# A NEW APPROACH TO DESIGN EDUCATION: EVALUATIONS OF 3D VIRTUAL WORLDS ON DESIGN TEACHING AND LEARNING

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*ABSTRACT: With the recent developments in information and communication technologies, 3D virtual worlds have the potential to make a major contribution to design education as constructivist learning environments. Considering the changing trend in design education, we have been employing cutting-edge technologies in our design teaching, allowing students to collaborate within the 3D virtual environments such as Second Life (www.secondlife.com) and Active Worlds (www.activeworlds.com), which support synchronized design communication and real-time 3D modeling. This paper reports our teaching experience and the students' learning experience, based on team-based design and communication skills-building in 3D virtual environments and presents the challenges faced by design education. In this paper, we will firstly provide a critical analysis of various design learning and teaching features in 3D virtual environments as constructivist learning environments, and secondly identify issues which address the core skills and cognitive processes involved when designing in 3D virtual environments.*

*KEYWORDS: 3D virtual worlds, design teaching and learning, affordances and constraints,*

## 1. INTRODUCTION

Design education is concerned with teaching theory and applications in the design of artifacts that could occupy human activities. Historically, schools of architecture taught "descriptive geometry" (Lee and Reekie 1949), based on a Euclidean understanding of form and space. The revolution of the paper technology in the fifteenth century can be considered as the "application" that enabled "the intellectualization of buildings", leading the notion of architecture as we know it today (Kvan, Mark et al. 2004). 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 (Gu, Gül et al. 2007). Innovative approaches to design education should include 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. 2007).

In relation to this view, 3D virtual environments offer many opportunities for design teaching. There are approaches which integrate the emerging fields of digital design into design education, such as employing parametric design, interaction design, experience design, graphic design, product design, etc. Despite these studies, there is still a general lack of research and practice which explores the potential of design teaching in 3D virtual environments as a constructivist learning environment. In such environments students habitat and manipulate virtual representations. Perkins (1991) classified constructivist paraphernalia including information banks, symbol pads, construction kits, phenomenaria and task managers. In this view, computational tools facilitate human memory and intelligence to interpret experience and to refine mental models. Thus computer-supported constructivist learning environments focus on how representations and applications can mediate interactions among learners and natural or social phenomena (Dede 1995).

In considering these changing trends in design education, we have been employing cutting-edge technologies in our design teaching, allowing students to collaborate within the 3D virtual environments including Second Life (www.secondlife.com) and Active Worlds (www.activeworlds.com). These environments support synchronized design communication and real-time 3D modeling. This paper reports our teaching experience and the students' learning experience, based on team-based design and communication skills-building in 3D virtual environments and presents the challenges faced by design education today. The paper firstly provides a critical analysis of various design learning and teaching features in 3D virtual environments as constructivist learning environments, and secondly identifies a number of key issues in addresses the core skills and cognitive processes of designing in 3D virtual environments.

## 2. LEARNING AND TEACHING IN VIRTUAL WORLDS AS CONSTRUCTIVIST LEARNING ENVIRONMENTS

3D virtual worlds distinguish themselves from other networked technologies by having place characteristics (place metaphor). It is not just another medium of communication but rather the ultimate "world" where we shop, are entertained and get educated (Kalay and Marx, 2001). Although virtual worlds have gradually become an important part of the holistic environment we inhabit, most often design schools have not recognized designing in virtual worlds as a design subject, rather the current focus is on the technical aspects as a computer aided design (CAD) tool for design simulation and remote team collaboration.

### 2.1 Approaches to constructing knowledge in computer supported education

Winn (1993) identified four different approaches in educational computing. The first one is based on behavior theory that gave rise to traditional approaches to instructional design (Dick and Carey 1985; Gagne, Briggs et al. 1988) that includes

1. predicting students' behavior (Reigeluth 1983),
2. reducing necessary knowledge and skills by using appropriate analytical techniques (Landa 1983), and
3. following a set of procedures to ensure that instruction developed by their systematic application will work effectively without further intervention from designers or teachers (Winn 1993).

