What we learnt from design teaching in collaborative virtual environments

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Abstract. *Collaborative virtual environments clearly have potentials to enable innovative and effective education, involving debate, simulation, role play discussion and brain storming and project based group work etc. Integration of the collaborative virtual environments into the design curricula offers significant potentials for design schools. In this paper, based on our previous teaching in collaborative virtual environments, the student's perceptions and evaluations of the courses, we discuss the pedagogy of design teaching in collaborative virtual environments, considering what skills the new generation of designers should have in terms of collaboration, communication and design.*
Keywords. *Collaborative virtual environments; collaborative design; design studio; communication modes; design representation.*

INTRODUCTION

With the recent developments in communication and information technologies, using Collaborative Virtual Environments (CVEs) in design activity has experienced a remarkable increase. Collaboration in geographically distant locations using information technologies has become the new way in which architecture firms and other related parties practise and communicate. As an ongoing process, today the communication and information technologies bring new challenges for design education that require the consideration of new pedagogical approaches employing emerging design medium. In design education, web-based tools, virtual design studios (Maher, 1999; 2000; Kvan, Schmitt et al. 2000) and 3D virtual worlds (Gu, Gül et al., 2009) have been widely used, especially in the form of online design studios. As a result, design education includes in the curriculum the demonstration of the impact of computer technologies have in creating "new ways of designing" (Kvan, Mark et al. 2004) integrating the teaching of digital skills (craft) and design thinking (art) (Kvan, Mark et al., 2004). Gül, Gu et al. (2008) pointed out the affordances of CVEs as constructive learning platforms aim to provide a shared "place" where distant design collaboration and communication could take place.

Based on the above framework, we offered several courses of design teaching in CVEs. In this paper, we discuss what we have learnt from those courses presenting an analysis of two courses. The aim of the first course was to provide a collaborative design

learning platform where students experience communication modes by creating a set of CVEs. The aim of the second course was to provide a collaborative design learning platform where the students have the opportunity to experience designing in CVEs. The reason of presenting two courses in this paper is to focus on the two aspects of collaborative teaching in CVEs which are communication modes and design representation.

This paper documents the convergence of technology and the design activity in a new learning domain. Based on our observation, the evaluation of the courses, the reports of the students, and the results of the questionnaire, we highlighted essential pedagogical elements which need to be considered when the design teaching activity involves CVEs.

COURSE 1: Designing Collaborative Virtual Environments

"Collaborative Virtual Environments" was offered as a full-semester (13 weeks) unit in the University of Sydney. During the last five weeks of the course, a total of 52 students (from the University of Sydney (USYD, in Australia) and the Istanbul Technical University (ITU, in Turkey)), geographically separated, collaborated on a joint-design project over several CVEs and designed 3D places in Active Worlds.

In order to communicate over the CVEs, the students are provided several tutorial sessions which taught variety of communication technologies. Then for the group projects, the students had given flexibility to choose a suitable medium for design collaboration. At the first several weeks of the course, the students in the USYD are asked to develop a web-based management system (WBMS) and then, they were asked to utilise this system to design together with the ITU students. Following the completion of the design project, each student in the USYD analysed their group's collaboration process submitted a reflective report including the analysis of their communication protocols. This final report is very valuable resource that reflects their perception of the overall collaboration experiences.

Course objectives and structure: The aim of this course is to impart to students an understanding of the similarities and differences of computer mediated and face-to-face communication; skills in the use of collaboration tools such as email, shared white boards, bulletin boards, video conferences and shared design environments. In order to develop the understanding of CVEs, firstly relevant literature, issues and problems in collaborative design and design examples were introduced and discussed through lectures. Secondly, the students were instructed to use a wide variety of collaboration tools and applications, and they reported in an essay to reflect their learning outcomes.

Design projects: With structured design supervision and technical tutorials, three design projects were assigned. The first project was an essay writing task which aims: to develop an insight into the technical issues involved in CVE for collaborative design, and an evaluation/critiques of the effectiveness of using a particular existing CVE system or method in the area of design. The second project included developing a web-based project management system (WBMS) which included the collaboration tools (blog/forum, calendar, schedules, task allocations, meetings, document links, etc.), the member's personal web-space links and the documentation of the design and design process. The students in the USYD and ITU used this space for the collaboration for the final design project. Third design project included designing two virtual places (a home page and a 3D place in Active Worlds) using 2D and 3D based CVE design tools (shared white-board and Active Worlds) with the collaboration of the ITU students in Istanbul. For assessment, the multi-criteria that cover different design and technical aspects were applied.

