Design Collaboration on the Web
– The History of VDS to u-Studio –

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Abstract

The aim of this paper is to discuss our current model of studio education and explain the outcome of our research which is based on seventeen design collaboration projects. Our study group has experienced collaborative design education on the web since 1996 with nine different institutions worldwide in order to have students trained for the process of group design. The authors will explain the objectives of educational design studio, the core subject matter and the teaching process based on our current education program and the history of the projects from VDS to u-Studio. The teaching method and educational grading focusing on the group design process will also be discussed in this paper.

Keywords: group design process, virtual design studio, educational evaluation and grading, CSCL, distributed students

1   Introduction

Architecture, Engineering and Construction (AEC) is changing rapidly due to the development of Information and Communication Technologies (ICT) through its penetration into the industries. E-mail and the web became indispensable for professional communication. Data-centric object-oriented 3D CAD is making its way into the AEC process not only as a powerful design tool, but also as a platform to integrate information among disciplines into the elaborated construction process. At the same time, the drawing-board style of design

education still prevails among architecture schools, even though they have adopted 2D CAD and 3D computer graphics. These tools are simple substitutions for conventional tools such as the pencil and the T-square, and are no more than an application for representing and presenting design thinking. Acquiring digital design skills is not sufficient for students to go into future AEC industries. AEC practice requires much more than CAD and CG.

Architectural practice is essentially collaborative work of the diverse professionals and disciplines. With the drastic change of AEC process due to ICT into consideration, collaborative works via computer networks became increasingly important to the architectural design education. Traditionally, the design education for undergraduates is emphasized on developing individual design skills and thinking. Group design studio at undergraduate-level is still optional in many educational institutions.

Our study group has experienced collaborative design education on the web since 1996 with nine different institutions worldwide in order to have students trained for the group design process. This paper discusses our current model of studio education and explains the objectives of educational design studio, the core subject matter, teaching process and educational grading focusing on the group design process through our history of the projects from VDS to u-Studio.

2   The objectives of the educational design studio

2.1 The subject matter

The primary goal of the collaborative design education on the web is for students to understand the design interaction of collaboration through the group design process. The followings are the objectives of this educational studio.

1) Design skill development in cyberspace.
2) ICT literacy acquisition and enhancement.
3) Experiencing and understanding the group design process.

2.1.1 Design skill development in cyberspace

It is presumed that students own their own PCs and have acquired basic literacy in information processing which include the use of word processors, spread sheets, presentation, and so on. CAD and CG skills are not required at the start. Our research group manage the Kyoto Institute of Technology (KIT) support team by Master's degree students. The support team prepares small assignments to start the projects and manuals to install 2D CAD applications that can be downloaded free as shareware. These assignments are sufficient for getting the students familiar with the specified 2D CAD. The students upload their homework progress on their own homepage. Afterwards the support team checks it and gives them advise in order to improve their design skills.

2.1.2 ICT literacy acquisition and enhancement

The effectiveness of communication is critical for students in information sharing, managing design tasks, and design collaboration to obtain final results.

In this studio, the students learn how to build an internet access environment and communicate with each other through design collaboration. We urge students to prepare ADSL and necessary interface facilities for PCs, subscribe to ISPs (Internet Service Providers) in order to establish their communication channel, and open their own homepage for the studio. All instructions and information on how to build a communication environment is described in a self-learning document on the project page. Handling synchronous and asynchronous communication tools including "chat room" with shared whiteboard, "design rooms" for posting ideas and sketches, and the "bulletin board" are explained in lectures via a video-conference system or video-streaming.

