COLLABORATIVE DIGITAL ARCHITECTURAL DESIGN LEARNING WITHIN 3D VIRTUAL ENVIRONMENTS

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Abstract. This paper introduces a collaborative learning approach to digital architectural design within a 3D real-time virtual environment within which students Inhabit, Design, Construct and Evaluate (IDCE) their designs virtually and collaboratively. The paper articulates the development and implementation of the IDCE model utilized within the 3D virtual environment for achieving collaborative digital architectural design learning. The effects of metaphors on constructing architectural designs within virtual environments are addressed.

1. Introduction

Do and Gross (1999) have outlined various ways to integrate computation and digital media into design teaching, describing six alternative models for digital design studio including computer augmented design studio, CAD-plus studio, virtual and web design studio, cyberspace design studio, intelligent building studio, and toys and tools studio.

The concept of virtual environment has emerged from advances in computer networking, image processing, modelling, simulation, and multimedia representation (Simoff and Maher, 1997). Virtual environments that mimic the spatial arrangements of the physical world have changed the role of 3D CAD systems from drafting to producing blocks of the new 3D virtual environments. Virtual Environments (VEs) are attractive platforms for learning in which they can provide opportunities for new kinds of experience to enable users to interact with objects and navigate in 3D space in ways not possible in the physical world. Claims have been made about the added-value that can be gained from interacting with these kinds of virtual representations including easier learning, better understanding and training, more engagement and pleasure (Psotka, 1995). These benefits are manifested on the key properties of VEs in their ability to captivate. For instance, Byrne (1996) suggests that immersion in 3D environments is highly motivating, inducing users to spend more time on a given activity. Allison et al. (1997) found that in their virtual gorilla

project users were highly engaged and very much enjoyed the experience. The users adopt the role of a gorilla in a virtual zoo, navigating the environment and watching other virtual gorillas respond to them.

Pedagogically, Wickens (1992) proposed that virtual environments encourage people to be more active in the way they interact with external representations, through having to continuously choose their position and viewing perspective when moving through the virtual environment. Wickens suggested that learning and retention of information can be increased. Kvan (2001) asserts that the advent of virtual design studios appears to raise promising opportunities for reconsidering the way we teach design. Utilizing virtual environments in architectural design teaching advances the concept of designing with computers in a paperless design studio (Reffat, 2002) to a multi user real-time 3D virtual environment for achieving collaborative designing and learning.

This paper introduces a new approach of teaching architectural design collaboratively within a 3D virtual environment in a virtual design studio wherein students were able to inhabit, design, construct and evaluate their designs virtually and collaboratively in a 3D real time environment. The effects of utilising various design metaphors on constructing 3D virtual design places are addressed.

2. Teaching Architectural Design within Virtual Environments

Design, especially architectural design, is usually a collaborative activity. This means that the social dynamics of team-work are often as important as the technical issues involved in solving a design problem. Therefore, learning to design requires collaboration of both the student and an expert facilitator. It is a collaborative experience where responsibility is shared (Schon, 1987). Learning how to design will be more effective if the setting is responsive to the needs of both students and facilitator (Franz, 1990). Furthermore, learning how to design in the initial stages necessitates that an emphasis be placed on the process as an outcome of learning rather than the final proposal.

Theories of design teaching include reflection-in-action (Schon, 1987), and problem-based learning (Koschmann et al., 1994). Common to these theories of teaching is that they are process focused. This process focus is in part what makes the virtual studio so interesting and also so easy to adopt as a medium in which to teach design. Teaching in a studio requires the teacher to engage the student in an action-based activity. The teacher guides the student and conveys tacit knowledge of design through working together with the student (Kvan, 2000). The concept of collaborative design has recently received renewed attention. Collaborative design looks at how the process can be improved in such a way that collaboration emerges from the process (Achten, 2002). Collaborative learning is an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or

students and teachers. Collaborative learning represents a significant shift away from the typical teacher-centred approach in which learning is viewed as an active and constructive process (Smith and MacGregor, 1992). To learn new information, ideas or skills, students have to work actively with them in purposeful ways. They need to integrate this new material with that they already know or use it to recognize what they though they know.

2.1. VIRTUAL ENVIRONMENTS IN ARCHITECTURAL DESIGN STUDIOS

Virtual Environments have proliferated and a large number of architecture and design schools are currently engaged in them as virtual architectural design studios. Virtual Environments can either support teaching in a single studio within an institution or bring together students from several institutions. There are various motivations for engaging architecture students in virtual design studios including instinctive feelings that Virtual Environments are important and present an essential learning for practice of the future, exploiting technology in design teaching, researching the nature of design communication and processes, and searching for ways to improve the educational experience of a student (Kvan, 2000).