The second approach is based on how information is presented to students (Fleming and Levie 1993). The emphasis in this approach is on how students process information and has a greater impact on what they have learned rather than on the accuracy of task reduction and prescription of instructional strategies on the basis of content (Winn 1993). Psychologists realize that cognitive theories of learning and instruction provide a sources for instructional designers to draw upon for guidance rather than behavioral theory (Winn 1993).

The third approach which is based on cognitive theories arose from the belief that the nature of the interaction between the students and instruction is a determinant of learning equal to, if not of greater importance than content or how information is presented (Winn 1993). For example, Anderson's ACT* cognitive theory (Anderson 1976; Anderson 1983) formed the basis of 'intelligent' computer-based tutors which included the following principals:

1. identifying the goal structure of the problem space,
2. providing instruction in the context of problem-solving,
3. providing immediate feedback on errors,
4. minimizing working memory load,
5. adjusting the "grain size" of instruction with learning to account for the knowledge compilation process and
6. enabling the student to approach the target skill by successive approximation.

The fourth approach relies on an understanding of how students interact with courseware, the assumption is that, knowledge is constructed by the students themselves, not through the delivered of the courseware (Winn 1993). In this constructivist view, the knowledge is constructed, not transmitted and the students actively learn (Jonassen 1999). For enhancing learning, students should be given opportunity for exploration and manipulation within the environment as well as opportunities for discourse between students (Dickey 2007). Within this content, students have opportunity to apply new knowledge and skills in a collaborative shared environment (Gül, Gu et al. 2007). We maintain the fourth approach in course development.

### 2.2 Design learning and engagement in virtual worlds

Integration of communication and information technologies into design curricula offers many possibilities to design schools and should be recognized for their significance for designing in new environments, leading research and development of new teaching theories. There are approaches which employ these emerging fields of digital design into design educations including employing parametric design, interaction design, experience design, graphic design, product design, etc. Despite those studies, there is still a general lack of research and practice in exploring and teaching the designing of 3D virtual worlds as a design discipline in its own right.

Learning in 3D virtual worlds is the latest development of distance learning. Historically, the most common tools for distance learning have been web-page-based platforms such as Blackboard (www.blackboard.com) and WebCT (www.webct.com) which have been used to support constructivist learning. These platforms are essentially networked databases which store course materials including lecture notes, text or graphic resources and assessments items as well as providing asynchronous communication such as recordings of lectures and discussion forums. Users access the databases through a graphical interface similar to a web page. They are most useful for recapturing what has traditionally happened in the physical learning environment. In scenarios where local and distance students co-exist in the same course, these traditional distance learning tools often disadvantage distance students by excluding them from the actual "actions". This limitation has appeared to be even more critical in the context of design education as the dominant method of design learning and teaching is largely project-based, which is most commonly situated in a design studio. The success of such methods relies on students' direct interactions with the academic staff - the "masters" - and with their peers through constant discussions and critiques. Traditionally, these interactions are face-to-face and often "hands-on".

Research of educational use of VR provides compelling evidence of the potential of the emerging 3D virtual worlds to facilitate constructivist learning activities (Winn 1993; Dede 1995; Dede, Salzman et al. 1996). One of the main advantages of VR is that students are able to view an object or setting from multiple perspectives (Dede 1995). Dede (1995) points out that virtual environments offer many benefits including opportunities for experimentation without real-world repercussions, opportunities to 'learn by doing', or 'experiential learning' and ability to personalize an environment. From the mid 1990s, virtual design studios (Kahneman and Tversky 1996; Maher 1999; Kvan, Schmitt et al. 2000; Schnabel, Kvan et al. 2001) have been established in architecture and design schools internationally. These virtual design studios aim to provide a shared "place" where distant design collaboration can take place especially synchronized communications and design activities. The forms of virtual design studios vary from the early approach of digital design data sharing to the more recent 3D virtual world approach where the designs as well as the designers, the learner, are simulated and represented in the virtual worlds allowing "design and learning within the design". This new phenomenon has caught the attention of many design academics. Kvan (2001) argues that while design education has traditionally focused on the product, virtual design studios allow students to learn more about the design process. Dickey (2005) suggests 3D virtual environments can provide "experiential" and "situated" learning. Clark and Maher (2005) examine the role of place in 3D virtual learning environments which encourages "collaboration and constructivism". Wyeld et al. (2006) identified the potential of the use of 3D virtual learning environments in supporting social awareness among design students focusing on the cultural aspect in virtual learning environments where students from different cultural backgrounds design collaboratively.