2.1.3 Experiencing and understanding the group design process
Experiencing and understanding the group design process is the most important part of the studio education. In order to accomplish design collaboration on the web, teams are organized with five or six students from different institutions. Students learn group thinking, design discussions, information sharing and social interaction such as negotiation, agreement and compromise in order to reach a successful design.
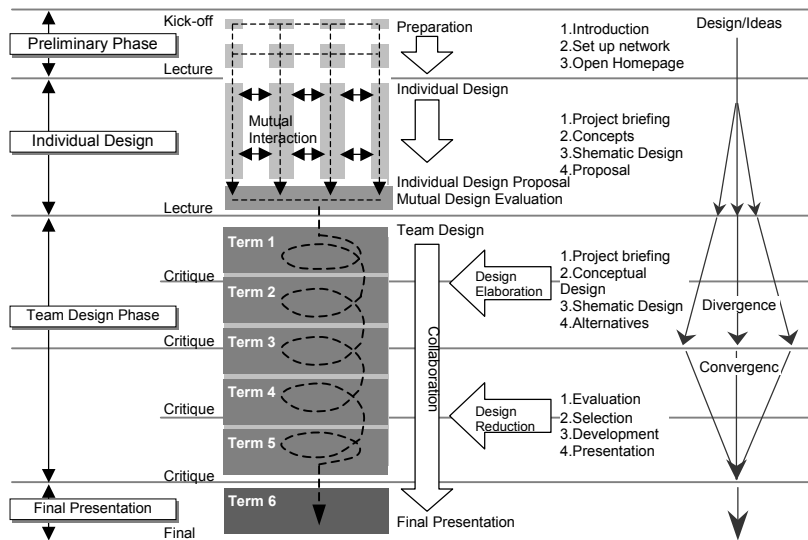
2.2 The teaching process

Figure 1: Project program

We need a process model or a scenario of design collaboration in order to describe tasks which allow students to create the final design (Chiu, Yamaguchi and Morozumi, 2001). The model or scenario is important for all the students to understand their position in the collaborative process. With these objectives of this studio in mind, we carefully designed the studio program based on our

experience since 1996. Figure 1 shows the program which usually covers about 12 weeks, starting from April and finishing in July. It is divided into the following four phases:

1) The preliminary phase (2weeks)
2) The individual design phase (2weeks)
3) The team design phase (7weeks)
4) The presentation and final jury (1week)

All the sites of institutions have installed video-conferencing facilities which include "iVisit" with video cameras and the "Virtual Network Computing (VNC)" remote control function. Once every two weeks during individual and team design session, all the students have lectures with these applications which run between all sites at preliminary phase or critique meetings for progress reports and presentation.

2.2.1 The preliminary phase

The program starts with a lecture using video-streaming to all institutions. The KIT support team introduced themselves to students. The teachers and the support team give a lecture which includes the concept of this project and program of this studio. They also discuss how to set up individual environments, personal home page buildings, and how to post individual ideas and sketches. How to communicate with each other synchronously or asynchronously is also explained. All the necessary information is described on the project page as self-learning materials.

2.2.2 The individual design phase

Before the team is organized, we advise each student to individually develop a conceptual design, in order to understand the design goal and various related problems. Without these preliminary tasks, each team may have to start from scratch to discuss the whole problems. The individual proposals are uploaded on their own homepages so that students understand who thinks what as well as to activate discussions among participants. At the end of this session, personal proposals are presented at each site through video-conference facilities.

2.2.3 The team design phase

This phase is the most important for teaching group oriented thinking and design. The students from all institutions that participate in this project are organized into teams based on the teaching staff's evaluation of individual proposals of students. In this design phase, each team creates alternatives and develops the final proposal. Teaching assistants who are Master's degree students from each schools help to activate and facilitate discussions among members of each team.
The design studio environment utilizes "design room" with "design pinup board (DPB)" as an asynchronous tool and "chat room with white board" as a synchronous tool, and other facilities such as "scheduler" and "bulletin board". However, the use of e-mail between members is forbidden in order to work in one platform so that every member can share all information and communications which took place in the studio. Sometimes all members cannot

participate 'chat room' due to personal matters. If the team works in one platform and the system tracks member's activities, he/she can catch up with their design process later in the team. All the same, teachers and support team can follow up students, and the study group can observe all the communication logged for the post-analysis of the design process.

In addition, there is a mobile system added to the studio. The participants of the project do not need any particular application or installation. The students only need a common PC browser and cellular phones which most of students own nowadays in Japan. Figure 2 shows the characteristics of the communication tool in the design studio that the authors have developed. The design studio is based on the central web sever, which includes databases, CGI and programs to control files which are uploaded to DPB and mailing services to cellular phones.
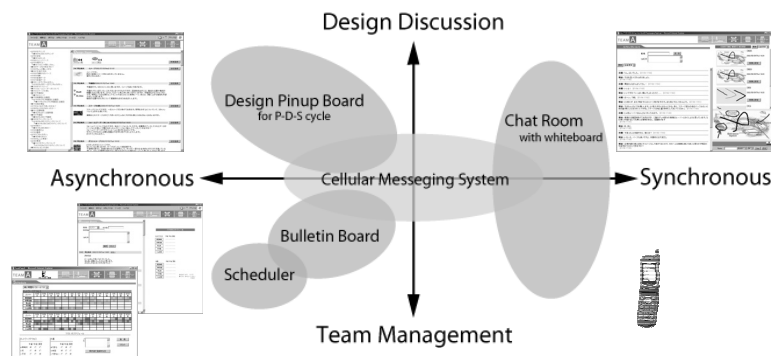

