Brainstorming is known as the most common method used for idea generation by group effort with time-limit. Instead of the development of various form of brainstorming to enrich the brainstorming result, the computer-based tools is developed and used to support the conduction of brainstorming by providing the functions, such as voting, database, information retrieving. Such tools are often integrated into computer-supported group meeting system. However, such integrated systems, often used for large size meeting room allowing tens of people meeting together and cost relative much, are unlikely favor to middle and small size company due to the consideration in cost and the limit in usability. For example, a studio-like design office might hesitate to install such systems to assisting their brainstorming, particularly in the case where the colleagues are separated at a distance which is often seen in the organization of modern design office.

The purpose of this study thereby is to explore the potential of computer-based tools in supporting brainstorming when the participants are separated at a distance. A brainstorming trial was conducted by three teams (Team A, Team B, and Team C). Each team contains six members that are experienced in brainstorming and the members of Team A and Team B are separated into two sites; two in one site and the rest in the other site. Team A was given one computer in each site and communicated via a Video Mediated Communication (VMC) which allows video and audio connection. Each member in Team B was given a computer and communicated via a BBS environment which only provided typing-as-speech tool, i.e. no on-line audio and video connection. Team C, on the other hand, conducted the brainstorming face-to-face, and therefore allow visual and audio communication. Each team conducted the brainstorming session for about one hour. The underlying scenario for such configuration is to stimulate the case where the design team needs to conduct a brainstorming session by using the communication tools at their disposal due to the members are separated geographically.

A comparative study is conducted in which the analysis focused on investigating the communication and coordination modes of each team. Rather, we inspected the differences of outcomes in quantity and quality, if they exist, between the three teams, since brainstorming is often expected to generate as many ideas as possible during a limited period. Results show that there is no obvious difference of outcomes in quantity between the three teams. Yet, the three teams did show differently in the mode of group communication and the role of the group leader. Comparatively, the members of Team A are observed to sub-group themselves, leading the team leader plays less dominance. The interpretation to the analysis results enables us to conclude that the computer-based communication tools could support distance brainstorming appropriately under moderate requirements in cost and technology. However, given the differences of communication modes between the three teams, we would argue that the communication channels might influence the communication pattern and group coordination in brainstorming session. Finally, we conclude this research by proposing the ways to improve the conduction of brainstorming.
1. Introduction

Team work is not new for an organization to enhance the quality and quantity of the answer against the problem [1]. Increasingly, the completion of design work needs group's effort, leading the request of communication tools to reduce the cost and time for traveling to place the face-to-face discussion. Many studies have devoted to the field using computer-mediated communication tools to support cooperative design work. On the other hand, the utilization of brainstorming in producing many ideas has been recognized. The pervasive usage of telecommunication tools and brainstorming in design work prompts an interest about how brainstorming is conducted over a distance. The study described in this paper attempts to explore such an interest with a view to suggesting the way improving the cooperative design activity over a distance and the design of telecommunication tools to facilitate cooperative design activity.

2. Purposes of Research

Literature suggests that brainstorming is not the case gathering a group of people together, giving them a problem, and collecting their ideas. Rather, brainstorming is an activity involving significant group interaction under the particular rules to enhancing its progress. The interaction amongst the group members could be impacted by the communication channels available to these participants. Prompts by the above, the aims of the study are:

1. to explore the difference between the brainstorming sessions over different communication models.
2. to investigate the reasons leading the difference revealed above.
3. to suggest the way to improve the brainstorming progress for design work over a distance.

3. Literature review

Obviously, different design methods are required to match the different needs due to division of labor in design, design subject, and design tasks [2][16]. To concept generation, brainstorming is worked out in “expanding” the thoughts, through incessant replenishment and making amending to stimulate the concepts generation [16]. Studies in brainstorming however, mainly discuss the conducting principles and suggest the possible variations in conducting brainstorming. For example, Cross (1994) addressed some conducting principles, while the other researchers addressed the conducting procedures and key points for the successful conduction [17][18][19] Also, many studies focus on the variation of brainstorming [20][21][22]
Nevertheless, these studies provided neither consolidated analysis nor comparable results proving the gain of effective performance and giving little intelligence about the way to evaluate the effectiveness of brainstorming [3][4][5]. Similar to the notices from previous literature [6][7][17][18], Hsu, et al (2003) argued that the interaction between the leader and the participants are important to the success of brainstorming, which could indicates that the affordness of communication tools could play dominantly to the success of brainstorming in the case where the participants are separately at a distance. [8]

In fact, many studies have addressed in the field using computer mediated communication (CMC) tools to support distance design activities, e.g. drawing, sketches and presentation [9][10][11]. Generally, Computer-mediated communication (CMC) tools can be classified in terms of ‘where’ (local against distance) the users are located and ‘when’ (synchronous against asynchronous) user interaction occurs [12] [13] [14].