## 2.3 Virtual worlds design

Today the communication and information technologies bring new challenges to design education which require the consideration of new pedagogical approaches employing emerging design fields. An innovative approach to design education should include a demonstration of the impact of computer technologies on "new ways of designing" (Kvan, Mark et al. 2004) integrating the teaching of digital skills (craft) and the concept of design thinking (art). In relation to this view, the emerging field of 3D virtual worlds offers many opportunities for design teaching that requires understanding the principles of virtual worlds design.

**Virtual World Design and Architectural Design:** The early development of 3D virtual worlds has been closely related to architectural design due to its use of the "place" metaphor. Through this metaphor, virtual worlds can inherit many of the characteristics from architecture. Massively Multiplayer Online Real Life Games (MMORLGs) as well as those examples which have the sole purposes of simulation such as virtual heritage worlds and military simulation worlds only mimic the physical world. As a result, the focus of these designs has been placed on virtual reality (VR) and social aspects in order to make the virtual environments as close to their physical counterparts as possible.

**Virtual World Design and Interaction Design:** Designing in virtual worlds goes beyond imitating the physical world and still focuses on accommodating human activities, in particular, interactions that are not readily available in the physical environments. The examples of virtual world design as interaction design include the largely popular interactive online games and the recently emerging agent-based intelligent worlds. Situated in such an environment, a software agent is capable of reasoning about the world and acting upon its beliefs and desires (Wooldridge 2000). Mediated with software agents, 3D virtual worlds become intelligent networked environments. Smith et al. (2003) develop 3D virtual worlds that respond to their inhabitants in reflective, reactive and even proactive modes. This is achieved by applying a multi-agent model which enables each component in the virtual world to be an agent. Using a design agent model, Gu and Maher (2005) develop dynamic 3D virtual worlds that are designed and modified as needed during use.

**Designing within the Design:** Maher and Simoff (2000) first characterize the design activities in 3D virtual worlds as "Designing within the Design". Unlike in the CAAD systems, virtual designers are represented as avatars that are immersed within the design. This concept has also been studied to enhance remote team collaboration in design practice (Rosenman, Smith et al. 2005). 3D virtual worlds provide an integral platform that utilizes team collaboration, design representation, modeling and in the case of designing virtual worlds, even design realization.

## 3. "DESIGNING VIRTUAL WORLDS" COURSE

"Designing Virtual Worlds" was offered as a full-semester (13 weeks) unit. The weekly format included a 1-hour lecture and a 2-hour design studio. The course attracted 20 postgraduate students from the disciplines of architecture, engineering, design computing and digital media, and involved them in exploring interesting ideas and new possibilities for 3D virtual worlds.

**Course Objectives and Structure:** the objectives of this course were for students to: (1) develop an understanding of the 3D virtual world as a new kind of environment design, (2) gain knowledge and hands-on experience in design and implementation, and (3) explore the use of 3D virtual worlds for design education. The course content was structured so that students could gain understanding the environment and the skills necessary for designing in 3D virtual worlds. For the students to develop their understanding of virtual worlds, firstly, they consulted relevant literature then design examples were introduced and discussed through lectures and group discussions. Secondly, students were instructed to inhabit and critically assess a wide variety of virtual worlds reporting their experiences in a short essay which involved them reflecting on their learning outcomes. In order for the students to gain adequate design knowledge and technical implementation skills, two design projects were scheduled as major submissions for the course.

**Design Projects:** With structured design supervision and technical tutorials, the two design projects (one individual and one group project) provided opportunities for students to:

1. develop and apply design principles of 3D virtual worlds,
2. master the knowledge and techniques for virtual world implementation, and
3. exercise individual design and group collaboration skills.

In the individual project, each student designed and implemented a personal virtual gallery for displaying her/his digital design portfolio. The whole class was then divided into four groups. Each group designed and implemented a virtual place. Through interactions between the avatars and the designed place, the group's understanding of virtual experience would need to be demonstrated. The virtual place and the virtual experience were recorded on a digital video.

