Dafoulas, G. & Saleeb, N. (2010), 'Harnessing 3D Applications for Technology Enhanced Learning', *Proceedings of EduLearn: International Conference on Education and Learning Technologies*, 5-7 July 2010, Barcelona, Spain, pp. 124-133.

HARNESSING 3D APPLICATIONS FOR TECHNOLOGY ENHANCED LEARNING

Georgios Dafoulas, Noha Saleeb

Middlesex University, United Kingdom
School of Engineering & Information Sciences, Middlesex University, United Kingdom
g.dafoulas@mdx.ac.uk
n.saleeb@mdx.ac.uk

Abstract

For several years computer supported cooperative work applications have been applicable to the field of e-learning. Video conferencing, computer mediated communication, shared whiteboards and so many other Groupware tools have been used in the past to facilitate teaching and learning online. Web 2.0 and social networking tools created a second wave of e-learning applications that assist learners to communicate. Previous work focused on investigating the feasibility of applying CSCW as well as Web 2.0 technologies in distance education and e-learning. However it seems that a significant part in the relevant literature is concerned primarily with the investigation of how such technologies affect communication, collaboration and similar activities. Over the past few years the authors have identified the importance of understanding the impact of using Web 3D applications in constructivist e-learning paradigms. Our focus was on defining the role of Web 3D applications as a complementary technology to the use of traditional Virtual Learning Environment.

In this paper we discuss the use of Second Life in a number of pilot studies ranging from seminar sessions and lectures to various collaboration activities between students residing in different locations. The paper describes the preparation of the learning environment in preparation for the delivery of different learning activities. Anecdotal evidence combined with survey results are discussed with respect to the ways the virtual world has enhanced the students' learning experience. A summary of key findings with respect to the impact of Second Life to both student learning experience and the role of the academic is also provided. The paper contributes in the field by identifying evidence of good practice as well as compiling guidelines and criteria for success in integrating Second Life applications to existing e-learning provision.

Keywords: Virtual worlds, Second Life, Web 3D applications

1 INTRODUCTION

This paper attempts to provide an overview of the deployment of 3D virtual worlds as alternative learning spaces. The authors discuss the development of technologies supporting virtual learning environments and present how such technologies have been used in a number of pilot studies. The aim of our research was to investigate various aspects of the use of virtual worlds in an educational context. Previous published work focused on architectural aspects of 3D worlds in an e-learning supportive role. Further work attempted a synthesis of aspects relevant to blended learning and the use of Second Life as a supporting mechanism for disabled students.

The use of 3D worlds in blended learning can lead to the investigation of:

(i) educational prospects ensuring assimilation, achievement and enjoyment from e-learning within 3D Virtual Learning environments such as Second Life,

(ii) the effect of 3D virtual architectural design elements of learning spaces on students and their e-learning experience.

The common theme on the above areas is recognising the design characteristics of the learning space as one of the vital aspects recognised in affecting students' physical learning. Our underlying research aim is to attempt the identification of such practices and success criteria virtual architectural design of 3D educational building facilities. There is currently a lack of firm guidelines or a set of criteria helping the development of virtual worlds and addressing architectural issues of virtual buildings used to support learning activities. In line with the research emphasis is the ability to increase the accessibility of the learning space and improve its suitability and desirability to students and staff. The theme is to augment e-learning experience within virtual worlds.

2 ARCHITECTURAL CONCERNS IN 3D VIRTUAL WORLDS

The relevant literature [1] argues that the nature of space in virtual environments (VEs) is fundamentally different from the nature of real space and consequently the architecture of VEs requires new theory and practice. Additionally, since the nature of space in the real world is fundamentally different from space in VEs, designers of virtual spaces should be provided with background knowledge from disciplines relating to issues of virtual reality technology rather than knowledge of technical issues relating to construction in the real world. On a separate note Downs and Stea [2] stated that "human spatial behavior is dependent on the individual's cognitive map of the spatial environment" (the process of acquisition, incorporation and storage of information, available in the environment is called cognitive mapping). It is thus logical to inquire the presence of an impact of the surrounding 3D learning environment on students' behavior and learning in 3D VLEs.

We have experienced different reactions to the developed virtual worlds depending on the domain and participants of the study pilots. The learning activities supported and the cohort size and membership were some of the factors affecting how the constructed buildings were used and perceived.

