Abstract. Design collaboration requires formal organization as well as technologies in supporting design communication and process. This paper documents the experience of a collaborative design studio held among three institutions. It briefly describes the scenarios and tools applied in the CDS, and the resulting design process.

1. Introduction

Virtual design studio (VDS) has been held among many institutions across the world due to emergence of the internet and computer-supported technologies (Kvan, 2000; Hirschberg, et.al., 1999; Chiu, 1998; Wojtowicz, 1995). WWW, whiteboard, e-mail, or video-conferencing systems are often used in communications. This paper depicts how to develop scenarios and motivate the development of systems and tools for supporting collaborative design studios (CDS). In CDS’2000, the graduate-level design studio is held in three academic institutions - National Cheng Kung University (NCKU, Taiwan), Kyoto Institute of Technology (KIT, Japan) and Kumamoto University (KU, Japan).

The objective of this study is to understand the design interactions of collaboration, the use of web-based groupware, the iteration of design, and provide constructive directions for future studio settings based on the CDS’2000 six-week experience held in early 2000. The design goal is to organize a design team or expertise, and submit a design proposal for an earthquake museum in memory of the death that more than five thousand people were killed in the strongest earthquake of the last century occurred in.
the central Taiwan on September 21, 1999. The NCKU team visited the site and prepared the site information including the 3D models of site on the web for all members.

2. Possible Scenarios for Design Collaboration

The design guidance for a collaborative design studio is the basis for running a studio (Chiu, 1998). Therefore, preliminary discussions among three primary instructors on the setting determine the orientation of CDS. During the six-week period of CDS, the tasks undertaken are as follows.

a. To organize the teams – teams are freely organized by individuals and should support the idea of collaboration.

b. To prepare personal web pages and precedent studies - this will help reaching consensus of similar viewpoints.

c. To define the role of individuals – it is helpful for design communication, and evaluating individual and team performance.

d. To track the process – different level of details are linked on the web for team members, instructors and external reviewers.

e. To maintain communication records – it can be analyzed for design evolution and future system development.

f. To provide constructive feedbacks – it is required in a participatory process, as a part of evaluation.

Because there are location, time, cultural, and language differences among CDS team members, several issues needed to be resolved for overcoming organization, process, and technical problems in design collaboration. Therefore, scenarios of design collaboration are developed. A parallel approach is applied to each institution because each has its own resource and systems. The following sections will describe how the teams are organized, the process is applied, and facilities and tools are used.

2.1. TEAM ORGANIZATION

Team organization is one of the major tasks in design collaboration, because it can affect design communication and performance (Chiu, 1998). As shown in Figure 1, subdivided teams and mixed teams were considered at beginning to achieve the purpose of collaboration. Due to the complexity of communication, a hybrid team approach was adopted, and five design teams were formed and each team consisted of four members from two institutions. Therefore, both the teams and institutions can trace the information flows, and could detect possible communication problems.
2.2. PROCESSES

The six-week design schedule is shown in Table 1. The main web site is used as the repository of design information and proposals. The process involved in CDS’2000 as well as design iterations is documented in http://www.arch.ncku.edu.tw/cds00/index.htm. Three institutions agree to use English in verbal and text communication, while graphic presentation remains critical to communication. Furthermore, dealing with dynamic team structure requires both synchronous and asynchronous communication at different levels, such as individual, team, and project levels. Synchronous and asynchronous
communication is applied respectively in the process, and each serves different functions.

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Tasks</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2/21-22</td>
<td>Introduction, Site visit</td>
<td>Preparation, Remote testing</td>
</tr>
<tr>
<td>2nd</td>
<td>2/28-29</td>
<td>Team organization, Define rule of games</td>
<td>Video-conferencing, Netmeeting</td>
</tr>
<tr>
<td>3rd</td>
<td>3/06-07</td>
<td>Conceptual Design</td>
<td>Video-conferencing</td>
</tr>
<tr>
<td>4th</td>
<td>3/13-14</td>
<td>Conceptual Design</td>
<td>Video-conferencing</td>
</tr>
<tr>
<td>5th</td>
<td>3/20-21</td>
<td>Design Development</td>
<td>Video-conferencing</td>
</tr>
<tr>
<td>6th</td>
<td>3/27-28</td>
<td>Final jury (remote jury)</td>
<td>Video-conferencing, Netmeeting</td>
</tr>
</tbody>
</table>

2.2.1. Synchronous Communication
All three sites installed 128K ISDN and video-conferencing facilities. Once a week, there was a group meeting for progress reports by two simultaneous bilateral video-conferencing. MS-Netmeeting with internet cameras was also used in a small group, aided by whiteboard (Figure 2). This kind of communication enhances the understanding of how collaborative design work. Particularly, the social interaction by face-to-face contact is important for understanding the personality.