The individual project exercised all required skills for designing 3D virtual worlds. These included architecture-related skills (place design), digital design skills (modeling, imaging, video and audio production, scripting and programming), communication and collaboration skills and generic design skills (problem-solving). In the group project, students were grouped with students from different backgrounds allowing them the opportunity to work on their own interest and with their particular expertise but still within the collaborative environment. For assessment, applied multi-dimensional criteria were applied to cover the different design and technical aspects and invited jury members from the areas of architecture, interaction and game design, and computer programming provided students with feedback drawn from the different perspectives.

## 4. EVALUATIONS OF 3D VIRTUAL WORLDS AS CONSTRUCTIVIST LEARNING ENVIRONMENTS

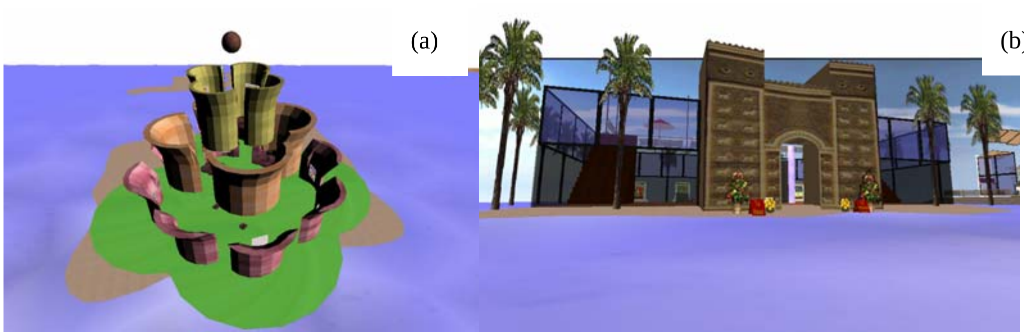
The approach of learning and teaching in virtual worlds has been presented as constructivist learning environments. Compared to other approaches where 3D virtual worlds are used as a technical tool for CAD modeling or virtual learning, this approach regards 3D virtual worlds as a design discipline which adds new dimensions to 3D virtual worlds. These dimensions include consideration of interaction design, metaphorical/virtual design and experience design other than mimicking the physical world. 3D virtual worlds as a design subject will prepare future generations of design students to develop an understanding of 3D virtual worlds as a new design environment which will become an important part of our holistic living environment. The emergence and further integration of this subject with the current teaching curriculum will provide new opportunities and challenges for architecture and design education, such as utilizing virtual worlds as new design platforms. In the following section, we discuss (1) design features of 3D virtual worlds and 3D virtual worlds as constructivist learning environments and (2) two aspects of human behavior that are core skills and cognitive behavior in the two of the most popular 3D virtual world platforms: Active Worlds (AW) and Second Life (SL).

## 4.1 Evaluations of design features in 3D virtual worlds

The approach for the evaluations of design features in 3D virtual worlds is borrowed from Dickey (2007). In his study, Dickey (2007) points out that affordance theory has relevance when examining learning environments. In the content of constructivist concept, the affordances and constraints of the learning environments affect the opportunities for construction (Dickey 2007).

Affordances theory is developed by Gibson (1977) who suggests that humans perceive in order to operate on the environment. Perception is designed for action that is called 'the perceivable possibilities for action affordances'. He claimed that we perceive affordance properties of the environment in a direct and immediate way, i.e. surfaces for walking, handles for pulling, space for navigation, tools for manipulating, etc. (Norman 1988).

Within this framework and based on our observations and discussions with the students during the lectures and design studios, we identified the affordances and constraints of AW and SL in the following section.




- **3D modelling features**

*Affordance:* AW supports the so-called library-based design method which comprises a set of objects whose forms are pre-defined outside the world and provided by the object library of the design platform. To modify the forms require object library updates. Also discovered was that in library-based designs, students with less modeling experience can rely heavily on the use of standard library objects provided by AW. As a result, the affordances of library-based designs provide the uniformed "AW look" due to the repetitive use of standard library objects, as shown in figure 1b.

