The Influence of Team Members' Thinking Style on the Collaborative Design Process

Guan-Ting Liu and Wenzhi Chen

Abstract Team member composition is an important factor in collaborative design. The purpose of this study was to explore the behavioral differences in the collaborative design process with different team members' thinking style composition. A design process of nine design teams with three different thinking style composition types was selected from a previous study. The material was transcribed and coded according to behavior, discussion, drawing, and writing. The numbers of concepts, sketches, and consensus were also calculated. The results illustrated different behaviors with different thinking style compositions.

Keywords Thinking style · Collaborative design · Behavior

1 Introduction

With the rise of globalized business, the importance of design has increased. In addition, products have become more complex, and collaborative design has become the mainstream of product design and design development to increase creativity and competitiveness.

The performance of the collaborative design team is affected by many factors. Members' composition is one of the most important issues for discussion [1]. A previous study [2] conducted experimental collaborative design projects to discuss the outcome of the different thinking style composition of team members. The purpose of this study is to explore the influences of team members' thinking

G.-T. Liu · W. Chen (✉)
Department of Industrial Design, College of Management,
Chang Gung University, 33302 Guishan, Taoyuan, Taiwan, ROC
e-mail: wenzhi@mail.cgu.edu.tw

G.-T. Liu
e-mail: guanting219@gmail.com

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style composition on the collaborative design process. A video of experimental collaborative design projects by Laio [2] was analyzed to explore the behavior through the design process.

2 Literature Review

2.1 Design Thinking and Protocol Analysis

A design thinking study integrates design studies and cognitive science. It focuses on the change in thinking through the design process [3, 4] to understand designers' thinking and problem-solving process.

The protocol analysis is one of the most used methods of design thinking studies for understanding the design thinking process of designers and their activities. It is based on information processing theory of psychology [5, 6]. The main argument is that thinking is the outcome of the human information process. Protocol analysis can be carried out through the coding, and decoding can reveal thinking behavior. However, this takes time, so it's difficult to analyze numerous subjects [7].

2.2 Thinking Style and Collaborative Design

Design is regarded as an intuitive activity and described as a black box [8]. Sternberg [9] proposed the theory of thinking style to illuminate the way people think. His study described 13 separate styles and five dimensions that comprise his theory of thinking styles, including functions, forms, levels, scopes, and leanings. Table 1 shows the dimensions, styles, and the essential characteristic of each style.

Table 1 Dimensions, styles, and the essential characteristic of thinking styles

Dimensions	Styles	Key characteristic
Functions	Legislative	Being creative
	Executive	Being conforming
	Judicial	Being analytical
Forms	Monarchic	Dealing with one task at a time
	Hierarchic	Dealing with multiple prioritized tasks
	Oligarchic	Dealing with multiple non-prioritized tasks
	Anarchic	Dealing with tasks at random
Levels	Global	Focusing on abstract ideas
	Local	Focusing on concrete ideas
Scopes	Internal	Enjoying working independently
	External	Enjoying working in groups
Leanings	Liberal	Using new ways to deal with tasks
	Conservative	Using traditional ways to deal with tasks

For design, collaboration means a process whereby team members work together, actively communicate to establish joint goals, explore through problem spaces, determine design constraints, and construct a design solution [10–12].

Interaction plays an important role in the collaborative design process. Does the thinking style influence the process and performance of collaborative design? Liao et al. [13] explored the relationship between team members' thinking styles and their performance in collaborative design. The Thinking Style Inventory was used to establish the thinking style profile of 20 undergraduate industrial design students participating in the experiment. The grades of the collaborative design projects implemented by the participants in a design studio course were also collected. The correlation coefficient of team members' thinking style profiles was calculated, and Pearson's correlation analysis was used to examine the relationship between project grades and team members' thinking style. Results demonstrated that the team members with different thinking styles had better performance in the collaborative design team. Laio [2] then conducted experimental collaborative design projects with the different thinking style types of the team members to verify the results. However, Laio only focused on the outcome of the project and did not discuss the behavioral differences of the design process. The present study, therefore, explores the differences in behavior on the design process of the different composition types of team members' thinking styles.