2.2.2. Asynchronous Communication
Asynchronous communication is used frequently at the individual and team level. Normally, team members often browse the web pages after images and drawings are transmitted by ftp, and discuss the progress of projects by both sides on the text mode, or simply by e-mail.

![Figure 2. WWW, Netmeeting, and Video-conferencing in CDS’2000](image)

2.3. TOOLS
Meanwhile, developing convenient tools to support messages broadcasting and desktop publishing has become necessary for collaborative design (Morozumi,
Therefore, the tools are not only to document design development but also indicate the status of each individuals involved in the process. Three institutions take different approaches to develop web-based systems or tools for managing design information and the process, Figure 3. These are all used and compared for understanding how to share design information and document the design process.

2.3.1. KIT - Digital Design Pinup Board
KIT's DPB (Digital Pin-up Board) is a web-based design platform for posting design information and design navigation at asynchronous mode, and its digital meeting environment is designed for synchronous communication (Yamaguchi and Toizumi, 2000).

2.3.2. KU – GW-Notebook
KU's GW-Notebook is a group-ware for asynchronous communication and project management (Morozumi and Shounai, 1999) with possible extension to synchronous communication. It is written with Visual C, as a special web working in an ASP environment. Users can access the individual, team, and project levels at three different types of Notebooks to handle communication.

2.3.3. NCKU - Quicknotes
Previous studies demonstrate that it is critical to deliver important information to the right person in the simplest way in design collaboration (Chiu, 1998 & 1997). Quicknotes, a simple web-based comments and message system integrated with SQL-server, is developed to remind designers respond to the in-coming messages or comments. Meanwhile, NCKU defines a framework and a format for the web pages, and handle information in an informal way instead of constructing a formal system.

3. Design Iterations in CDS’2000

The above scenarios are based on the possible distributed and multiple systems that can overcome communication barriers. While there is one hour time...
difference between Taiwan and Japan, the communication performance is mainly subject to the bandwidth of internet. However, time, language, or location barrier is less important than the professional skills in communication. Nevertheless, design communication and collaboration gradually bring design development to a consolidated proposal. Meanwhile, design alternatives emerged during the design process and are convergent at the end of studio as a result of interaction with the design community.

3.1. DESIGN ALTERNATIVES EMERGED

The design alternatives are the evidence for understanding the status of design. After reviewing the progress report in each week, the changes are summarized for comparing the interactions among team members. For example, Figure 4 illustrates design iterations of five groups in the third and the fourth weeks. Group-3 and Group-4 even changed design alternatives due to poor communication. Indeed, collaboration required coordination and the leadership in design communication, particularly when passive interaction occurred. The scenario of choosing hybrid team organization demonstrates the strength of identifying the problems.

3rd Week

![Diagram of 3rd Week](image)

4th Week

![Diagram of 4th Week](image)

Figure 4. Design alternatives emerged in the 3rd and 4th week.

As evidenced in the studio, design collaboration through asynchronous or synchronous design meeting is not only seeking a place for exchanging and sharing information, ideas, concerns of individuals, but also functions as a place for understanding the context and situation of a project, exploring and
developing design concepts and ideas, and reaching a consensus of a team (Yamaguchi and Toizumi, 2000). Apparently, without the groupware or tools, the communication will be more difficult to trace important information to reach the final results. It is useful for designers if the groupware can detect the possible obstacles or conflicts in the design process by visualizing the design changes.

3.2. INTERACTION WITH A DESIGN COMMUNITY

Does the design performance directly link with the effectiveness of design collaboration? It is presumed and preliminary observed that in design collaboration, design performance is related with three aspects: (1) design knowledge: design concepts and strategies that respond to the issues in the design program, (2) presentation skills: visual presentation on the web or oral skills, and (3) social skills: participation and interactions in the process. These aspects may link with each other. Even the process is documented in three institutions, the third one is less observable and measurable while the first and second ones are more explicitly demonstrated. However, design alternatives cannot be emerged without design collaboration.