*FIG. 1: Student designs in AW, a)a customized model uploaded to the server, b)a model used the library objects*

SL supports the parametric design method which comprises a set of objects whose forms are determined inside the world by selecting geometric types and manipulating their parameters. They can also be freely adjusted within the world at a later stage. Design platforms that support the parametric design method are therefore modeling tools as well. The affordance of SL encourages students to generate models that look unique. Figure 2 shows students example in SL that is the virtual idol and the virtual big brother projects.

*Constraints:* The approaches to generating customized models can be cumbersome as users are unable to model directly in AW. The first option for creating a model is to use a CAD or a modeling application. Then converting the model into 'rwx' format requires the consideration of the scale, texture, positioning in AW. It is also important to consider how to separate the model into different objects as behaviors in AW which can only be applied to an object but not a part of the object. For example, if a model as a whole is to be used in AW, actions can only apply to the whole model. If each component is to have its own behaviors, it is a requirement to have a separated the model and export different parts of this model individually. It can then locate and combine the components together as a whole in AW. Figure 1a show a customized object designed by a student who uploaded the model multiple times.

Another approach to generate customized models for AW is to modify existing files in 'AlphaWorld Building Objects' library using the techniques to rotate, scale, and change color or texture. The first step is to download an existing model from "models" folder that you want to modify, and then unzip the file and open the 'rwx' file to make any necessary modification, rename and zip the modified file using the required naming style and upload to the "models" folder on the AW server.

Alternatively SL, on the other hand, provides a platform where students can start designing from the early stage using basic geometric forms. Though, this may be a challenge for students who are novice designers. Some students commented that they had to sketch their design ideas into a piece of paper to aid their understanding of the overall design layout they then they started to model the building in SL.

- **Collaborative design and workspace awareness**

*Affordance:* AW and SL support synchronous collaboration. Both virtual worlds have a text-based communication features. Users can communicate by typing onto the chat dialogue box in AW. In SL, similar to AW, the text appears on the avatars head, as illustrated in figure 3. Both AW and SL afford the presence of designers/learners (awareness of self and others), architectural metaphor/place (awareness of the place); navigation and orientation (wayfinding aids).

In AW, users could only manipulate/rotate/change the properties of their own object. In the group project, it was observed that the affordances of ownership of the objects require a structured-task division whilst designing collaboratively. That means that students need to determine the overall concept of the design and distribute the parts to construct the model. In SL, the ownership of the objects is not an issue, but one user only can manipulate an object's properties/location at a time. Thus these features of the 3D modeling environments might encourage the designers to work individually on separate parts of the design model in a collaborative task.

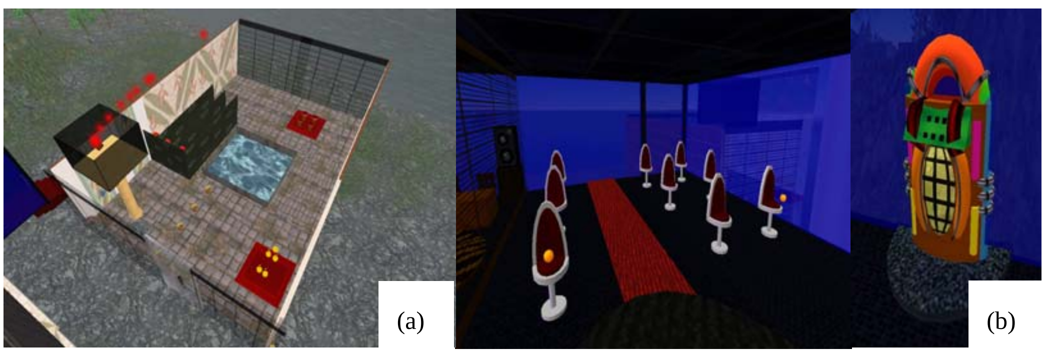



*FIG. 2: Students designs in SL, a) Virtual Big Brother house, b)Virtual Idol*

Constraints: AW allows individuals to move freely around the 3D workspace while still providing information about the shared design representation and the position of the others (via the presence of the avatars) however the technique of manipulating the design objects does not support workspace awareness. In AW, students are not able to see others' modeling actions, unless the command is finalized. Therefore maintaining collaboration and monitoring each other's actions became an issue.