Virtual Environments provide powerful communication and navigation environments wherein users can collaboratively design in centralised or distributed environments. Some examples in this field include “Phase X” (Schmitt, 1997) that is a design course at ETH, Zurich which starts using the computer as a medium but in a passive approach. “Phase X” expanded on the idea of paperless studio by building more dimensional computer models, networking the designs and focusing on abstract concepts. The concept of space as an element has been developed in “Sculptor” (Kurmann et al., 1997) to enable the designer to design interactively in real time with the computer in a 3D environment. The combinations of solid and void elements, positive and negative volumes, enabled the designer to facilitate the computer at the early stages of conceptual design. “Roomz” (Strehlke and Engeli, 2001) is a workplace called “Myscenario” that allows three types of interactions: changing the wall colours, placing objects within the space and creating a path through the space.

A collaborative virtual studio in an immersive environment (VeDs) (Schnabel et al, 2001) was conducted. It appears that an immersive VE permitted students to experience their ideas differently from non-immersive environments in which the interaction of idea and creation was direct, and that each stroke had an immediate impact on the design. Collaboration was possible and teams engaged in intense discussions about design, concepts and forms. There have been various teaching contexts conducted in virtual design studios in the last decade as shown in Figure 1. Some of these teaching contexts included design in parallel (Bradford et al, 1994), joint designs (Cheng et al 1994; Wojtowicz et al 1995), sequential exchange and creation (Kolarevic et al, 2000), and web-based bulletin board with graphic support (Kvan, 2000).

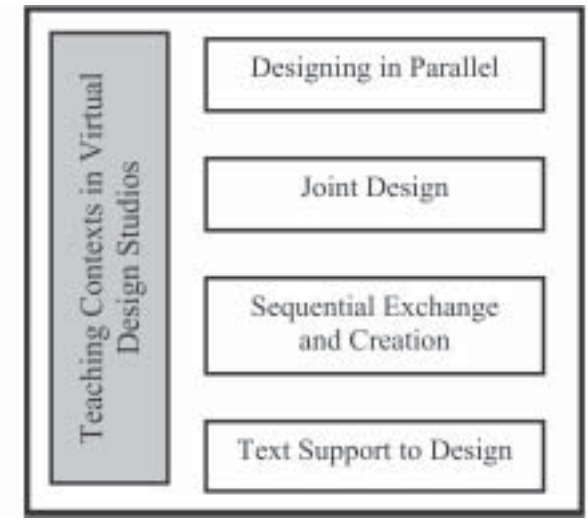

*Figure 1.*Some teaching contexts conducted in virtual architectural design studios in the last decade.

2.2. FEATURES AND LIMITATIONS OF CURRENT VIRTUAL ENVIRONMENTS (ACTIVE WORLDS)

Virtual Environments provide a space in which multi-users can communicate, educate, learn, design, collaborate, be entertained, explore and interact. The design of the VE itself, the interface, has a direct impact on the efficiency and effectiveness of the VE to achieve its purpose. Usability, temporal and spatial efficiency and responsiveness of the human-computer user interface (HCUI) in 3D Virtual Environments (VEs) can be related to developments including intelligent situated agent response (Reffat, 2003), constructivist and collaborative designing in VEs, as well as to the efficiency of the 3D VE interface itself. Navigational ease and clarity can be developed using visual metaphors and familiar processes. Data visualisation models and visual responsiveness of the VE can also be enhanced using metaphoric representation. Integrating these aspects of the HCUI, metaphors can be used to design thematically organised VEs and to define parameters of semantic-based designing within Virtual Environments that provide a collaborative studio situation (Beilharz and Reffat, 2004).

Broadband bandwidth is a limiting factor currently governing the speed of mobility, resolution of visual and sonic objects, and quantity of data transferred in (near-) real-time in a multi-user online environment. While bandwidth will evolve, there are ways in which the interface can be designed to enhance performance while maintaining interactive and responsive characteristics that improve the user experience. These include metaphoric interface design that is compact and familiar.

Overcoming limitations of graphic capacity and bandwidth by innovative solutions to information representation and navigation is addressed by using metaphoric representations which embody or symbolise tasks that will be conducted in the VE. There are some important limitations that should be taken into account while adopting Virtual Environments (basically Active Worlds), in architectural design studios. These limitations include: (a) modelling in 3D worlds, (b) Firewalls, and (c) hardware and language communication issues (Brown et al., 2001).