In the case of a simulation of a real-world place, all spatial entities and objects of the environment are modeled precisely so as to imitate their physical existence. However when we need to design a virtual environment which comprises several spatial entities, which do not necessarily have real-world counterparts and which will accommodate the interaction of the operator with the VE, the design of the VE may benefit by making use of architectural design knowledge [3]. The virtual campus we created for the investigation of how learning is affected by specific issues of virtual architecture and design aspects of virtual worlds was based on such knowledge. Three buildings were used to emulate the experience offered in lecture amphitheatres, classroom based lab sessions and seminar rooms.

Minocha and Reeves [4] categorise 3D building styles as follows:

- Photo-realistic (identical replica of equivalent in reality)
- Artistically-realistic (similar to equivalent in reality)
- Functionally-realistic (has no equivalent in reality but is realistically designed), metaphorically-realistic (implies realistic functions)
- Hybrid (mixture of realistic and imaginative design)
- Fantasy (imaginative design defying reality)
- Abstract (ambiguous design).

The authors of this research provide a comparable categorization as follows:

- Static, Realistic – emulating real life architecture

Emphasis is given to the development of an environment that provides a realistic experience in terms of the whereabouts of the involved students and staff members. Since our focus was to map out the different perceptions of the use of technology we tried to avoid introducing too many architectural 'surprises'. The introduction of a number of variants affecting the learning experience would affect the control of the learning experiments.

3 ADVANTAGEOUS THEMES

In earlier parts of the research investigation we have identified, derived and compared three disadvantageous themes with thirteen major advantageous themes and their sub concepts for using 3D VLEs to deliver education, each theme beneficial in three approaches:

- Proving that 3D VLEs augment and complement traditional learning techniques in physical classrooms to help reach higher educational achievement.
- Proving that 3D VLEs provide additional opportunities and options for e-learning unavailable within 2D Virtual Learning environments such as WebCT and Blackboard.
- Proving that 3D VLEs can, furthermore, not only sustain traditional methods of learning but can offer e-learning prospects that are not probable to achieve using conventional real-life methods of education.

The first approach is typical of the efforts scholars invest in this field where technological advances are tested against their effectiveness in supporting and enhancing traditional learning. The second approach provides a new perspective in e-learning and more specifically the development of visual representation of learning environments. The main difference between these two approaches is that although the first one is concerned primarily with the aims and objectives of the learning activities, the second emphasises on interaction issues in e-learning applications. The final approach deals with the evolution of the educational sector and the provision of new learning paradigms.

A number of benefits of the development and use of virtual worlds and 3D VLE applications in learning and e-learning are discussed in the following thirteen sub-sections.

3.1 Involvement

Definition:

Student participation, interaction and contribution during a 3D VLE e-learning session, comprising the subsequent concepts grouped according a number of classification codes.

<u>As supplement to real life education</u>

- *Active student roles:* New roles emerge as students move from physical campus or online discussion boards to the virtual world classroom. Learning centres on discovery, yet students may feel space confined with a restricted view of their role in the physical classroom.

<u>As benefit over 2D VLEs</u>

- *Object ownership:* The ability to buy or freely possess personalised accessories, buildings, gadgets etc. in each user's individual "in-world" inventory, gives a feeling of belonging and true existence adding to loyalty to the virtual world.
- *Embodiment and sense of belonging:* The embodiment of the user in the form of an avatar and ability to renovate its shape, skin and style, can transform the sentiment towards the space of a virtual world into a sense of belonging to a place.
- *Sense of presence:* The ability to communicate, add face gestures and body movements to the avatar, adds to the sense of presence within the scene.

3.2 Activities

Definition:

Positive actions and behaviour undertaken by students in 3D virtual environments can be categorised into a number of different concepts.

<u>As supplement to real life education</u>

- *Experimentation:* The virtual world opens up opportunities that the physical world does not offer.
- *Exploration:* This also includes exploring new ideas that might be impossible or too dangerous to approach in reality.

3.3 Existence

Definition:

The nature of presence as a user in 3D VLEs varies completely from real life, enriching the e-learning process.

<u>As benefit over Real life Learning</u>

- *Distributed / co-present existence:* 3D VLEs enable immersion by being spaces inhabited by users, who their physical bodies are spread out all over the world and their avatars are in the same space.

