Collaborative Design in CAAD Studios: Shared ideas, resources, and representations

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This paper is to discuss the shared experiences among two institutions learned from the collaborative design project with a three-stage structured design process. The collaborative methodology is developed for participants in the studios to learn how to utilize shared ideas, resources, and representations. Design communication and interaction is taken place through internet in the asynchronous mode. The shift from conventional design studios to collaborative design studios requires several changes, including the tools, the communication media, the remote reflections, and more importantly, the design process, the team organization, and the networked design culture.

Keywords: collaborative design, computer-aided architectural design, computer-supported collaborative work, shared representations

1. Introduction

The virtual design studios (VDS) or collaborative design studios, which are recently taken places in major institutions around the world, create a new paradigm for computer-aided architectural design (CAAD) [Mitchell 1995, Maher, et. al. 1993]. A VDS comprises of a team of designers who collaborate via electronic communication in a distributed environment. Several institutions can participate in the studio project, where the students work on a site selected by their own studio instructors and provide resources to students at other institutions involved in the project. The asynchronous or synchronous mode can be used in VDS. While the collaborative methodology is similar, each cooperative design project has its unique setups and focuses [Wojtowicz 1995].

Meanwhile, during the last five years in Taiwan, a growing number of building projects were undertaken collaboratively by local, regional, or/and international organizations [Chiu 1995]. The emergence of collaborative design in architecture is critical for designers, consultants, and their clients to overcome the crisis in communication due to subdivided responsibilities, and more importantly to share and exchange design ideas, expertise, and experience. Similarly, the collaborative approach in practice is recently applied to design studios at architectural schools.

Furthermore, the National Information Infrastructure (NII) project, an information super highway extended from the Taiwan Academic Network (TANet) as shown in Figure 1, was initialized in 1994 by the government for promoting remote education and public services [NSC 1994]. Because most CAAD programs in architectural schools in Taiwan are newly established, it is necessary to share scarce resources and expertise by a collaborative design framework.

This pilot study is therefore to demonstrate a working model experimented in CAAD studios at National Cheng-Kung University (NCKU) in the southern Taiwan and National Taiwan Institute of Technology (NTIT) in the northern Taiwan. Two other institutions, Tung-Hai University (THU) and Tam-Kang University (TKU), also participated in the remote jury process. The educational goal is to promote design cooperation in CAAD studios among various institutions on a country-wide basis, and provide students shared ideas and experience through stimulation, critique, and suggestions from design communication and interaction in a large-scale housing project. The research goal is to develop a collaborative paradigm for supporting collaborative design. The
collaborative methodology is addressed below, followed by the design process, how design communication and interaction are taken places electronically, and the lessons and reflections from this project.

Figure 1 The TANet and institutional locations

2. The methodology for collaborative design

The collaborative design studio brings up the issues of where, when, and how design can take place, while the conventional design studio is more concerned about what is design, and who is doing design. The shift from a conventional design studio to a collaborative design studio (CDS) are different in the manner of location, time, tools, communication, and reflections, as shown in Figure 2. The world wide web (WWW) provides the platform for representing and storing all design information. The web will support the asynchronous activities among the participants through access to various design information. The synchronous collaboration will be supported through video conferencing facilities, shared whiteboard, and shared CAD systems.

<table>
<thead>
<tr>
<th>Setups</th>
<th>Location</th>
<th>Time</th>
<th>Tools</th>
<th>Communication</th>
<th>Reflections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Design Studio</td>
<td>Same place</td>
<td>Synchronous</td>
<td>Freehand</td>
<td>One-to-one or one-to-many</td>
<td>Face-to-face</td>
</tr>
<tr>
<td>VDS or Collaborative Design Studio</td>
<td>Different places</td>
<td>Asynchronous or synchronous</td>
<td>CAD system Digital tool video-conference Whiteboard</td>
<td>Many-to-many</td>
<td>Remote</td>
</tr>
</tbody>
</table>

Figure 2 Comparison of conventional and collaborative design studios
From the designer’s point of view, the key question is how technologies can support the collaborative design in the design process. Figure 3 demonstrates that design communication and interaction among two persons or groups in the networked environment could be occurred by “shared” ideas, resources, and representations. Ideas are shared, and give an impetus to design. Designers can use these ideas to explore different design alternatives or possibilities. While different designers may interpret differently, ideas can be used to facilitate communication, understanding, and further design development. Designers can access design information by shared resources such as internet or distributed database, and use shared representations by ftp or file conversion. The recent studies on emerging shape will ease the interpretation of shapes by computers. The research on computer-supported collaborative work (CSCW) and the collaborative workgroup tools is in progress [Maher et. al. 1993].