Interesting at brainstorming which is almost conducted under synchronous condition, this study will focus on the CMC tools supporting synchronous communication, which can be classified into three: typing-as-speech, voice conferencing system and video conferencing system. Typing-as-speech conference systems, having widely been used for the communication over a distance via limited internet bandwidth, enable the users to converse by typing messages into a shared communication space. Voice conference system enables the users to conduct oral converse using limited internet bandwidth. Unlikely, video conference systems provide real time visual as well as verbal information, making the users see and hear each other at the same time.

Hsu et al (2003) has argued that the leader plays importantly to the success of brainstorming. In face-to-face situation, the leadership between the leader and the other participants can be established and maintain easily during the session. In remote design brainstorming, this may not be such a case, leading the different quality in the participants’ interaction between the co-local and remote conditions and therefore, making the difference in the outcome of brainstorming.

Furthermore, the interaction in distance brainstorming could even differ in the case where the communication tools provide difference communication modes. For example, typing-as-speech tools enabling the participants hide themselves behind the screens might provides less cues for interaction than that provided by video conference system, making the quality of interaction to be different. Given the above, this study arranged a trial recruiting three design teams conduction a brainstorming meeting for a design project via different communication environment, with a view to exploring the difference of the interaction, and how the affordance influence the progress of brainstorming.

4 The brainstorming trials
The following sections will introduce the conduction of the brainstorming trials in this study including the participants, the facilities used in the trial and the procedure.

4.1 The teams and equipment

Three groups each containing 6 participants are involved in this trial and asked to develop the ideas based on Germany Braun’s design competition (cf. Appendix A). Members within each group are familiar each other. Group A members are co-located. Group B members are separated into two sites; the leader and one participant located in one room while the rest were in the other room. Each was given a PC enabling group communication via typing-as-speech conferencing tools. In Group C, the participants distributed as those in Group B, and communicated via two video-mounted PC with free video conferencing system at each site. The leader and one member share one PC while the other four share the other PC. For the aspect of design work, Group B and Group C can share on-line drawing, and files by the same groupware, i.e. NetMeeting. The scene of each group was illustrated in Figure 1.

Figure 1, the scene of each group

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Group A" /></td>
<td><img src="image2.png" alt="Group B" /></td>
<td><img src="image3.png" alt="Group C" /></td>
</tr>
</tbody>
</table>

Each group was provided with A4 papers, markers, tapes and design magazines. All sessions were video recorded. A questionnaire survey was given to each group after the brainstorming session to collect the personal information and comments for the brainstorming.

5. Results and Analysis

The analysis includes: evaluation of concepts, comparison of meeting process, mood, and variation of ideas generated within three group members by inspecting the correlation between the frequency of speech turns and concepts outcomes.

5.1 Concepts evaluation

The object of using brainstorming is to gain as much as possible ideas during a short period with few costs. Therefore, the success of brainstorming can be evaluated by assessing
the quantity of outcomes [16][19][20]. The relationship between the amounts of issues, concepts and time are shown in Fig 2 and Table 1.

### Table 1. Relationship between proposed directions for solution and the number of idea

<table>
<thead>
<tr>
<th>Time (mins)</th>
<th>3</th>
<th>6</th>
<th>9</th>
<th>12</th>
<th>15</th>
<th>18</th>
<th>21</th>
<th>24</th>
<th>27</th>
<th>30</th>
<th>33</th>
<th>36</th>
<th>39</th>
<th>42</th>
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<th>51</th>
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<th>57</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>10</td>
<td>12</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Time (mins)</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>12</td>
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<td>18</td>
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<td>48</td>
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<td>57</td>
<td>60</td>
</tr>
<tr>
<td>Group B</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>2</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>3</td>
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<td>(amount of idea)</td>
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<td></td>
</tr>
<tr>
<td>Group C</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
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</table>

Fig 2. The relationship between the amount of ideas, directions and time

### 5.2 Creative Analysis

Seven steps for conducting the brainstorming suggested in literature are referred in this trial; they are preparation, subject briefing, proposing direction for problem-solving, choice to the direction, Brainstorming, the most “innocent” concept, questionnaires. The analysis to the difference in the progress of brainstorming amongst the three groups is presents in this section by reviewing the video tapes. To each step, the reasons making the difference of the time lapse between the three groups are discussed. The time lapse for each step in the three groups can be seen in Fig 1 and Table 2.