3.4 Communication

Definition:

Contact methods during e-learning sessions between students, teachers and transportation between locations, are innovative within 3DVLEs, characterised by several coded concepts.

<u>As benefit over Real life Learning</u>

- *Public and private messaging:* Students can communicate via text or voice, ask confidentially whenever they please, without interrupting others, by corresponding with classmates or teacher via private messaging channels, thus overcoming shyness.
- *Teleporting* can be done in seconds between different 3D sites, whether existing or representations of historical simulations.

<u>As supplement to real life education</u>

- *Alternative communication support:* Using alternative communication support for 3D VLEs via voice in the virtual world, voice over IP, or by means of a conferencing tool.
- *Ease of guest lecturing:* Speakers can also be invited in without their actual physical presence.

3.5 Educational aids

Definition:

Additional methods and objects are available within 3D VLEs to assist delivery of e-learning including the ensuing concepts grouped as follows.

<u>As supplement to real life education</u>

- *Ease of snapshots:* the simplicity of recording pictures for future reference to events / lectures.

<u>As benefit over 2D VLES</u>

- *Cheap file upload* is also available for presentations, images etc.
- *Streaming music* can also be used by instructors during live lectures.
- *Presentations on 3D objects:* PowerPoint presentations and streaming videos can be placed on cubical objects and presented to students in a more interesting manner.
- *Sandboxes to practice building* are used freely by students and instructors in VLEs like Second Life.
- *Supporting all learning styles:* Some people learn best by listening to course content, others by seeing and visualizing, and some using a hands-on approach.
- *3D learning stations and objects:* Learning stations "in-world" can be designed to provide content to students who are absent or who need extra time to study and reflect. Students can take notecards by touching 3D objects, listen to podcasts, or watch streaming video covering lesson material.

<u>As benefit over real life learning</u>

- *Session message logs:* Instant messages can be saved as logs for future reference of lectures.
- *Online assignment submissal:* Students can also submit assignments in the form of notecards easily to teacher by dropping it over his avatar or profile.
- *Program execution in linden language:* Submission of a program assignment can be done in SL Linden scripting language (LSL) to see the program run directly in the environment and working.
- *3D architectural assignments* can moreover be submitted in a virtual environment as 3D models that can be rotated around or entered inside. Students can create any structure, using built-in tools to construct their ideas as a form of virtual sketching. These 3D objects and models help students express ideas and offer a context for discussion during class projects.
- *Engagement in real world issues*: interacting with clients through SL provides insight into the real world through virtual work encounters.

3.6 Interaction

Definition:

Different types of networking options between users are offered in 3DVLEs, characterised by certain key concepts

As supplement to real life education

- *Social spaces* existing within 3D VLEs provide successful shared communities. These are also *cultural spaces* opening up opportunities to truly engage and communicate with others to learn about different customs, behaviours and ethnicities.

As benefit over real life learning

- *Networks of distant users* can be created for the sharing of skills and knowledge through blogs, wikis and knowledge repositories.
- *Network evolution and Future group work:* Any network within a 3D VLE can develop and increase in size with time to include people from many backgrounds or collaborative universities.
- *Instructor practical role shift:* In virtual worlds, the instructor's role shifts from being the "sage on the stage" to being the domain specialist or facilitator.

3.7 Security

Definition:

User identity protection and account safety are vital issues within 3D VLEs, demonstrated a number of concepts

As supplement to real life education

- *Anonymity safety*: The sense of safety through anonymity of a user's identity.
- *Username & password*: environments necessitate authorisation of the participant in the form of a user name and password.
- *Free registration* to 3D VLEs is available for student users.

3.8 Output

Definition:

The degree of productivity of courses within 3D VLEs can be assessed through two main concepts.

As benefit over 2D Virtual Learning Environments

- *Immediate instructor feedback* within the synchronous class experience in a 3D VLE.
- *Early assessment of course* can be performed by students since the learning process and measurement instruments are observable.

3.9 Educational Strategies

Definition:

3D learning environments can provide innovative instructional techniques, methods or archetypes for facilitating learning.

