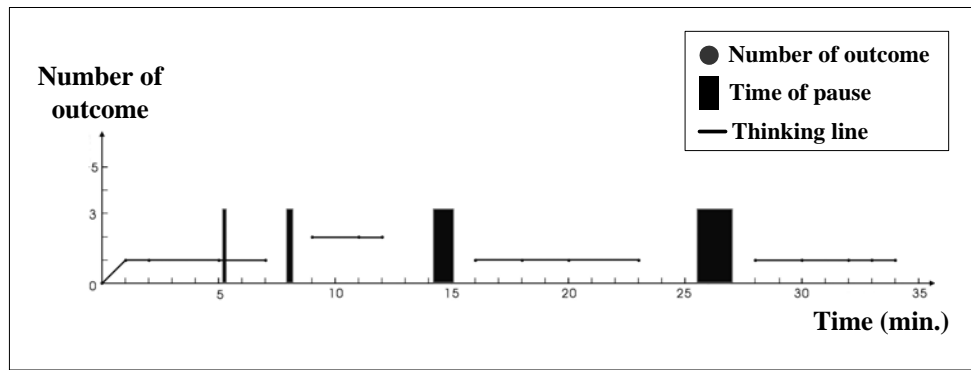


Fig.7 The Group B's thinking line

7. Discussion and Conclusion

When designer were making design proposals, they would usually apply design methods to assist the idea generation, to inspire more ideas and to recall the experiences related to daily life. The above analysis does allow us to propose that the design method could affect design thinking and lead the ideas developed in a systematic and procedural mode. Briefly, the influence of the analogy method can be summarized as the following:

Design outcome

To design outcome, the use of analogy method can improve the ideas in feasibility, development and achievement compared to those produced without using a method. This suggests that overall, the use of a design method could benefit the design practice in idea development in the quality concern.

Interaction of idea development

There were three influences caused by the analogy method.

- (1) Mode of thinking: With guidelines of analogy method, there would be wider range of idea development, and the mode of thinking was more open.
- (2) Continuity in thinking: The idea development would present more conceptually by utilizing the analogy method. So that another could follow by previous idea rather than the final design outcome. Therefore, there would be more expectation in the follow-up stage.
- (3) Direction of design outcome: By applying the analogy method, the direction of outcome development could spread out from the original design problem until completion of the trial. The idea development began form diverse direction, and the final design outcome appeared variously kinds of ideas.

In each group, the familiarity between the group leader and the members, and the subjective analysis to the design outcomes could influence the study. Addition to the analysis results discussed in the above, a major contribution of this research was a postulation of a strategy that could evaluate a design method, and explore how a design method would affect design thinking. The concept of "time-axis" in protocol analysis was employed in this study to analysis the relationship between the design outcome and the interaction of idea generation.

This study has shown that the analogy method could provide the structured manner for idea generation. However, such a study remains uncertainty about in what extent the structure affects the design thinking. On the other hand, the time and cost consideration limited the conduction of the second trial, raising the issue of reliability. Therefore, future studies might be undertaken by adding the third group given the other method in order to explore the structured design thinking, and recruit more participants to carry out the second trial.

Finally, the following study could focus on the analysis of the oral data and contents by a more thorough way, e.g. inheriting of idea development and interaction between each member. As a result, the value of a design method and its applicability to design thinking could be illustrated more precisely and completely.

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