Figure 2: Communication tools and their characteristic

2.2.4 Presentation and final jury

The final week is devoted to prepare the final presentation of the team proposal just before the evaluation. Via a video-conference system, each team presents the proposal to the audience each of the sites. Sometime we ask other institutions and professional architects to join group of evaluators at the sites or via internet.

3 From VDS to u-Studio

3.1 Collaborative environment and educational programs

A network educational collaboration carries out in three different types; the "school-to-school" type, the "centralized system and distributed students" type, and the "ubiquitous studio with centralized system" type. The "school-to-school" environment has been the mainstream for the network educational collaboration. The "centralized system and distributed students" type is an environment which students and participants can join into the project from individual environments without gathering together. Most of the asynchronous communication tools correspond to this environment with the spread of the internet these days.

There is the "ubiquitous studio with centralized system" type which enhances the centralized environment with no limitation of work locations. For example one can work at his home, a café or in a train.

Our study group has held seventeen projects of the collaborative design education on the web since VDS96'. The educational environments of the design studio and our education program have been modified from time to time in accordance with the concept of the 'ubiquitous environment' in mind. In the VDS'2000 which was a project practiced between Tokyo Denki University, Tohwa University and Kyoto Institution of Technology, the environments shifted to the "centralized system and distributed students" type from the "school-to-school" environment. All students were able to work from home or any other place. The system of the design studio was developed to supply one shared platform include communication tools to work in the team. That is to say that the system requires only a common web browser to go into the platform and join the project so that all participants did not need to install particular equipments and applications. The project was renamed "design collaboration on the web" (DCW) in 2001. The environment was upgraded with the mobile service which can become a function of the ubiquitous studio. The students were able to grasp the situation of the group design process anywhere and any time in this environment. The authors also made efforts to improve the education program while evaluating the system. The "Plan-Do-See cycle" education program was proposed and examined in the DCW2005 project to support the group design process. The analysis of the examination showed that the students who are novices could interact easily with the in-group members.

Figure 3 shows the priority of our objectives for the educational design studio started from VDS '96. The authors have studied and developed the communication tools and education programs to teach ICT literacy, design skills and group design process. The environment has become the ubiquitous studio with centralized system, which will be a platform to carry out the project named "u-Studio" in 2006.
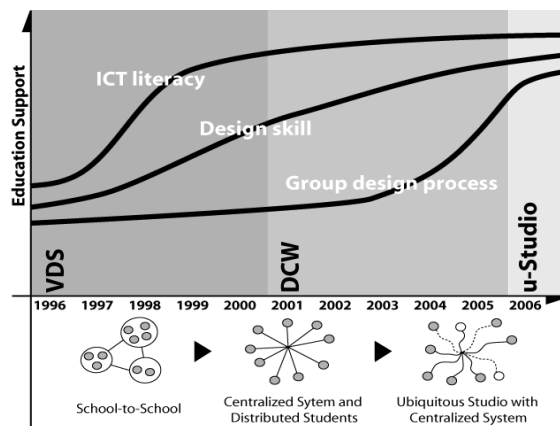