As benefit over 2D VLEs

- *Classroom emulation* allows for re-creation of the physical classroom environment within the 3D world.
- *Game based learning - treasure, scavenger hunts:* With little time and a lot of content to cover, one way to realize effective learning is to use game-based techniques to pique students' interest especially with the resemblance in appearance of 3D VLEs with game settings [1].
- *Role play:* enacting or assuming an alternate character to oneself is a widely employed learning technique which can also occur virtually within a 3D VLE.

- *Guided Tours* are used to show learners in a 3D synchronous environment the location of items and features within an area. A tour can be led by the instructor or it could be a pre-programmed item the avatar carries with him that takes him on a virtual "guided tour" without the need for a live person.
- *Conceptual Orienting:* learning to create plans, e.g. for business, entails providing the student with examples and non-examples of a concept and then allowing him to determine the attributes that do and do not apply to the concept.
- *Operational Application:* This is "learning by doing" in the virtual environment. Students must follow the regulations and constraints of the physical world to achieve a goal. The facilitator monitors the students and then makes remarks or commendations.
- *Joint Co-Creation:* This is when more than one person collaboratively craft items within the 3D world.
- *Critical Incident involvement:* students are positioned into an environment or predicament analogous to the real situation, where they have to use their former knowledge to resolve a problem.

<u>As benefit over real life learning</u>

- *Practical training:* Students get the chance to be given real life situations to train at within a 3D VLE allows them to brainstorm together.

3.10 Performance

Definition:

Speed, efficiency, quality of technical connectivity and delivery issues online while using 3D VLEs for e-learning are palpable through the following concepts.

<u>As a supplement to delivering real life education</u>

- *Faster MONO virtual machine:* on August 29, 2008, the entire production grid of SL was updated to being able to use the Mono Virtual Machine (VM). The LSL scripting language remains, but executing on the Mono VM gives up to 220 times speed increase, reduced lag and improved stability [19].
- *Dot-net languages' support:* An additional benefit is that any dot-net language that compiles to the Mono VM can be uploaded to execute in SL.

3.11 Setting

Definition:

The importance of the surrounding environmental arrangement and background settings of the spaces, where educational sessions are held within 3D VLEs, constitutes the following succeeding concepts.

<u>As benefit over real-life physical learning conditions</u>

- *Untraditional class settings,* including non confinement to having chairs facing forwards, helps revolutionize to capture students' attention by moving freely within the learning environment, putting chairs or sitting in any position without affecting the view.
- *Easy class management* can be attained, for few problems can arise from noisy interruptions of students since communication is either text-based or even with audio transmissions, only one person can talk on the system at a time. Instructors can also block or remove inappropriately behaving students.

3.12 Perspective

Definition:

The viewpoint and angles of perception of a user within a virtual 3D space are essential factors denoted by the consequent encoded concepts.

As benefit over 2D Virtual Learning Environments

- *Customisation and conceptual imagination of avatar:* As mentioned before, alteration of the personal representative avatar in the virtual world allows for the user's identification with it.
- *Virtual reality versus virtual world view:* The option of changing between virtual reality view (in first person by looking through the eyes of the avatar within the environment) or as a virtual world view (in third person by watching the avatar move) can change the feeling of immersion in the environment.
- *Adjusting cameras and lighting:* This can be done by adjusting cameras/ lighting etc within the 3D environment to change the angle of perception of the real user within the 3D VLE despite the position and direction of the avatar.
- *Day and night settings* can also be customised within a 3D VLE according to users' preferences.
- *Attractive 3D graphical setting:* The three-dimensional (3D) graphical settings themselves are very attractive and vivid for users.

As benefit over Real life Learning

- *Viewing and hearing from any position:* Viewing and hearing any part of the learning space from any angle with clarity, regardless of the position of the avatar (even if seated behind the lecturer), eliminates the need, like in real-life, to sit near an instructor or find acoustic solutions for hearing a lecture.

3.13 Locations

Definition:

There are multitudes of places to visit and learn from, in 3D VLEs.

As benefit over real life learning places

- *Imaginary, dangerous, historical or unreachable places:* Students are able to examine and explore a variety of places that are imaginary or difficult to reach or teach in.

4 METHODOLOGY

The authors have followed a practical grounded theory approach and the presence of three advantageous themes for using 3D VLEs to deliver education to disabled users are supported by evidence:

- Proving that 3D VLEs augment and complement traditional learning techniques in physical classrooms to help reach higher educational achievement.

