Evaluating the Performance Associated With Idea Flows in Industrial Design Teams

Shuo-Fang LIU and Yuan-Chin HSU*
Department of Industrial Design, National Cheng Kung University, Tainan, Taiwan
*Corresponding author

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Abstract. In industrial design education, design projects are discussed through team cooperation. However, only the discussion outcomes are typically collected. The cooperative relationships among team members are not recorded. This study adopted the idea flow analysis method proposed by Alex “Sandy” Pentland and proposes a mode, denoted as industrial design team idea mode (IDTIM), for analyzing the ideas developed by industrial design teams. Students from a design department at a university were recruited as the research subjects, and these subjects applied two types of discussion mode to execute the experiments. The experiments entailed using a reality mining approach to observe the students’ discussions according to five categories of interaction patterns. The IDTIM was applied for executing analytical tasks. The results are as outlined follows: (1) A team with high cooperation performance developed design works with relatively high quality; (2) visualizing the idea flow information facilitated clearly understanding the perspective of student team cooperation; and (3) using the IDTIM technique assisted instructors in effectively instructing team design projects.

Introduction

In future global competition scenarios, individual glory will be replaced by team cooperation because team cooperation has the advantages of enhancing problem-solving ability, elevating productivity, and effectively utilizing resources (Parker, 1990). On the basis of the theory of social physics, a methodology was established in this study for evaluating the performance of team cooperation among students involved in design projects. Based on the overall research theories, a mode, denoted as industrial design team idea mode (IDTIM), was developed for analyzing the communicated ideas among team members to evaluate the effectiveness of team cooperation. Specifically, this mode could be used to predict the outcome of a design project by evaluating the interaction patterns of team members. Pentland (2014) reported that the total productivity of a group could be predicted by measuring the interaction pattern of the members of that group. The greatest advantage of visualizing the distribution of idea flows through graphs was that various meeting records could be graphically demonstrated to visually reveal the opinions and feedbacks on team interaction patterns and thus enhance the social intelligence of a team (Kim, 2011).

Methods

To date, numerous theories and methods have been developed for evaluating team cooperation. This study was implemented on the basis of the theory of social physics because social physics is a quantitative social science that illustrates the exact mathematical relationships among information, idea flows, and human behaviors (Pentland, 2014).

Establishment of the Discussion Modes

Dimbley and Burton (1992) defined communication channels and divided communication mode into unilateral and multidirectional modes. The current study hypothesized that the use of an instructor–student communication method in a design project may influence the performance of
team cooperation. According to the difference between these communication modes and the suggestions of relevant studies, the traditional discussion mode and team cooperation mode were developed in the current study. Figure 1 illustrates the interactive forms of these two discussion modes: (1) **Team cooperation mode**: In this mode, the instructor served in an assistant capacity and engaged with the student team when the team cooperation mode was initiated. (2) **Traditional discussion mode**: In this mode, the instructor served in a guidance capacity, and each student discussed the project proposal and its relevant questions with the instructor.

![Figure 1. Project discussion modes.](image)

**Subjects**

The research team visited a university in Taiwan and recruited fourth-year students aged 21–22 years from the industrial design department. A total of five teams comprising students enrolled in a design seminar were recruited. Each team contained five students, thus indicating that a total of 25 students (20 males) participated in the experiment. When the experiments were executed, a researcher in the research team was appointed to take notes of the discussion processes, to record the interaction patterns in team communications, and to collate the idea flow distribution and team cooperation performance of each team.

**Experimental Design**

Four major tasks were executed in the experiments. First, during the student discussion process, the project discussion mode was executed and the students’ interactions were recorded. Second, after students completed the project discussions, the researchers visualized the idea flows generated from the student teams. Third, the IDTIM was employed to analyze the cooperation performance in each team. Fourth, conclusions were drawn and reports were written. After these task items were established, the researchers implemented a strategy for guiding fourth-year college students of an industrial design department to participate in the experimental simulations. Subsequently, the overall experimental design was further divided into the following parts: subjects, experimental process, and evaluation method. Finally, after the project items and experimental processes were confirmed, the two types of discussion mode (i.e., the team cooperation mode and traditional discussion mode) were constructed and included in the experimental activities. Figure 2 illustrates the experimental design.