3. IDCE Model for Collaborative Digital Architectural Design Learning within Virtual Environments

Collaborative learning is in contrast to the competitive process usually seen in the traditional design studio. It is argued here that virtual environments can be used constructively to create a collaborative learning discourse. In collaborative learning, students work together as members of a learning community by questioning each others and discussing and sharing information. Flexibility, interactive communication and collaborative learning are key features in a virtual environment design studio. A teaching model has been developed and implemented for first year design computing students at the University of Sydney to enable students and studio instructor (author) to work collaboratively within a virtual environment for digital architectural design task. The IDCE teaching model as shown in Figure 2 involves inhabiting, designing, constructing and evaluating designs in the virtual environment. These four activities form the corner stones for collaborative digital architectural design learning in the 3D real-time virtual environments (Active Worlds).

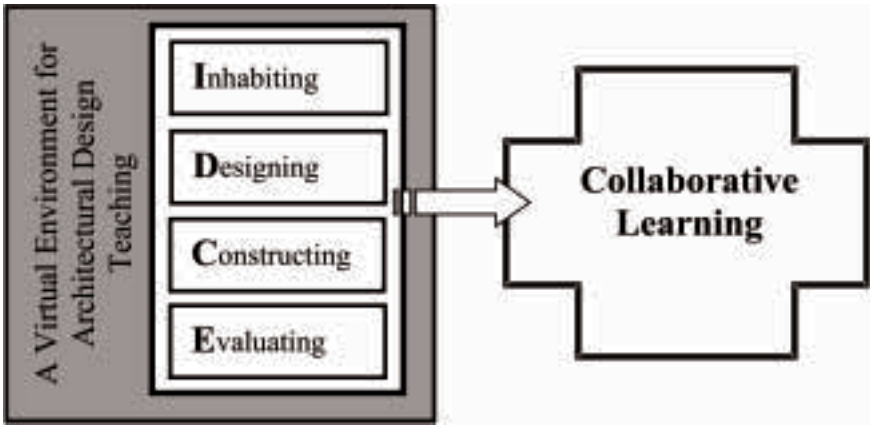

Figure 2. The IDCE teaching model for collaborative digital architectural design learning within a 3D real-time virtual environment.

3.1. INHABITING THE VIRTUAL ENVIRONMENT

In order to live well, we must truly "inhabit" a place, rather than merely taking up temporary residence. The real space in which virtual environments exist and its efficient functionality towards multiple display ends plays a critical role in the success of application development and ultimately the creation of presence. The components for creating a dynamic space for enabling virtual environments lies all around us. It requires an open mind to bridge the many disciplines and create a plan, which can efficiently incorporate all the needs and functions demanded by such an environment. Virtual environments demand the synthesis of multiple professions into a single real space.

Students were assigned a task designed to allow them to experience inhabiting the virtual environment and was carried through into three phases completed while we were synchronously in a selected virtual environment; (a) Exploring and understanding; students familiarised themselves with the virtual environment that they were visiting, navigated their ways through, and reflected on how they found the navigation within this virtual environment; (b) Interacting: reflected on how the subject, theme and design of this virtual environment got them engaged and interacted with the environment; and (c) Inhabiting: discussed and analysed their experiences in inhabiting this virtual environment.

3.2. DESIGNING THE ARCHITECTURAL PROJECT IN THE VIRTUAL ENVIRONMENT (USING A METAPHOR)

Designers frequently use organizing principles derived from metaphors to tackle design problems. Metaphorical thinking enables to understand design experience in terms of another experience. Each student was requested to select a metaphor to drive the design. An initial set of metaphors was introduced and discussed with the students. Reports obtained from students showed that the use of metaphors played a significant role in identifying design concepts, framing design situations and specifying design goals. This phase was initially commenced via text at a discussion board for each group sharing similar metaphors. Secondly, students mapped the structural relationships between the metaphor as a source and their design problem as a target in a form of sketch design. This was conducted using various sketching tools outside the virtual environment. Sketches were placed on the discussion boards for each group within the virtual environment and critique sessions were conducted for each group with the participation of all studio groups. Students were then refined their design sketches and were requested to articulate the elements by which their designs will be constructed in the virtual environment.

3.3. CONSTRUCTING THE ARCHITECTURAL DESIGN WITHIN THE VIRTUAL ENVIRONMENT

Each student was allocated a virtual piece of land with an area of 600 square metres (20m width × 30m length) at the Virtual Design Computing Studio, Active Worlds server at the Faculty of Architecture, University of Sydney. Students were requested to design and construct their 3D virtual café considering the following guidelines: objects are constructed in their real size, achieving a sense of presence, directedness and engagement in the design of their virtual cafés, building objects in the virtual café that are reactive to user's actions, and collaboratively and virtually interact with at least 5 students and evaluate their designs during various times while constructing their designs. Students were collaborating with their peers while designing and constructing their virtual cafés within the virtual environment (Active Worlds). Design collaboration with the Studio Instructor (author) was often conducted within the virtual environment during and outside scheduled studio times.