- Proving that 3D VLEs provide additional opportunities and options for e-learning unavailable within 2D Virtual Learning environments such as webCT and Blackboard.

- Proving that 3D VLEs can, furthermore, not only sustain traditional methods of learning but can offer e-learning prospects that are not probable to achieve using conventional real-life methods of education.

The fundamental difference between the physical and virtual worlds are important to identify since in the later (i) there are no constraints on budgets, (ii) no engineering natural forces and material strength limitations, (iii) no infrastructure requirements, sound, ventilation regulations or even gravity which can be defied to have 3D virtual buildings floating in midair or immersed under the deepest ocean. Such innovative construction techniques have also been used to erect virtual university campuses in 3D VLES to produce a wide variety of designs from realistic depictions or replicas of physically existing campuses, to completely imaginative embodiments. The development of virtual educational environments has proved an attractive challenge for institutions and educationists that are seeking to reap the benefits of the virtually limitless architectural exercise. The lack of cost and other constraints allow educational efforts to expand the horizons of learners and provide a plethora of opportunities in supporting learning activities of various natures.

An important aspect of such activity has been identified by the authors in the sense that there is no academically conducted research that directly correlates between the new e-learning blended learning techniques sprouting within 3D VLEs, and the design specifications of the 3D virtual spaces within which this e-learning is taking place. It is yet unclear how design specifications impact on the effectiveness of e-learning in 3D VLEs. One of the factors that have been proven to affect learning in the physical world, the degree of assimilation of knowledge, achievement and enjoyment of students from education, is the architectural design and physical building characteristics of the space. The concept of space is described as the environment in which students learn in, involving elements that affect accessibility and satisfaction from this space. Such design features include color, texture, dimensions of space, lighting, and ventilation amongst others. On the other hand, sparse study explores the effect of 3D architecture in virtual worlds in general on users, as well as their satisfaction and contentment from it. Our current research focuses, on closing this gap by raising the query on and capturing the specific architectural design elements of virtual educational buildings within 3DVLEs. We seek to develop a mapping of those elements, proposed by students to provide satisfaction and contentment from their e-learning session, hence giving the opportunity to issue recommendations for future learning space enhancement.

The methodology we have followed is based on the gathering of data from a series of e-learning experiments set in pilot studies classified against two main criteria. First we have identified different e-learning opportunities that can be borrowed for such an investigation consisting of several learning activities such as lab sessions (designing an entity relationship diagram) and seminar exercises (investigating a possible crime scene and identifying clues). The pilots were also directed towards administrative and academic members of staff who were able to assess such an environment in terms of providing support to aspects of their role that could potentially shift in the 3D VLE.

Learners are divided into three groups (i) under-graduate students, (ii) post-graduate students, and (iii) adult learners and researchers. Data collection techniques included surveys to demonstrate students' perception of the visual qualities of the spaces, preferences and suggestions for a better learning environment. Data analysis focused on in this study involves comparing satisfaction results attained from the identified three groups of learners, subsequently examining the impact that this might have on a student's blended learning experience. Moreover this research can help initiate the development of a framework or recommendations for building codes, for educational facilities within 3D Virtual Environments, to complement existing codes for erecting such facilities in the physical real-life world.

The results of this research disseminate recommendations for possible applications of the technology through the use of a variety of educational scenarios in 3D Virtual Learning Environments. The key contribution is to initiate discussions, trigger debates and offer brainstorming opportunities for students with respect to the use of such assistive technologies in Higher Education. Additionally, this study offers insights in preliminary stages for defining the effect of environmental factors on a disabled student's e-learning experience within 3D Virtual Learning Environments. More specifically the use of 3D VLEs could address issues relating to learning & technology, open educational resources and inclusion.

5 PILOT STUDIES

In this section a number of figures is used to discuss some key aspects of the pilot studies that surfaced while assessing student behavior during significant changes in the architecture of the 3D VLE settings. The main activities students engaged with included discussions in seminar sessions to clarify coursework elements and the delivery of the specification required for a group projects involving geographically dispersed students required to collaborate over time zone differences.