![Figure 2. Design of experiments.](image)
The aforementioned experimental planning and procedure can be divided into the seven steps, and each step is explained as follows: Step 1: Organize the research team for this study; Step 2: Recruit the research subjects; Step 3: Plan the reality mining project; Step 4: Prepare resources (such as a video recorder, camera, and IDTIM form); Step 5: Enter the experimental site, Step 6: Record the discussion contents on the IDTIM forms; Step 7: Report on the tasks executed by teams.

Heath (1993) revealed that the complicated relationship between communication mode and a person’s role imperceptibly influenced the design process. The different roles (i.e., protagonist, supporter, attacker, and the neutral) identified by psychologists are associated with distinct social signals (Lepri, 2009). From the different positions associated with each role, the researchers in the present study presented the idea flow of each team member by connecting the communication signals produced by this member. The conditions of a general student project discussion were observed, the conversation contents among the protagonist, supporter, attacker, and the neutral roles were analyzed, and the communication signals were divided into five types, namely proposal development, approval, supplementation, questioning, and rejection. From the observed and analyzed results, five interaction pattern categories were developed to accurately measure idea flow and decisions (Pentland, 2008). When the interaction pattern derived from each team member was recorded, a 5-point Likert scale with anchors ranging from 1 to 5, which corresponded with the five interaction patterns, was employed. Each interaction pattern was assigned a specific icon to enable easy identification (Table 1).

<table>
<thead>
<tr>
<th>Role in a team</th>
<th>Interaction pattern</th>
<th>Icon</th>
<th>5-point Likert scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protagonist</td>
<td>Proposal development</td>
<td>![Proposal Icon]</td>
<td>5</td>
</tr>
<tr>
<td>Supporter</td>
<td>Approval</td>
<td>![Approve Icon]</td>
<td>4</td>
</tr>
<tr>
<td>Neutral</td>
<td>Supplementation</td>
<td>![Supplement Icon]</td>
<td>3</td>
</tr>
<tr>
<td>Neutral/attacker</td>
<td>Questioning</td>
<td>![Question Icon]</td>
<td>2</td>
</tr>
<tr>
<td>Attacker</td>
<td>Rejection</td>
<td>![Rejected Icon]</td>
<td>1</td>
</tr>
</tbody>
</table>

Analysis of the Derived Visual Information

After all the five teams completed the experimental simulations, the interaction patterns among team members as recorded on the IDTIM forms were converted into idea flow curves. The following figures separately illustrate the distribution of each team’s idea flow curve. In these figures, the amplitude frequency of the curves represents the interaction patterns and communication signals of the team members. Visualizing the idea flows revealed each member’s communicating conditions, and the amplitude frequency of the curves clearly demonstrated the decision-making and discussion conditions during proposal development processes among team members. Regarding the discussion modes, Teams 1–4 employed the team cooperation mode, whereas Team 5 employed the traditional discussion mode. The overall results of the interaction patterns derived from the five teams were presented through idea flows. In addition, the derived information was visualized to observe team member conditions in the design project discussions and to roughly compare the differences between the discussion modes. The observed overall idea flow patterns and the detailed analysis of each team’s discussion mode are presented as Figure 3. Finally, this study provides the following key points after analyzing the results of the two discussion modes:

1) The team cooperation mode had a higher motivational effect on students’ proposal development compared with the traditional discussion mode.

2) Students who applied the team cooperation mode demonstrated high participation and an increased learning willingness.
(3) The traditional discussion mode benefitted students in mutual interaction and learning.

![Image](image1.png)

**Figure 3. Teams of idea flow curves.**

**Discussions**

After conducting several investigations, the researchers participated in a design project involving instructors and students and observed how the students developed design-related perspectives and generated concepts through interactions and discussions. The selection and decision-making strategies of the subjects were the most critical factors that must be observed in this process. Specifically, the researchers examined the stages of design thinking experience proposed by Brown (2009) and divided them into convergent thinking and divergent thinking. Convergent thinking aids people in making decisions from few existing selections, whereas divergent thinking provides people with more options. On the basis of the meaning of the design thinking experience stages, the present study determined that the traditional discussion mode was applicable for the design convergence stage and the team cooperation mode was suitable for the concept development stage. Accordingly, this study concludes that the project discussion method employed in industrial design education can be integrated with design thinking experience procedures to propose a discussion mode that corresponds to the stages of design thinking (Figure 4). The team cooperation mode was appropriate for the “create-choice” stage. Moreover, the traditional discussion mode was suitable for converging the concepts at the “make-choice” stage.

![Diagram](image2.png)

**Figure 4. Discussion modes corresponding to the stages of design thinking.**

**References**