In order to initiate collaborative design, a CDS also requires several changes, including the design process, the team organization, and even an unique project program or site. Based on previous studies, a collaborative methodology is developed as a working model for this project, which includes three parts:

Figure 4 Collaborative design framework
2.1. Framework

A collaborative design framework should first define a project program which allows different teams participate in a structured process. Figure 4 shows the collaborative design framework including the operational and communication level. The request for design information are driven design tasks, and shared resources are used at both levels. Designers can share ideas by visual interface to access shared representation. In the process, design communication and interactions are necessary toward collaborative design.

2.2. Information delivery model

Interactions in collaborative design relies on information delivered from one side to another. Apparently, activities of requesting, manipulating, and receiving information are associated with project organizations. Therefore, two kinds of teams (the designer and the consultant) are organized for studying the communication and interactions among designers and consultants, and parallel design teams.

2.3. Media and representations

Collaborative design in a distributed environment relies on the effective communication media and representation. In the past, design communication depends on face-to-face contacts for project initiation, evaluation, and decision-making. Today, it is convenient to deliver design information through common media such as fax, electronic-mail, or more advanced media such as video-conferencing. The world wide web supports the asynchronous activities among the participants through access to various design information. This study will focus on the discussion of the representation of design information, how users interpret the information, and how electronic tools are used.

Consequently, according to the above intentions, course works are arranged for collaborative design in a large-scale housing project in An-ping, Tainan, which is a newly re-claimed site with an important historical background. As shown in Figure 5, the project site is adjacent to one important historical landmark and park on its left side. The site is subdivided as six orthogonal blocks, and from left to right is with low, middle, and high density. The project scope includes urban design and architectural design. The design organization and the process is described below.

![Figure 5 The project site](image)

3. The Design Organization and the Design Process

In this project, as believed, collaborative design is a highly structured process when computational tools are engaged, particularly the development, control, and assembly of design information. Therefore, this collaborative design studio adopted a three-stage process which was successfully implemented in the recent Taiwan's Tung-hwa campus planning project. In Tung-hwa, the master plan and the principle architect were selected from the international design competition, and collaborative efforts were contributed to refine the master plan, and used
workshops to exchange design concepts and details on each major building [Chiu 1995]. Figure 6 demonstrates the design process and the design organization.

Figure 6 Design organization and design process in CDS

Students had to participate in the first two continuous stages and each stage take about four weeks. Students at NCKU prepared the basic design information such as regulations, maps, and photos of the project site, and converted into digital files and stored in a local server. Participants can access design information from the internet. Then students in two schools organized the design teams according to their preferences. Six design teams were formed and named after the Taiwanese Professional Baseball teams in the spirit of teamwork and competition. As shown in Figure 7, two other teams were also formed as design consultants and worked on environmental issues such as energy and lighting design, as closed to the real world.

Figure 7 Design teams in a distributed network environment

In the stage one, each team was given a request for proposal (RFP) to prepare a design proposal for the entire project site. Each team should submit digital images and documentation of design concepts regarding the building massing, layout, open space, environmental design, and the relationship with roads and pedestrians. In the process, each team would have an overall understanding of the site. The project manager, in this case, the instructors, chose the best proposal among these ones as the master plan or guideline for the next stage. The winning team of the master plan also become the principle designer of the project, and should coordinate any changes from the master plan. As shown in Figure 8 and 9, the selected master plan has an unique design character which imposed one inclined axis on the orthogonal blocks to link the historical landmark to the community center, and became an important communication topic and design challenge.
In the stage two, the parallel design team process became collaborative design. Each team was assigned a block as shown in Figure 10 and started to develop its schematic design. While each site has different site conditions and requirements, each team has to solve their design interface problems collectively. Meanwhile, the consultant teams joined with each design team to work on their specific environmental design problems, particularly, to define an appropriate program for the community center.

In the stage three, the focus is design development by using CAD systems, particularly starts from developing housing prototype to generating variation. This stage was developed as another CAAD course, and will not be discussed here.
In this manner, teams in the CDS can deal with a larger scale project from urban design to architectural design. Because of the participation in the first stage, each team clearly knew their role in the project. Participants could compare different approaches to the master plan or discuss their thought. This arrangement provided the students opportunities of cross-examining design.

The design communication or debates were post on the web, and stimulated other teams' thinking. Figure 11 as an example, one design team and two consultant teams studied and discussed the alternative for the community center by scanned images, AutoCAD 3D modeling, and 3D Studio Animation. The other design teams were also involved in discussing the function of this community center and the approach of adopting the axis visually in compliance with the master plan. Design communication became an important way of clarifying viewpoints or stimulating ideas. Meanwhile, in terms of design development, students also worked from prototyping to variations to demonstrate their adaptability in various sites.