COURSE 2: Designing IN Collaborative Virtual Worlds

The Collaborative Architectural Design Studio between the University of Newcastle (Australia) and Rangsit University (Thailand) took place in the "NU Genesis", a virtual island in Second Life. Students

were introduced to a wide range of synchronous and asynchronous design and communication tools including Second Life. Each student group was required to maintain a weekly log. The log serves as a tool for monitoring their collaboration, and used for self-reflection. In addition to the log book, students who completed the studio were asked to answer a questionnaire which has very valuable in terms of the evaluation of the course and the perception of the students' achievements.

Course objective and structure: The aim of this course was for students to understand and develop the essential skills of collaborative design and modelling using 3D virtual worlds; and to develop the understanding and hands-on experience of 3D virtual worlds as an extension of conventional architectural design. In order for students to develop the understanding of collaborative design in 3D virtual worlds, firstly, relevant theories such as the development of core skills for teamwork, as well as design and collaborative cases in 3D virtual worlds were introduced and discussed. Secondly, students were guided to inhabit and critically assess a wide variety of design examples in 3D virtual worlds, as well as various design and communication features supported in 3D virtual worlds. In order for the students to develop and practise the design and collaborative skills in 3D virtual worlds, a remote collaborative design project was used as the major assessment item.

"Virtual Home" design project: With scheduled supervision in design development supplemented by tutorials for technical skill development, the collaborative design project titled "Virtual Home", provided opportunities for students to experience and practice collaborative design in 3D virtual world. They also developed and applied design principles and technical skills for virtual world design. The design brief requires each group to design and implement a place in Second Life, which will demonstrate their concept of a "Virtual Home" and this will challenge the boundaries of a physical home design.

EVALUATION OF THE LEARNING EXPERIENCE: STUDENT'S PERCEPTION

The above mentioned collaborative design courses provided us a rich collection of data which includes design outcomes (projects, final products), the student's comments, log books, self-reflection journal entries and the questionnaire results. To understand the essence of design teaching in CVEs, the results of the analysis of the data are employed. In the following section, we summarise some of the results gathered from the analysis, indicating the student's perception of design learning in CVEs (more details about the results of the questionnaires and the design outcomes can be found in Gül, Gu et al. 2007; Gül, Wang et al. 2008).

Course 1: The sample size of the first case is quite ideal with 30 from a class of 33 students responding. The students have at least one year experience in using general CAD tools which may imply that the students are quite well computer literate. On the other hand majority of the students experienced Active Worlds for the very first time. The students therefore considered as both novice designers and virtual world users.

Students commented about the communication modes and tools. 83% of the students consider the synchronous communication mode as effective/very effective. 47% of the students consider the asynchronous communication mode as effective/very effective, 29% of the students stay as neutral when comparing the tools.

Student's perception indicates the preference of immediate response and feedback from the peers. Students were divided in their opinions of how effective Active World was for communication. 41% of the students rated the chat channel in the Active Worlds effective/very effective as a tool to communicate and share ideas while 46% of the students rated it as not effective/not very effective.

Selected comments from the students includes:

> "I believe [synchronous and asynchronous collaboration] they both have an important part to play in collaboration [...] it would be increasingly difficult to do any project without a mix.

Synchronous collaboration allows fast and clear communication […]. Asynchronous allows flexibility above boundaries and solidification of ideas […] It was a good way to communicate and organise events and dates in advance […] sometimes took too long for people to respond".

"I disliked the long delay of receiving feedback in emails. I did like the way that the blog allowed us to write our ideas formally and in great detail...The chat windows were the most effective for understanding across cultures and easiest to use".

"I liked being able to send messages and having a record of what has been said when using message boards to collaborate, however I didn't like the time it took to get responses. It is much quicker to just talk to people in a synchronous environment to get the job done, but this is sometimes unavoidable".