A. Warm up: unlikely Group A and B, Group C failed to exercise the warm-up steps effectively.

B. Briefing: both Group B and C have electronic whiteboard allowing the leader post the
topic and the rules of brainstorming efficiently. Due to the typing work, Group B spend more time in this step than Group C.

C. Direction proposal: comparatively, Group A spent less time in this step than the other two groups. The possible reason might be that Group A needed no repetitive explanation as well as confirmation process.

D. Direction classification: due to only few ideas were proposed, Group C skipped over this step and ran into the next step directly. However, in the case where more ideas are produced, one participant to manage these ideas are needed in order to reduce the leader’s loading.

E. Direction choice: giving no oral message and the participants’ images, Group B spend more time in voting than the other two groups.

F. Concept development: the Group C members were encouraged by the leaders. Also, the participants failed to concentrate on the discussion. The interval producing no idea is long comparing to the other two groups. The Group B participants might talk enthusiastically but diverge from the subject, while the leader did little in re-directing the progress.

G. Concept evaluation: similar to step e, giving no oral message and the participants’ images, Group B spend more time in voting than the other two groups.

Table 2. The relationship of session steps and time lapse for each group

<table>
<thead>
<tr>
<th>Steps</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time lapse</td>
<td>Time lapse</td>
<td>Time lapse</td>
</tr>
<tr>
<td>A</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>7 (12)</td>
<td>9.5 (15)</td>
<td>3 (9)</td>
</tr>
<tr>
<td>C</td>
<td>12 (24)</td>
<td>18 (33)</td>
<td>24 (33)</td>
</tr>
<tr>
<td>D</td>
<td>10 (34)</td>
<td>1.5 (34.5)</td>
<td>0 (33)</td>
</tr>
<tr>
<td>E</td>
<td>4 (38)</td>
<td>19.5 (54)</td>
<td>10 (43)</td>
</tr>
<tr>
<td>F</td>
<td>17 (55)</td>
<td>21 (75)</td>
<td>32 (75)</td>
</tr>
<tr>
<td>G</td>
<td>6 (61)</td>
<td>39 (114)</td>
<td>8 (83)</td>
</tr>
</tbody>
</table>

Figure within bracket is the time lapse in toto
Fig 3. The relationship of session steps and time lapse for each group (● one minute quiet thinking)

5.3 Summary

In general, the difference amongst the three groups can be summarized as following:

(1) The advantage of traditional face-to-face mode is that participants can communicate richly, encouraging the idea generation and participation.

(2) The advantage of typing-only mode is to avoid the face-to-face embarrassment. The atmosphere for discussion is free, leading the participants express their ideas enthusiastically. In the case where many ideas generated at the same time, the readability is reduced and the input could be blocked due to the mess in reading space. The leadership is difficult to maintain due to the leaders is busy in managing the progress of meeting.

(3) The poor quality of video caused repetition and negative interaction, leading the participants failed to see each other and influencing the leader to coordinate the progress.

6. Discussion

Face-to-face mode produces better interaction, efficiency and joyful atmosphere. The leader can control the process and understand participants’ moods. Besides, some participants might be shy to contribute in such a communication mode. On the other hand, with high privacy, typing-only mode is comfortable, allowing many exaggerated even impracticable ideas to be produced. The order of ideas list is influenced by typing speed and the need to read and pay attention to the screen. However, the screen changed too fast to the participants read and think carefully about the ideas, leading the ideas to be presented with abbreviated words, which reduce the readability.

It is surprised that video mode fails to provide a kind environment for brainstorming. The reasons might include the bad video quality and lagging causes the communication less alive and reduce the participatory.

7. Conclusion
If the quantity of idea is a key index to the success of brainstorming, then typing-only mode over-performs to face-to-face and the video connection modes. Suggesting by the participants, the reason is mainly due to the higher privacy making the participants can freely imagine and “say” what they want with less social pressure.

Unlikely in the traditional meeting, the leader’s role and influence in distance brainstorming is getting down. In distance mode, the cue and channel to manage the progress in face-to-face mode are lost. This suggests that the leader’s role in distance brainstorming can be redefined.

In summary, the interaction in brainstorming is influenced significantly by communication tools. The differences include the discussion mode, leadership representative and the quality of outcomes. Since the transnational collaborative design is imperative, it is worthy further exploring the way providing appropriate communication tools for distance brainstorming and re-shapes the leadership and participant in brainstorming.

8. Reference

Appendix A

The Braun Prize places great emphasis on people as the focus of product development and therefore on product concepts which represent real innovations in design and technology and which helps people in their everyday lives – in the home, at work or school, during sports and leisure activities or in the context of health and healthcare.