Figure 11 Snapshots of student works on the community center

4. Design communication and interaction

As estimated by local architectural firms, only 10 percent of the project time of a typical architectural project is contributed to design, while 30 percent of time is spent on drafting, and 60 percent of time is spent on communication [Chiu 1995]. The effectiveness of design communication becomes critical for designers to share design information. Two types of team organization are typically found in practice, i.e. mesh and star, as shown in Figure 12. In either type, the project manager could coordinate and control the information flow. While the scale and type of project may determine the level of communication, both types are often used simultaneously among groups or within groups. Figure 13 shows the information flow in this CDS, each team has one coordinator and information were passed to each other freely as the mesh network. Within each team, the information was passed by the coordinator to each member as the star network. Sometimes, team member talked to other team members directly, without passing the hierarchical structure. In fact, students were encouraged to freely discuss their opinions among or within the teams. That is particularly important in a distributed design environment to overcome communication barriers.
In the design process, site selection is also an important issue for collaborative design. Because if the site are subdivided into smaller lots, design communication becomes more critical and more complicated. As shown in Figure 14, if only three teams (A, B, C) participate, the scheme C will have more variation than the scheme A and B, but the designers will spend more efforts to solve interface problems in order to balance the difference or maintain a consistent space structure. In this CDS, the site selection is closed to the scheme B for balancing the requirements for communication and difficulty among two schools.

During the second stage, similarly, each team spent the first week in conceptualizing their ideas, then decided certain design directions in the second week, developed design in detail in the third week, and finalized their project in the fourth week. The contents of design communication were mostly related to the technological as well as the design issues. Different expectations and communication results were occurred in each team. By tracking the communication frequency, Figure 15 demonstrates four outcomes during the design process. Case A and B represent the positive result, while Case D shows the negative result due to the misunderstanding or reluctance to sharing thoughts.
From the educational viewpoint, students learned from the process about what could happen to design without appropriate communication, and what could cause poor design interaction. The effectiveness of communication will be needed for further examination.

5. Lessons and Reflections from the CDS

The design experiment lasted for over eight weeks. The final jury was completed in a distributed mode at four schools (NCKU, NTIT, THU, and TKU). Within two days prior to the final jury, each juror reviewed all teams' works from the web asynchronously, and comments on each team were collected and posted in the web. At the final jury, these comments were discussed remotely and synchronously by the intercom system. Teams were invited to clarify their concepts instead of representing or explaining their works. Reviews and Reflections were recorded.

The following observations were made about this collaborative design project.

5.1. The collaborative methodology

The collaborative methodology defined in this project is workable and useful. The master plan provides a guideline for teams working in a large scale housing project from urban design to architectural design. In the structured design process, each team and its team members knew better about their role and the relations with other teams. Collaborative design changes our focus of design from the result to the process.

5.2. Team organization and work scope

In this CDS, the work scope of each team was defined by the site boundary. Within each team, team members worked similarly toward design collaboration by selecting design tasks, such as modeling or drawing. These kinds of teamwork can be improved by coordinating the aspects of design, such as the spatial structure or elevation. Thus teamwork could not only produce collective design but also result in competitive design as the competition among the professional baseball teams. Meanwhile, two consultant teams actively involved in teamwork are critical for collaborative design.

5.3. Shared representations

While PC, MAC, and various CAD software were used, scanned sketches were widely used, particularly in the stage one. DXF was the required format for exchanging or re-editing models. Using the hypertext's linkage concept in visual-oriented representations at the web, students had to organize their thoughts as well as digital images in a tree structure, and that is distinguished from conventional representations in sequential order. This change also affects viewers' reactions and the human-computer relations.

5.4. Remote critics and reflections

In the project, we have seen good and bad examples of student works in terms of design directions and representations, and both provide useful lessons for students. Remote critics and reflections in the asynchronous mode provide useful two-way communication platform. Jurors can even re-edit the digital image or model by
taking snapshots from screens or downloading files from distributed database. Synchronous interactive communication will be complemented to the asynchronous mode.

5.5. Networked design culture

The proliferation of electronic mail, remote file transfer, bulletin board systems and interactive computing are evident. The evolution of teamwork is moving from individual toward workgroup computing [Watson 1995, Newton et. al. 1993]. A networked design culture is essentially important for supporting collaborative design. Indeed, for CAAD to be more than a set of drafting and modeling tools, it must be placed firmly in the design culture, both in professional education and practice. The essence of this culture is rooted in collaborative design.

The above observations are based on only a preliminary analysis of the project. Nevertheless, they highlight some of the desirable features of the future distributed design environment.

6. Conclusions

Today, design collaboration in distributed locations is feasible due to the growing distributed, high-performance computing, high-speed data transfer, and the emergence of global networks. It is practical to perform asynchronous or synchronous communication.

The shared experiences learned from the collaborative design project among NCKU and NTIT provide both faculty and students important lessons. The collaborative design is a process of learning about how, when, where design can be taken place, and involving how to utilize shared ideas, resource, and representations. This pilot study is an evolution of course structure in design studios, and change the major concern from the optimal result of design to the design process and team organization. Future plan is to setup a collaborative design studio with all major architectural schools in Taiwan as a country-wide network, and next bridge with an international network.

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