The students have been consistent regarding their satisfaction of the final design outcome. 72% of the students were satisfied/very satisfied with their design decision and solution in homepage design task, and 68% of the students were satisfied/very satisfied with their design decision and solution in 3D place design task in Active World.

Teamwork skill development remains as the most challenging aspect in applying online tools for design collaboration. Students indicate that it has been difficult to work together as a group due to the inability of having group members meeting face-to-face. 47% of the participants "agreed/strongly agreed" with this statement as they considered "... face-to-face meeting was the most productive", and 32% "disagreed/strongly disagreed". Further, 46% of the students consider managing team activities difficult in remote design collaboration.

Course 2: The sample size of the second study is quite ideal with 32 from a class of 36 students responding. The students have at least one year experience in using general CAD tools. The majority of the students (96%) experienced the 3D virtual world, Second Life, for the first time. The students are therefore considered as both novice designers and novice virtual world users.

Once again, students' perception has been largely divided, indicating significant differences in the affordance of new design communication technologies among students, even when they have similar background and experience. 32% of the students considered 3D virtual worlds for communication were "effective/very effective". 42% of the students considered the synchronous communication mode in 3D virtual worlds as neutral when comparing to asynchronous communication tools such as email.

Selected comments from the students include:

"... Synchronous (communication) was most effective when meeting however asynchronous (communication was most effective) when organising meetings and giving group information".

"… Text-based chat was the most appropriate. Audio can be a helpful tool but depends on the connection".

Students have been largely divided regarding their satisfactory level on the 3D virtual world in supporting decision-making and design solutions that came out of the collaboration. 39% of the students rated their experiences as neutral, and 39% of the students were "dissatisfied/very dissatisfied". As shown in the following direct quotes from the students, their opinions are often conflicting, reflecting on both the strength and weakness of 3D virtual worlds from their collaborative experience, and in relation to features of general CAD applications that are familiar to them.

"... 3D collaborative modelling … instantaneous and easy to relate ... I like that the group could

see objects being made instantaneously … could discuss ... dislike that it was hard to meet at the same time".

"3D is easier to understand the concept of the design and gives an impression of how it looks/ behaves ... Second Life was an entertaining, novel mode of communication, but was not often helpful, as it required every group member to be online".

Teamwork skill development remains as the most challenging aspect in applying 3D virtual worlds for design collaboration. 51% of the participants "agreed/strongly agreed" with this statement as they considered "... Face-to-face meeting was the most productive", and 25% "disagreed/strongly disagreed". 55% of the students failed to establish a plan or procedure collectively within their groups for working together.

Nevertheless, 40% of the students do "agreed/ strongly agreed" that teamwork tasks encouraged collaborative learning. 42% of the students were not sure as they rated neutral. 48% of the students also believed that they gained knowledge and skills from their group members during the collaborative project.

Summary: The above results of the questionnaire indicate polarisation among students over the user perception and tool preference during the design collaboration in 3D virtual worlds. The results together with our observation on and discussion with the students unveil some challenging aspects, especially the issues related to the affordance of new technologies and the management of teamwork, when applying 3D virtual worlds for collaborative design learning. They have also directly impacted on the overall satisfaction of students. The outcomes of the collaborative projects (the design outcomes can be found in Gül, Gu et al. 2007; Gül, Wang et al. 2008) clearly indicate that the students are able to develop, collaborate and implement designs in 3D virtual worlds to a satisfactory level. However, the results show that students have been frustrated with various issues emerging from the collaboration including: lack of design support in 3D virtual worlds; inability in teamwork management; delay in responses from collaborators; language barriers; cultural differences; lack of shared design understanding; and lack of common goal in collaboration. Based on our findings and observations, a pedagogical approach is presented when the design curricula involves CVEs.