Figure 3: Education support and environment

3.2 The history of the projects

Table 1: The history of the projects

Year	Month	Project and Subject	Participants	Features of environments
1996	4 - 9	**VDS '96** : Kumamoto Artpolis Project *Sense of Place*	MIT, KU, KIT 9 graduated students	International project using ICT applications. Used CuseeMe, e-mail, FTP, Timbuktu, personal web page.
1997	4 - 7	**VDS '97** *Architectural Museum*	TDU, KIT 5 4th year students	Asynchronous design teaching through the student's personal web page and e-mail.
1998	1 - 2	**Remote Collaborative Workshop 1998** *MIT architecture department renewal*	MIT, MU, TUD, CUHK 15 2nd year students	Lecture on TV conference from MIT. Mixed team organization US and Japan students to carry out short design collaboration.
	4 - 7	**VDS '98** *Architectural Museum*	TDU, KIT 29 4th year students	Installed first Design Pinup Board (DPB) system. Invited guests to final presentation for evaluation.
1999	1 - 2	**Remote Collaborative Workshop 1999** *Shapeglamour*	MIT, MU 16 2nd year students	Remote collaboration using the communication system developed by MIT.
	4 - 7	**VDS '99** *Architectural Museum*	TDU, KIT 24 4th year students	Installed process visualization DPB prototype and Chat system.
2000	1 - 2	**Remote Collaborative Workshop 2000** *Shapeglamour*	MIT, MU	Organized design part and communication part in a team to carry on the group work. Examined simultaneous interpretation system.
	2 - 3	**Collaborative Design Studio 2000** *Earthquake Museum in Taiwan*	NCKU, KU, KIT 20 graduated students	International project between Taiwan and Japan. Used KIT system, KU system, and NCKU system in a same time.
	4 - 7	**VDS 2000** *GINZA on the Web*	TDU, KIT, TU 28 4th year students	Shifted studio environment to centralized system and distributed students type from school-to-school type. Installed 3D design pinup viewer system
2001	4 - 7	**DCW 2001** *Village Center*	TDU, KIT, TU 40 4th year students	Installed Active Message of Pinup Information Service, scheduler and file uploader system. Add individual phase into the program.
2002	4 - 7	**DCW 2002** *Kurokabe visitor center*	TDU, KIT, TU 31 4th year students	Install post-it tool, auto-thumbnail image system and file search system. Added column page and consultations page.
2003	4 - 7	**DCW 2003** *Village Center*	TDU, KIT, TU 44 4th year students	Installed chatting white board system and mutual evaluation system. Added step by step self-learning materials on the project page.
2004	4 - 7	**DCW 2004** *Village Center*	TDU, KIT, TU 51 4th year students	Carried out design collaboration with 9 teams of 51 students.
	9 - 1	**Digital Design Studio 2004** *Poster of chairs*	NU, KIT 26 2nd year students	Design collaboration against 2nd year students. Mixed face to face lecture and remote support on the web.
2005	4 - 7	**DCW 2005** *Next University*	TDU, KIT 19 4th year students	Added P-D-S cycle education program. Installed PDS cycle Design Pinup Board.
	4 - 7	**Digital Design Studio 2005 (I)** *Poster of chairs*	NU, KIT 42 3rd year students	CAD and CG design education program mixed face-to-face lecture and remote support with individual adviser through internet.
	9 - 1	**Digital Design Studio 2005 (II)** *Execution of portfolio*	NU, KIT 36 2nd year students	Modified Digital Design Studio 2004 program to support CAD and CG design education on the web.

CUHK : Chinese University of Hong Kong MIT : Massachusetts Institute of Technology
KIT : Kyoto Institute of Technology MU : Miyagi University
KU : Kumamoto University TU : Tohwa University
NCKU : National Cheng Kung University TDU : Tokyo Denki University
NU : Nihon University TUD : Technical University of Darmstadt

Since Prof. W. J. Mitchell of MIT proposed the concept of global design collaboration via internet as the virtual design studio (VDS) in 1993 (Mitchell,

1994), many VDS projects have been executed throughout the world. Our research group also has begun a collaborative design project on the web since 1996. The project of VDS '96 Kumamoto Art polis was performed together with MIT, Kumamoto University and Kyoto Institute of Technology. This was the first project that examined a team organization over the framework of institutions. The students from each university were mixed and divided into three teams. They practiced the design process from the early stage of conceptual discussions to forming ideas through this virtual design studio (Morozumi et al., 1997).

The history based on our experience of seventeen collaborative design projects with nine different institutions and universities is described in Table 1.

4 Teaching method and grading

Visualizing the design process makes students realize what they are doing and helps them understand where to go (Matsumoto, Sasada and Yamaguchi, 2000). Programming and implementing the group design process are also highly effective to make a successful collaboration. The authors focused on 'visualization and awareness' and 'behavioral analysis and interaction' to establish an educational method for the group design process.

4.1 Visualization and awareness

Our study group developed design pinup board (DPB) system in 1998 (Kawasumi and Yamaguchi, 1999) and has studied it since then. Visualizing the design process on DPB is essential not only for students to grasp the situation of the design process, but also for advisers and the faculty members to be able to support their design process. At the same time, the issue of the difficulty of understanding the design process due to many hierarchies of the data classes became obvious. The database of DPB expanded with the uploaded information of individual proposals and comments while the group design was in progress, so that the data classes became too massive to overview.