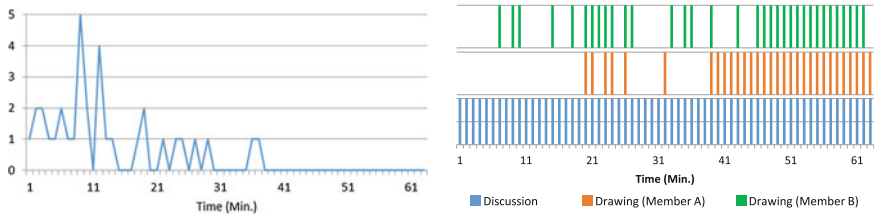
3 Method

This study explored the influences of team members' thinking style composition on behavior through collaborative design. The video of experimental collaborative design projects by Liao [2] was used as raw material and analyzed.

3.1 Experimental Collaborative Design Projects and Subjects

A nine-team video was selected from Liao's [2] study according to team members' thinking style composition. Teams were divided into three groups:

- *Group A* (*Ne-Cor*): the team members' thinking style profile was strongly negatively correlated (correlation coefficient < -0.6); this means the team members' thinking style was complementary.
- *Group B* (*No-Cor*): the correlation coefficient was very close to zero; this means there were no significant relationships between team members' thinking styles.
- *Group C* (*Po-Cor*): the team members' thinking style profile was strongly positively correlated (correlation coefficient > 0.6); this means the team members had a similar thinking style.



(A) (B)

Fig. 1 Sample of the number of concepts (**a**) and the coding of the discussion and drawing (**b**) through the design process

Each team had two members. A one-hour experimental design project was conducted to collect the data. Each team was asked to design a device to avoid oversleeping. Each design project took about 60 min.

3.2 Data Coding and Analysis

The content of the collaborative design projects' video was transcribed then coded and analyzed. The whole process timeframe was separated into minutes. The content of each minute was coded by discussion, concept generation, drawing, and writing when these behaviors were taking place. Figure 1 shows a sample of the number of concepts and the coding of the discussion and drawing behavior through the design process. A multi-coding strategy was adopted to code the behavior; therefore, when the team members performed the discussion and drawing at the same time, both behaviors were coded simultaneously.

4 Results

4.1 Numbers of Concept, Sketch, and Consensus

The average number of concepts generated, sketches, and consensus with different groups are presented in Fig. 2. The PO-COR group generated more concepts and sketches than other groups. The NE-COR group had the fewest number of concepts, but they had more consensus than the other groups.

The results demonstrated that the PO-COR group spent time generating the concept and sketch but possibly had different opinions on the design topic and problem and so struggled to find consensus. The number of concepts and sketches of the NE-COR group was equal to that of the NO-COR group, but their consensus was higher than the other groups. The team members of the NE-COR group appeared more appreciative of the other team member's contribution.

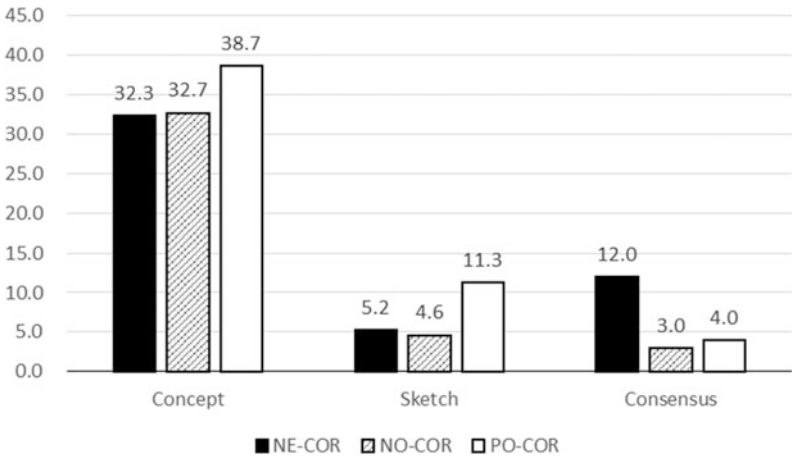


Fig. 2 The number of concepts, sketches, and consensus of each group

4.2 Time Consumption

Figure 3 presents the time taken for discussion, chatting, drawing, and writing in the design process. All groups spent a lot of time on the discussion, but the discussion time of the PO-COR group was lower than that of the other two groups. The NE-COR and NO-COR group also spent some time on chatting that did not relate to the design topic. The drawing time of the PO-COR group was highest, and the NO-COR group was lowest. The writing time of the NE-COR group was lower than the other groups.