Previous behavioral studies of design collaboration focus on the observation based on the individual level (Simoff and Maher, 2000; Craig and Zimring, 2000; Chiu, 1997). Individual contribution should be recorded based on the accomplishment as well as task dependency. In fact, team members but only interact with each other, but also interact with other team members or a design community of all participants. Furthermore, a teamwork process should consider that each team presents a subset of a design community, and its interactions are dynamic.

3.3. REMOTE REVIEWS

Design collaboration is a learning process of sharing information, and bringing in external expertise and generating design knowledge. The function of design reviews is more than examine the performance, but rather provide constructive feedbacks. With the ability of navigating the process on the web, reviewers can even provide feedback earlier.

Meanwhile, final review in CDS’2000 is separated into two parts - the local jury and remote jury, each serves different functions. Remote jurors provide immediate feedback based on the design result, while local jurors motivate the discussions with special comments or inputs after browsing the design works and the process on the web. Both are complementary to formal studio instructions.
4. Discussion

The findings in the process provide the foundation for further discussion in terms of three aspects: first, the capability of the groupware and the impetus for developing new tools; second, the design behaviors, such as the impact of the system used in enhancing design communication in a studio; and third, the scenarios used in the process.

4.1. THE ROLES AND FUNCTIONS OF GROUPWARE AND TOOLS

In general, current design collaboration are organized based on four factors: (1) design culture, (2) time constrains, (3) design orientation, and (4) availability of communication and computer-supported systems. To respond to the needs, design collaboration need a referential, documentation, project management, communication, and evaluation system.

Because each team is working with at least two systems, either NCKU-KIT or NCKU-KU, it is possible to compare the systems and evaluate what are the most desired functions for design collaboration. Most students prefer the system should be simple and easy to use, and need message posting or pin-up to situate them or co-members in the process.

Meanwhile, establishing an environment to share and exchange information among participants is the minimum requirement to start CDS or VDS, but it does not necessarily provide environment for creative and productive work. We need to explore conditions to enhance motivation of participants, good program to exchange or build design discussions through the project period, and need to explore good programs or even tactics for a fruitful result. It is also true that groupware or tools that based on good programs.

4.2. DESIGN SCENARIOS

Should CDS introduce structured organization for team works? How real is CDS compared to the process in practice? Whether the parallel approach of adopting each systems or tools in the process is appropriate? These questions reflect how instructors or participants respond to the situations that are considered important in the process. Time, facilities, people and even expertise are all important resource in design collaboration. It is more desirable to utilize resources or systems of all institutions, while the system is generally centralized in most VDS exercises. Learning to define design scenarios is one of the goals in the CDS. However, scenarios may be changed to adopt new situations, and it needs in-depth studies for understanding the impacts on design collaboration.
4.3. DESIGN AND COMMUNICATION BEHAVIORS

From the behavioral point of view, while visual communication is the foundation of design collaboration, language barriers in oral communication often imposed a stress effect on teams as well as technical barriers. Furthermore, collaboration is a deeper, more personal synergistic process as indicated by Kvan (2000), and its process involves negotiation, agreement, and compromise in order to achieve success. Collaborative design is a social process, and requires informal meetings or warm-up exercises to reach practical purposes. Behavioral studies based on the cognitive protocol study involve large-scale information management, and will require computer-aids for automate the information collection and analysis.

4.4. FUTURE EDUCATIONAL AND RESEARCH AGENDA

This study suggests that what should be considered in future studio settings, including (1) provision of theoretical background of collaborative design studies and design guidance for integrating design programs and the new design environment, (2) uses of computer-supported groupware, and (3) management skills of dynamic design organization. These contain the educational and research agenda.

For educational purpose, the pedagogical issues remind us possible changes in future educational orientation as well as new settings. While VDS or CDS becomes a design platform as an experimental setting (Mitchell, 1996), but the real impact on education should be reconsidering the function of design studios and group teaching. How the future curriculum adopt the VDS or CDS as the standard platform will rely on further studies of design collaboration in education and in profession.

For research purpose, groupware should be used for functional as well as research purposes. The development of web-based or wireless groupware requires more tests in the field. For example, NCKU’s Quicknotes system is later developed as DECADE, a Distributed Environment for Collaborative Architectural DEsign. The module of evaluation of team participation as well as a virtual meeting room is integrated for future studio and practice uses. Similarly as Phase-X, groupware that can visualize the changes in design development will facilitate designer’s decision in future development (Branko, et.al., 2000; Hirschberg, et.al., 1999). Therefore, how the groupware can detect the possible obstacles or conflicts in the design process will become one of the areas for future development.
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