DEVELOPMENT OF DESIGN CURRICULA INVOLVING CVES

As the pedagogical approach, we combined problem-oriented learning and studio-based design education to provide a platform where students were exposed to and explored variety of CVEs. In terms of the course structure, the lectures in which students would be exposed to several CVEs and related design issues should be used as the grounding for integrating design knowledge. The healthy exchange of different points of view is as important as the reinforcement of shared opinions. The structured discussion sessions would contribute to the development of shared understanding of the design issues in and off CVEs and enhance the critical thinking. This requires a combination of technical/ theoretical lecturing practise and the studio/ practical sources. The backbone of the technical/ theoretical lecturing practise consists of:

- Historical developments in the area,
- Existing collection of designs in CVEs and their critique,
- The social and psychological aspects of the CVEs, and
- The future developments of CVEs.

Following the accumulation of the theoretical knowledge, the development of various skills is necessary. Thus, a set of tutorials in which students would gain knowledge of and practice in using the tools should be formed. These technical tutorials should provide the basic knowledge about how to operate a particular piece of software. The studio/ practical sources consist of the followings areas of experience:

- Existing use of CVEs in design practise,
- Applications of the advance information and collaboration technologies, and
- Tutorials to operate and design in CVEs.

Enhancing learning by designing: Finally, students should be given opportunities to apply the knowledge and skills that they have developed during the course, so different sets of design tasks in CVEs should be given. Design tasks should have several components such as individual design, collaborative design, employing different skills and knowledge: space-place design and digital design. CVEs offer variety of design opportunities to students including the facilitation of different communication modes (synchronous and asynchronous) and design representation (2D and 3D modes). Based on our teaching experience and the course evaluations, we highlighted the following issues that need to be considered for the development of the design curricula involving CVEs.

Communication Modes in CVEs

The communication mode determines the way communication occurs. If a face-to-face mode is adopted, instant feedback is available and this may enhance the effective understanding between all parties. If another mode such as online communication is the option, then the absence of a shared physical environment makes it vital to provide complementary contextual information to enable participants to understand the message being communicated (Yang 2007). For learning in virtual environments, the concept of mode is relevant to the following two key concerns:

- The key elements of face-to-face communication and interaction should be supplemented with well-designed task specifications and well-chosen learning materials; and
- The material used for learning in virtual environments needs to be adapted to suit this mode of learning (Steeples, Jones et al. 2002as cited in) (Yang, 2007).

In the CVEs context, the latter one is the available communication mode that includes two forms of communication: asynchronous and synchronous.

Asynchronous communication has many advantages of enabling distributed collaboration, whereas prolonged response and weak awareness of people and events make the teams hard to build quick trust (Gül, Wang et al., 2008). Asynchronous collaborative working indicates that each team member can provide and contribute a part, which is necessary for solving the problems without direct and immediate communication in a formalised way by exchanging the ideas and suggestions (Scherer, 2004).

Synchronous collaboration seemed to have benefits to overcome the above mentioned difficulties, but in a distributed working situation, it is often not easy to overcome the problems caused by time differences. Synchronous collaboration generally occurred during allocated meetings in remote locations and studio. The students reported that they used the virtual world's (Active Worlds and Second Life) communication tools, which are mainly based on text. Students also reported that other synchronized platforms such as Microsoft MSN and Skype were used. The most common asynchronous communication tool which the students used was email. Thus the course structure should include skills and knowledge of using both communication modes and a variety of collaboration media providing a constructive design learning platform.

We experienced that in general the communication modes have an impact on the development of the core skills such as, expanding self-awareness, increasing understanding of others, talking and listening more productively, initiating faster, better resolutions to conflicts, and acquiring greater skill in negotiating. In the first phase of the collaboration, most of the students experienced problems in building trust and social communication as well as receiving and giving timely feedbacks. Students reported some difficulties in working with a new partner in distance and lacking physical contact.

Thus developing trust and establishing social communication become very important for distant design learners. Group discussions, scheduled synchronised meetings and developing a shared goal support building up trust and development of shared understanding of design. To reinforce the collaboration, students should be encouraged to exercise the core skills using variety of communication and collaboration tools. Particularly, they must employ range of collaboration management tools such as, task management (allocation and monitoring), meeting scheduling and minutes, design and communication document sharing, blogs, forums and so on. With the use of these tools the students will develop an understanding of the collaborative design process and gain hands-on experience of collaboration in a design situation. Our experience shows that student's learning can be enhanced by encouraging the self-monitoring of the collaborative design process. In addition, the careful consideration of the nature and complexity of collaborative design tasks to facilitate collaborative learning in CVEs is vital.