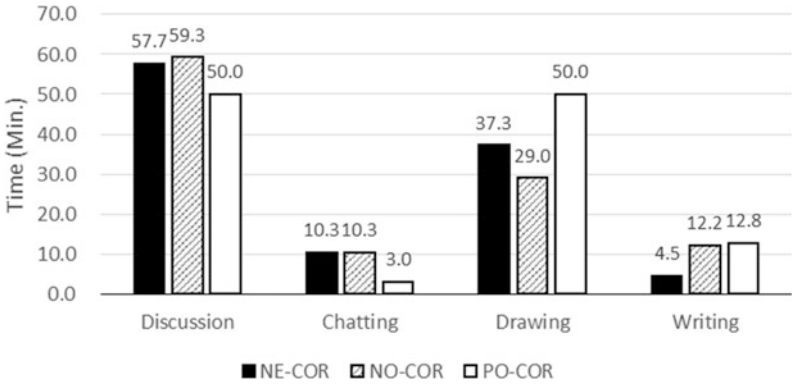


Fig. 3 The time spent on discussions, chatting, drawing, and writing for each group

The results demonstrated that the PO-COR team spent more time on drawing but less time on discussion, whereas the NO-COR team spent the most time on discussion and less time on drawing. The NE-COR team fell midway between the two.

4.3 Average Time of Concept Generation and Consensus

The average time of concept generation through discussion and drawing and the time to achieve consensus was calculated and is presented in Fig. 4.

The NE-COR and NO-COR groups on average spent 1.8 min to generate a concept through discussion. The PO-COR group took 1.3 min, suggesting that the PO-COR group can generate more concepts than the other groups. The average drawing time per concept was similar for the different groups; however, the average drawing time per concept of the NO-COR group was lower than the other two groups. The average time to achieve a consensus was different between the groups; the NE-COR group had the lowest average time, and the NO-COR group had the highest.

Based on the results, the NE-COR team had the most efficient discussions, while the NO-COR team had the lowest. Therefore, the NE-COR team could achieve consensus in a short time and so formulate the design direction and continually generate or derive new concepts or ideas. The NO-COR team needed more discussion time for achieving consensus. They were able to generate many concepts but could not agree on the direction of the ideation.

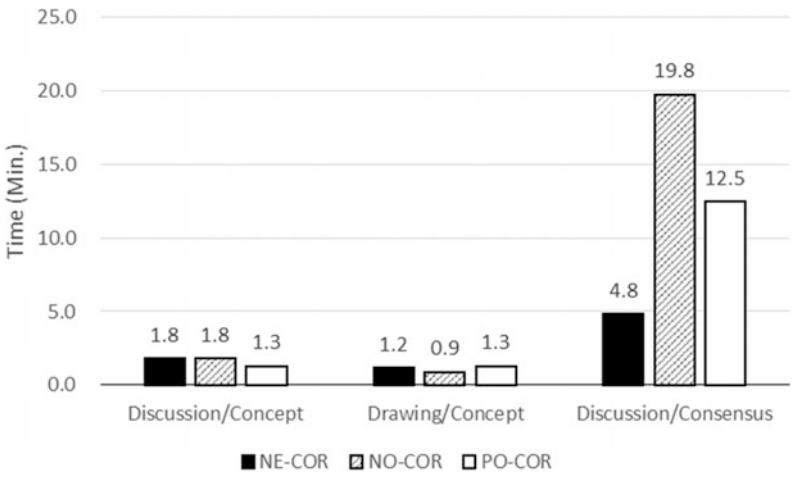


Fig. 4 Average time of concept generation within discussion and drawing, and the time to achieve consensus for each group

5 Concluding Remarks

Communication and interaction are important factors that impact the collaborative design process. A previous study [2] found the thinking style composition of team members affected the outcome of collaborative design projects. This study explored the behavior of different thinking style composition in the design process. The main findings were the following:

- In the PO-COR group, team members had a similar thinking style, generated more concepts, made decisions earlier, and spent a lot of time drawing the sketches. However, consensus was low.
- In the NO-COR group, there was no significant relationship in team members' thinking style; they took a long time for discussion and had difficulty achieving consensus.
- The NE-COR group had a negative thinking style composition, achieved more consensus, and continually developed concepts.

This study found different behaviors in the different thinking style composition of the design team in the collaborative design process. However, the sample size was small, and the coding only focused on behavior quantity. The results should be verified. The protocol analysis and Function-Behavior-Structure ontology model should be used to identify the pattern of behavior and increase the understanding of the collaborative design process.

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