"3D design proposal viewer (3D DPV)" which has the time axis to visualize the group design process was developed to resolve the issue in 1999 (Matsumoto, Sasada and Yamaguchi, 2000). When a proposal has been uploaded from a member to DPV, it creates a "design cell" which is a "dot" locating on the coordinates of three dimensions in DPV. The coordinates include the time axis of the height dimension. All the comments and related ideas from other members are added into this "design cell" as a data, which define its location of the coordinates and the color of the dot. The color of the dot changes depend on the number of members, which indicates whether the proposal is individual idea or team idea. Therefore the 3D DPV shows member's impression and agreement to improve the understanding of the group design process (Figure 4).

In order to succeed in this collaborative work, it is important not only to understand the group design process, but also to keep the interaction effective through active communication. As a first step to activate communication, we focused on the design of the synchronous communication. The authors added the

whiteboard in the "chat room" (Figure 5). The whiteboard has a function to attach a background digital file of some pictures and drawings which someone created in their individual work so that members can write on it to discuss their ideas clearly and interact effectively with each other.

As a second step to improve asynchronous communication, we focused on awareness support. The "post-it" tool was installed on the DPB in order to enforce awareness through the visualization of the design studio (Figure 6). When a proposal was uploaded to the DPB, this tool could help members in a group to evaluate it quickly and easily without typing words. The color of the label showed who remarked. The barometer of the label indicated how much they were paying attention to the proposal. In addition, the comments also can be attached to the label.

As another approach for the awareness support, "Active Message of Pinup Information Service (AMPIS)" was developed in 2000 in order to grasp the situation of the group design process anywhere (Matsumoto, Onishi, Yamaguchi and Morozumi, 2001). This service works when the individual proposal is registered or when the comments and remarks to the proposal are uploaded to the design studio. The DCW sever creates a notification and send e-mail to member's cellular phones automatically. Figure 7 showed a student responding to members with AMPIS in a train. Though these developments for visualization and awareness, this AMPIS leads our studio to ubiquitous system.
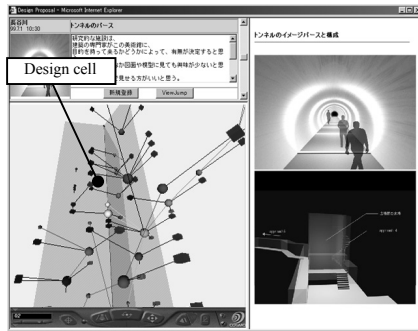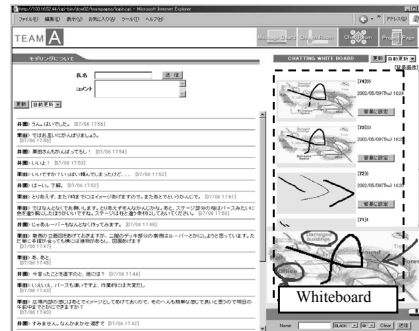

Figure 4: The 3D Design Pinup Viewer
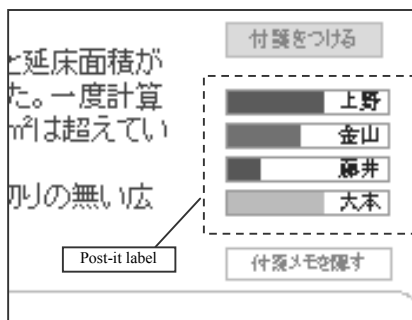

Figure 5: The whiteboard in the chat room
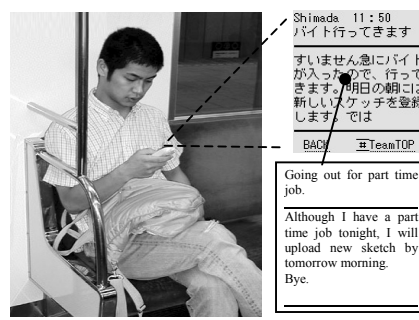