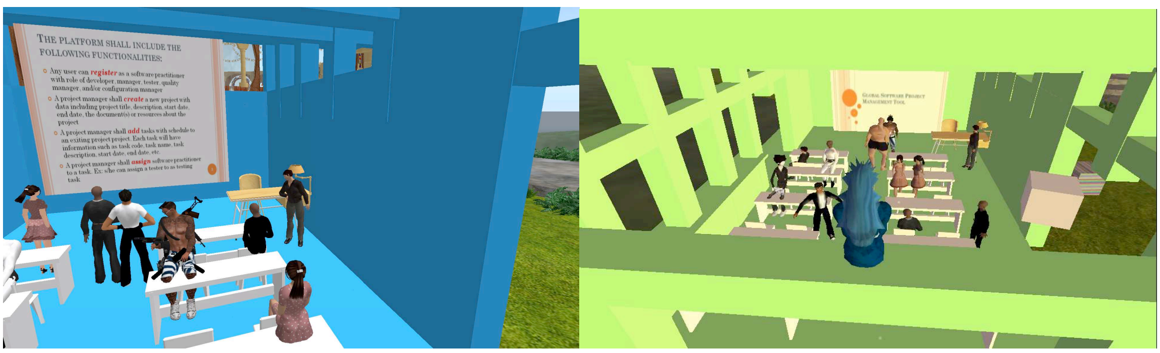

Figure 1 – Colour variation

Figure 2 – Space perception

Figure 1 provides an interesting perspective of how the frequent change in the colours of the associated building affected the learning activity. Students engaged in discussions and followed the slide show while the colour changes were taking place. It became evident that the disruption was not just the frequency of change but also how the colours blended with the learning environment. An interesting perspective was how the students decided to accessorise themselves with different artifacts which freely exchanged during the session including rockets, bicycles and even guns! The user in figure 2 provided an opportunity to realise that the environments offered an opportunity for isolation if required and removal of traditional constraints in terms of body posture and positioning in the classroom. It was possible for this student to detach herself from the rest of the class and concentrate on the activity. An interesting finding was that she treated her avatar as a traditional body that needed to be physically present in the space where the session was taking place. Others decided to stay with the session through the discussion while their avatar wondered to other parts of the virtual campus.

The following snapshots (figures 3 and 4) concentrate on the shape of the seminar room and effects of textures changing in the walls, ceilings and floors. The more traditional setting in figure 3 offered an environment where students decided they wanted to sit down and attend the discussion. Once the comfortable seating was available in figure 4 with the removal of floor and ceiling textures, students decided to disengage their bodies and wonder around exploring what was available. An interesting perspective was the amount of time spent by each student adjusting their external appearance and the fact that nudity was an option they wished to explore…

Figure 3 – Facing direction

Figure 4 – Freedom of movement

The following figure 5, demonstrated that parallel activities such as asking questions, engaging in group discussions and taking surveys was possible but also affected the learning experience as students had to move their avatars to certain parts of the 3D VLE. The lack of boundaries in figure 6 demonstrates how students chose to fly immediately after the traditional walls and other constraining structures became transparent!

Figure 5 – Parallel activities

Figure 6 – Lack of boundaries

6 CONCLUSION

Our initial investigation of using 3D VLE in educational settings and e-learning pilot studies has offered a plethora of anecdotal evidence which we are trying to group together into a meaningful set of guidelines. Such supporting mechanisms are proving essential to a field that is still in its early stages.

It is critical to understand how architectural features affect the learning experience in virtual worlds and establish a code of practice for those who wish to build and explore such settings.

REFERENCES

[1] Bourdakis, V. & Charitos, D.: "Virtual Environment Design; Defining a new direction for architectural education", in Brown, A., Knight, M. & Berridge, P. (eds.), "Architectural Computing: From Turing to 2000", Proceedings of the 17th international eCAADe conference, Liverpool, ISBN: 0-9523687-5-7 (1999).

[2] Downs, R.M. and Stea, D.: Cognitive Maps and Spatial Behaviour: Process and Products, in Image and Environment. Downs, R.M. and Stea, D. (eds). Edward Arnold. London (1973)

[3] Charitos, D.: Defininining Existential Space in Virtual Environments, Proceedings of the international conference: Virtual Reality World 96, Stuttgart: IDG Publications (1996).

[4] Minocha, S., Reeves A.J.: Interaction design and usability of learning spaces in 3D multi-user virtual worlds, Human Work Interaction Design 2009, Pune, India, (2009)