Designs were constructed from objects that were either imported from the Active Worlds (AW) object library or were designed and modelled using 3D CAD modelling tools and were converted and exported to the AW object library and later imported to construct the proposed design.

The ability to design interactively, test the consequences of actions and to explore different ways of solution refinement is crucial in designing. A design medium that provides such capabilities would benefit the experienced designers and strengthen the novice designer's ability to gain depth in designing. This design medium allows designers not only to manipulate and explore the design space and its spatial arrangement directly and interactively through a real time 3D environment but also to explore and refine their designs in real time.

3.4. EVALUATING THE CONSTRUCTED ARCHITECTURAL DESIGN IN THE VIRTUAL ENVIRONMENT

Live feedback from peers and studio instructor were constant during the implementation of the IDCE model within the virtual environment. The effect of metaphor on the construction of architectural designs within the virtual environment was evident during collaborative activities that took place at the design, construction and evaluation stages. The design, construction and evaluation stages are not sequential processes but rather a constructive loop. Each architectural design has received five peer feedback and evaluation in addition to the design instructor's feedback. Examples of students' designs of the virtual design café are shown in Figure 3.

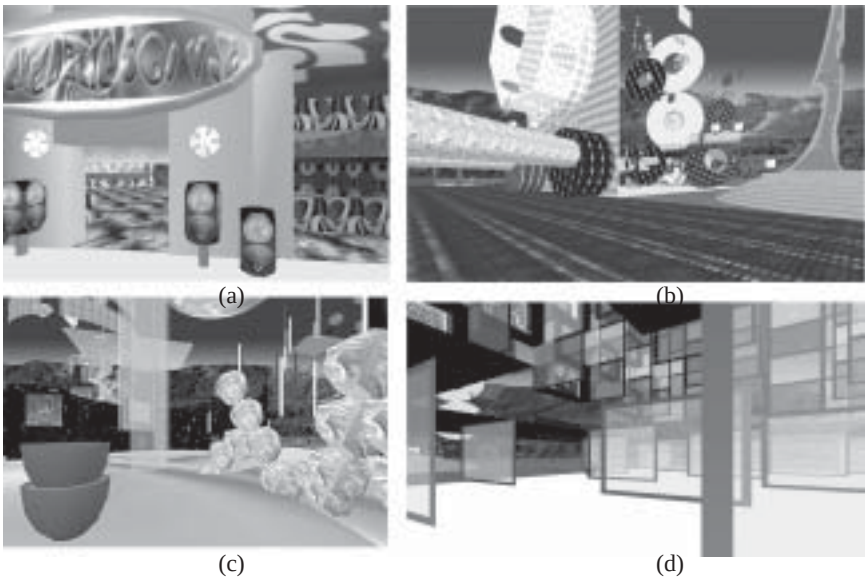

Figure 3. (a) Textures and patterns from the fashion metaphor mapped on to architectural structures; (b) 3D objects are suspended in space, unaffected by gravitational restrictions; (c) Animated 'rocks' suspended in 'mid-air' act as teleportation nodes; (d) Numerous translucent panels partially enclose spaces using fashion-based metaphors of layers and transparency.

4. Discussion

In collaborative learning situations, students are not simply taking new design ideas or information but creating something new with these ideas and information. Collaborative learning has as its main feature a structure that allows for student conversation since learning is inherently social.

Furthermore, learners are diverse. Students bring multiple perspectives, diverse backgrounds, learning styles, experiences and aspirations. A design studio can encompass a wide range of learning styles (Accommodators, Divergers, Assimilators and Convergers) if its programs: start from ill-defined design problems permit a range of communication media and engage students and teacher over a relatively long duration allowing more freedom in learning approaches (Kvan and Yunyan, 2005).

Creating a collaborative learning can be a wonderfully rewarding opportunity but it is full of challenges and dilemmas. The design studio is no longer solo teacher and individual students with their own designs. It becomes more an interdependent community with all joys, tensions and difficulties that attend all communities. Moreover, the definition of a teacher as keepers and dispensers of disciplinary expertise is no longer valid. Nonetheless, wanting to be a facilitator of collaborative

learning and being good at it are very different things. Learning collaboratively demands responsibility, persistence and sensitivity, but the result can be a community of learners in which every one is welcome to join, participate and grow.

This paper has introduced the IDCE model to promote collaborative learning in digital architectural design within 3D real-time virtual environments. The ICDE model of collaborative learning has the potential to provide platform for active exchange of ideas, increase the interest among participants and promote critical thinking.

Acknowledgements

The author would like to acknowledge and thank the KFUPM for supporting this research. Also, thanks are due to the University of Sydney, Key Centre of Design Computing and Cognition and Design Computing students.

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