Design Representations in CVEs

Most of the CVEs afford the collaborative 2D sketching and 3D modelling. A number of sketch-based interfaces have been developed for a variety of disciplines: architecture (Trinder, 1999), engineering (Stahovich, 1998) software modelling (Chen, Grundy et al., 2003) and user interface design (Plimmer and Apperley, 2003). Most of these sketch-based interfaces include a main drawing surface and drawing tools like line, shape, hatch, etc. The main idea behind these interfaces is to mimic the traditional sketch tools such as pencil and paper by including ambiguities (LaViola, 2006). Thus, these systems are interested in 2D pen and mouse-based gestures. User studies show that sketch-based interfaces offer more compelling interaction opportunities than their traditional counterparts (Plimmer and Apperley, 2004), and even the first-time users quickly become adept at using the systems (Kara and Stahovich, 2004).

In our teaching we employed several shared white board applications, such as Groupboard, which has a set of multi-user java applets including whiteboard, message board, drawing and editing tools and file-uploading and saving on the server. In addition to those applets, facilitating full communication channels such as, video - audio and text communication channels support collaborative design activity providing the awareness of the users and their activities. Collaborative 2D sketching tools can be employed in the early phase of design and during the design development. Speaking a common design language, making design decisions and understanding each other's design intentions become straightforward for the users of 2D based collaborative platforms.

Most 3D modelling systems use Euclidian geometry and wire-frame, shaded, and rendered views to represent the design intention. Computer technology has been increasing its expressive and geometric power to enable the design process in which a digital model can be used throughout the whole process for realising the design (Achten and Joosen, 2003). In this new design processes, the digital models are considered as new design representations that have a consistency and long life-span which does not require continues reconstruction, in contrast to sketches and physical models, which involve considerable redrawing, tracing and scale-model-making (Achten and Joosen, 2003). Increasing use of computer visualisation, digital models, which become more common in design practice, can be recovered by a layperson. This gives an advantage to digital models that could save time in the preparation of client presentations.

Observations show that many designers work in a quite mixed manner, that is, they produce working sketches to generate and elaborate design ideas suggested during model-making, and designers make models to better understand the design solution (Peng, 1994). Therefore, students should be given a chance to use a combination of the design media in a single design task. In order to employ range

of design media in the process, students should be provided the knowledge and skills of operating several design tools.

In CVEs, the models can be produced by (1) the parametric modelling method, which comprises a set of 3D models whose forms are determined inside the virtual design environment by selecting geometric types and manipulating their parameters (for example Second Life), or (2) the object-oriented modelling which comprises using a set of preloaded library objects (for example Active Worlds). The models can also be adjusted at a later stage by editing or library updates. Most 3D virtual worlds also support different viewpoints such as first-person view and third-person view during modelling. Therefore 3D virtual worlds well support the examination of spatial arrangement of the design elements; and the development of students' spatial abilities. 3D virtual worlds allow individual avatars (human-shaped user representations) to move freely around the collaborative design environment while still providing information about the shared design representation and the position of the collaborators (via the presence of the avatars). This visual inspection opportunity of the 3D virtual worlds is very important for the design students who need to gain the skills and ability to think in 3D space.

It is very important to provide adequate tutorial sessions to teach variety of the design features of the CVEs. The design tasks should be complex enough to hold students' interest and to be challenging, which should require employing cognitive skills. In order to support design development and to suit different design preference, the given task should make use of the different types of communication and design representations. The design problem should require the development of a variety of skills that include architecture-related skills (place design), digital design skills (modelling, imaging, video and audio production, scripting and programming), and generic design skills (problem-solving and team collaboration).

FINAL REMARKS

The practice of design today is extremely varied and multifaceted and no course could offer training in depth for all areas of design practice. Consequently it is vital that students gain from the courses a firm grounding in fundamentals, skill to think creatively and logically, and ability to explore for themselves those areas they wish to pursue in detail. The students should be given a chance to develop hands-on experience with the latest design technology, devices and tools in the field. Finally, it should be the aim of the curricula to enable the students to adapt without difficulty to the rapidly changing professional practise.

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