In contrast, SL provides more workspace awareness through 'consequential communication' and 'feed-through'. For example, in SL, when a student is modeling/manipulating an object, a light blob indicating the link between the avatar and the object appears, and when the student types the avatar also types, this behavior supports workspace awareness through 'consequential communication' (see Segal 1995 for the definition). In addition, in SL, when a student is transferring or moving an object, these manipulations are visible to others. This 'feed-through' (see Dix, Finlay et al. 1993 for the definition) behavior supports workspace awareness. Due to these features of SL, the students are aware of each other's actions and can focus on the development of the design model in a collaborative design task.

For both platforms, it is important to moderate the discussion in a large class as multiple trends often emerge during online discussion.


*FIG. 3: Screen shots: a)AW showing the chat box at the bottom and the text balloon on the head of the avatar, b)SL showing avatars and text balloons on their head and the list of messages on the left of the screen.*

**Scripting/programming for interactivity**

*Affordance:* Both AW and SL enable in-world scripting to support interactions in the virtual environments. AW provides a library of scripting for common interactions such as creating a hyperlink, teleporting, object animation and so on. User can easily implement simple interactions using this library of existing scripts. SL scripting is more robust supporting a scripting language called LSL, a computing language similar to Java.

*Constraints:* Although creating common interactions is simple in AW due to the library of implemented scripts. It does not support advanced level interactions. The robust scripting environments in SL on the other hand do support advanced interactions. However it is very difficult for designers to master without a computing background. Figure 4 shows students examples in SL and AW. In SL a group of students designed a gaming experience for its users allowing different experiences in each floor, as shown in figure 4a. In AW, a student designed a place that is become visible when the avatar visits (figure 4b).

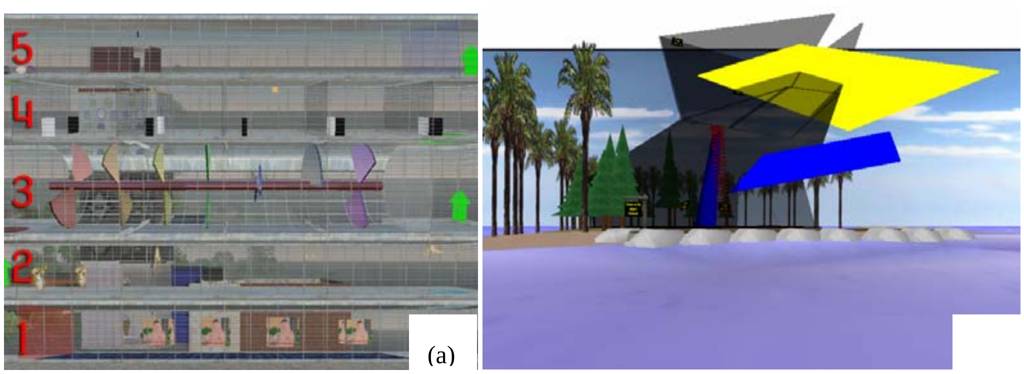



*FIG. 4: Providing interactivity. (a) a virtual gaming experience in SL, (b) an exploration of space in AW.*

## 4.2 Evaluations of human behavior in 3D virtual worlds

Teaching in virtual worlds requires the understanding of human behavior, in particular understanding the key aspects of human communication and cognitive processes are essential.

**Core Skills in 3D Virtual Worlds:** The core skills are essential for design collaboration in 3D virtual worlds, therefore they are essential skills for students to gain and should be embedded in courses in 3D virtual worlds. Bellamy et al. (2005) identify the core skills for designers to effectively participate in collaborative design as follows:

- Leadership is important because it decides the balance of relevant skills and contributions required from team members. Team leader(s) need to be able to create teams that identify the important "social links" between team members (Baird, Moore et al. 2000).
- Co-ordination and structuring skills are required for team members to work collaboratively in a virtual environment (Lahti, Seitamaa-Hakkarainen et al. 2004).
- Feedback abilities are also important skills for team members. This is crucial because large amounts of information often need to be validated in virtual worlds (Baird et al, 2000).