Figure 6: Post-it Tool

Figure 7: Use of AMPIS

4.2 Behavioral analysis and interaction

All the synchronous communication which took place on DPB, the 'bulletin board', and the 'chat room' was logged into the DCW sever. In order to observe the characteristic of the interaction process in design collaboration between distributed sites, the communication data that is accumulated in the "chat room" was analyzed. As a result of this analysis, a hypothetical model of the interaction process was defined in 2004 (Onishi and Yamaguchi, 2004). The model suppose to work under the educational environment with beginners, the flat organization and the distributed work. The structure of the interaction process is described in Figure 8. The interaction process consists of three phases; 'expression', 'evaluation', and 'acceptance' based on the idea and the design problem.
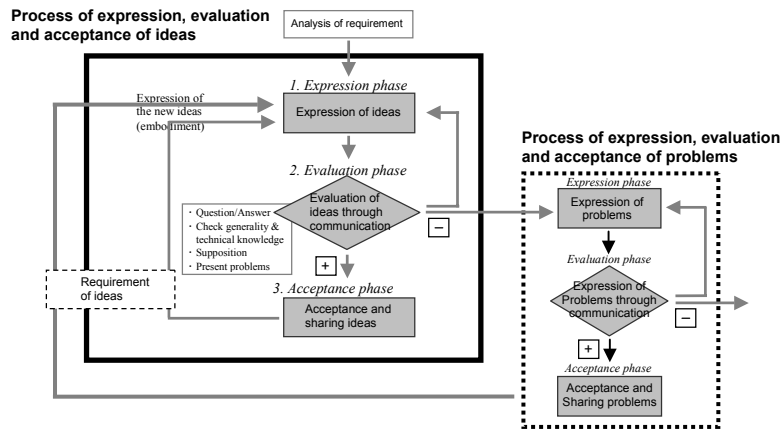

Figure 8: A hypothetical model of the interaction process

The group competition can motivate students to learn with higher achievements and even cultivate their cooperativeness by competing through collaboration rather than competing for the result. However, in a novice and flat team made up of undergraduate students, the level of design discussions tended to the lowest level, because each member tries to seek and share common topics of design discussions among co-members.

In order to resolve this issue, our study group proposed the education program with a "Plan-Do-See cycle" model in 2005. This "Plan-Do-See cycle" is modified model based on Deming's "Plan-Do-Check-Act" cycle which is well known in the quality management process model (Deming, 1982). The aim of this education program is to support the collaboration of undergraduate beginners making the asynchronous communication toward the effective interaction. The authors developed new DPB system which suited to the P-D-S cycle program, so that it was examined in the DCW2005 project.

When the DCW2005 project finished on July 2005, the questionnaire survey carried out as a primary experiment to observe student's feeling on the interaction process. One of the concerns is to ask how you feel other student's response to your pinup. The question is divided by six arguments and asked an

answer to select "usually", "often", "occasionally" and "rarely" (figure 9). While the answer of "usually" and "often" stands low level against "disappointment" question, it accounts for average 78% of students who have a feeling pleasure by other students' reaction. This can explain a fundamental advantage for activating interaction between students.

The authors examined derivative ideas from the log data in DPB. Figure 10 shows the rate of uploaded pinups on DPB divided if it is the derivative pinup from other member's proposal or own idea, when the P-D-S term switches from "Plan" to "Do" and from "Do" to "See". The result is that 77% of "Do" pinups and 71% of "See" pinups are derived from other member's "Plan" and "Do" pinups. This may suggest that the P-D-S cycle education program has a potential to activate interaction effectively between members (Matsumoto, Kiriki, Naka and Yamaguchi, 2006).
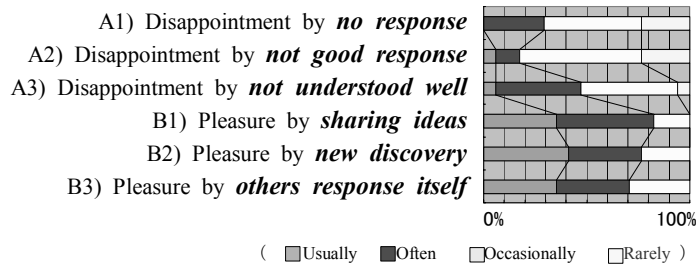
A1) Disappointment by *no response*
A2) Disappointment by *not good response*
A3) Disappointment by *not understood well*
B1) Pleasure by *sharing ideas*
B2) Pleasure by *new discovery*
B3) Pleasure by *others response itself*

0%   100%

(▨Usually ■Often ▢Occasionally ▢Rarely)