- Interpersonal relationships between virtual team members can impact on the team's ability to provide a satisfactory product. In addition, social collaboration appears to play an important part especially when researching and determining limitations.
- Trust is not easily created in a computer-mediated environment including 3D virtual worlds, especially when team members have no prior experience with others. The commitment of others fosters trust, but this trust may not reach its highest level until the end of a task (Jarvenpaa and Liedner 1998).

In general, communication presents challenges in virtual worlds. A number of factors constrain these interactions, for example: (1) A lack of visual cues and auditory input might influence understanding. Even when visual cues are used (e.g. augmented with video conferences or web cameras) team members' abilities to communicate using non-verbal interactions (such as body language) can be inhibited (Hoyt 2000). (2)Technology does present some advantages when communicating over distance as they often allow more focused and concise information exchange between team members (Gabriel and Maher 1999; Maher and Simoff 2000), and assist team members keeping to their task (Cleland and Ireland 2002). (3) In addition Baird et al (2000) find that the virtual environment may not foster skills such as feedback. Furthermore, Williams and Cowdroy (2002) note that communication is easier if team members have previously worked together. (4) Synchronicity is also an issue as virtual teams can operate in both synchronous and asynchronous virtual environments (Maher and Simoff 2000). (5)Research has shown that simply mimicking co-located settings such as teleconferences may result in fewer social interactions between team members as well as difficulties in sharing visual information (Gabriel and Maher, 1999).

**Collaborative Design Process in 3D Virtual Worlds:** Understanding the processes of collaborative design is crucial for the development of learning materials and tools in virtual environments. Researchers (Gül and Maher 2006; Maher, Bilda et al. 2006) point out that the design process and the realization process are different between the co-located sketching and the designing in 3D virtual worlds. Therefore it is necessary to consider those differences during course development. The differences are:

- The designers had the situation of immediacy to construct the design representation, rather than exploring alternative design solutions. They concretized their design solution without much iteration in the design process actions. They decided on a particular design idea and constructed it, demonstrating longer attention spans.
- The designers stayed in the distributed design situation, where they worked on the modeling individually and came together for the negotiation and evaluation, staying in low-level design ideas. The designers created the 3D model through the "continue" action in longer spans, thus allowing them to focus on the spatial relationships of the 3D objects.

## 5. CONCLUDING REMARKS

3D virtual worlds have the potential to make major contribution to design education as constructivist learning environments. This paper has demonstrated how AW and SL support the constructivist learning environment by investigating the affordances and constraints of modeling, communication and computational features of 3D virtual worlds. In addition it has been shown how core skills and collaborative design processes in designing within 3D virtual worlds are developed. Based on issues discussed above, the following should also be considered for design teaching:

**Learning environment design:** The environment needs to be carefully designed as most of the current virtual worlds are not specifically developed for education and are not readily usable by students. 3D virtual worlds allow learning by "doing" and experimenting. Academics should set design problems and tasks which are complex enough to challenge and explore the new ideas and knowledge to make full use of these environments. In addition, the design problem requires employment of critical thinking and cognitive skills. The virtual world design should address teaching and learning support as well as peer support and to include them as "in-world" features forming an integral part of the learning environment. The virtual world design should reflect the latest development of 3D virtual world design and research as well as the focus of the course. This is very important, as the design of this environment is one of the few examples which can inform the students' early understanding of virtual world design. The virtual world design should be modified and adjusted accordingly and regularly to reflect the class scale and student background.

**Skill development:** Designing in 3D virtual worlds requires the knowledge and skills in the use of different applications, media and interfaces/devices. Thus students should be given series of support sessions which provide basic skills and knowledge of using these applications and tools. It is also possible to consider forming student groups that contain experts from different disciplines for the collaborative projects. Exchanging ideas, sharing design documents (sketches, images, visual ideas and etc.) and sharing and developing design concepts and knowledge are essential for engaging students in collaborative design.

**Course development and moderation:** Design content and technology content should be carefully balanced to match the students' backgrounds and capabilities as well as to suit the different teaching focus. Students should also expand their knowledge and skills to operate variety of information and communication technologies integrated in the virtual learning environments. Monitoring the progress of students' learning is essential in all design-related subjects. This requires ongoing evaluation of students design activities, which also provides the students and the teaching staff with feedback as the projects progress.

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