Figure 9: How student feels member's reaction

	from others Plan	by onself
Do from Plan	77%	23%

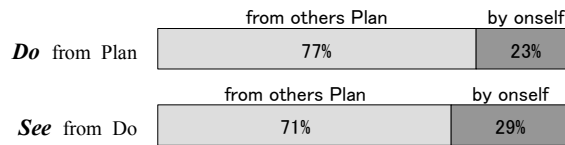|	from others Plan	by onself
See from Do	71%	29%

Figure 10: The rate of "Do" and "See" pinups derived from other's pinup

4.3 Discussion of evaluation and grading

The "chart of uploaded files" page which describes the number of uploaded files in each member was added in the team page (Figure 11). The advisers and the faculty members can grasp a progress of student's work from the chart and give an advice to students during the group design process. In addition, the chart is also used for evaluating each other in team members, which seems to motivate students to keep the group design going.
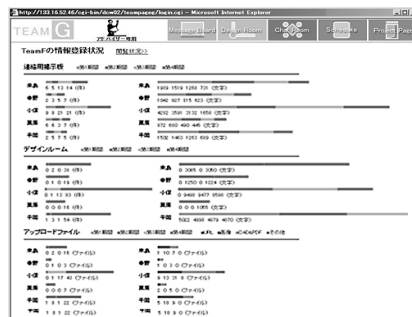

Figure 11: Chart of uploaded files

All the communication as well as the uploaded files of sketches, pictures and drawings was logged into the database on the server so that it is possible to count up the quantity and make the statistics out of individual communications as words, pictures and other pinups. We were also able to observe who spoke a lot and who did not. However it is difficult to observe who contributed to the final proposal, moreover, how to grade students with these statistics.

Our research group has considered "organizational IQ" which has been examining since the latter half of '90 by the study group from MIT and Stanford University. The authors have made "Team IQ" with the self-team evaluation indices for the collaborative design education based on the organizational IQ (Matsumoto, Onishi, Naka and Yamaguchi, 2003). Figure 12 shows the indices measuring the team IQ through a questionnaire survey. The bar graph in Figure 12 indicates the score of team IQ (maximum three points) that is the sum of the score counted by the result of the questionnaire survey. The dots on the line chart are plotted by the numbers of uploaded files in each team. The correlation between the team IQ and the numbers of uploaded files is defined with a correlation coefficient of 0.91. This can explain simply that a team who has uploaded more files to communicate and interact between members achieves higher number of team IQ.

Although the team IQ can be a factor to evaluate a team, it is still difficult to say how the students contributed to the final proposal. Moreover, this is not enough to grade individual student. The authors will keep making an effort for this issue in our studies.

The indices of team IQ
1) Understanding of requirement.
2) Comparison to other team's proposals.
3) Collection of necessary information for design.
4) Presenting and exchanging ideas in a group.
5) Presenting and exchanging references in a group.
6) Considering and reflecting advices.
7) Sharing a design direction.
8) Defining criterion and process for ideas
9) Informal communication.
10) Accepting a result of informal communication.
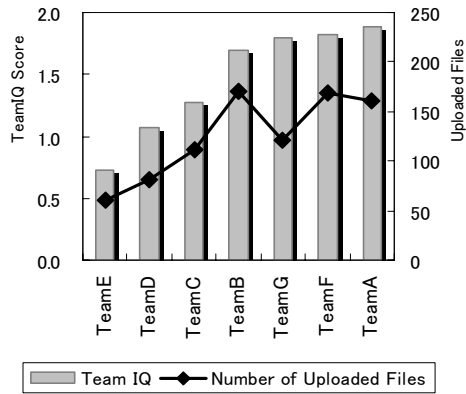11) Acting on one's own initiative.

Figure 12: Correlation between team IQ and number of Uploaded file

5   Further studies

The authors have been developing a collaborative design system on the web as a ubiquitous environment with our group design education program. The "u-Studio" project will be effectively carried out from 2006.

In our future study, we need to develop a system that can record all the information exchange and student's activities which took place in the studio in order to unveil the design process in detail, which we believe only way to be able to evaluate and grade individual student accurately. The P-D-S cycle education program will also need to be improved from the perspective of flexibility in order to manage cycle times and speed. In addition, with drastic changes in the AEC process due to 3D CAD applications, the educational effects of 3D CAD will most likely be studied in the "u-Studio" more thoroughly.

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