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Report to the College of Engineering:

A comparison of 3D immersive worlds for teaching and learning of Distance Education Students

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Abstract

Synchronous e-Learning (people learning something together at the same time, but not in the same place) and the constant development of such online opportunities for Distance Education (DE) students will possibly follow the same way as WWW already does. However the concept of teaching and socializing in 3D Virtual World needs a thorough searching to identify the new challenges for the educators, the new characteristic of these environments and what does the future hold in correlation with the evolution of 3D Web. Our research both from the engineering and the educational point of view suggests that 3D immersive virtual worlds support deep learning and help learners make meaning in ways similar to those used outside of virtual environments. In the following we are identifying some educational patterns that should be followed when 3D Worlds are used; we are comparing some of the well known VWs and extending the role of Virtual Computing Lab (VCL) from a static remote desktop application to a socializing and cooperative platform.

E-learning

In today's worlds of corporations and employees re-engineering themselves to keep up with an ever changing economic, and market environment, training has become one of the top issues. Universities in a similar pace are trying to offer newer methods for more efficient education. Thus internet education is gaining stronger and stronger recognition due to its specific benefits over traditional classroom teaching [8]:

- Flexibility: Available anytime, anywhere
- Learning type accommodates different types of learning styles
- Cost savings
- Allows for "self paced" learning
- Provides just-in-time Learning

There are many approaches and definitions of E-learning and with the computer/technology development even more tools are offered to the students to use throughout their learning process. Matt Comerchero introduces e-learning as a means of education that incorporates self-motivation, communication, efficiency and technology. Also he mentions that now Distance is eliminated because e-learning content is designed with media that can be accessed from properly equipped computer terminals and other means of Internet accessible technology [7].

However there are also some disadvantages of the e-learning process that have to be identified:

- Learners or students need to have access to a computer and internet, and to have basic computer learning skills

- Students need to be highly motivated because most of the work they do is on their own. Moreover without the class routine structure, students may get lost or confused about course activities and deadlines
- Another disadvantage is that students may feel isolated from the instructor. Instructions are not always available to help the learner so learners need to have discipline to work independently without instructor's assistance

Transitioning from 2D to 3D Synchronous e-Learning

Some of the e-learning disadvantages mentioned before were tried to be solved with the synchronous 2D learning method. The student can be anywhere, may log in into his computer and watch the demonstration of the instructor. The notion of synchronous makes the e-learning process an interactive process where the students can choose both from voice, chat, text and sometimes even raise hands. Other tools have been also introduced such as white boards, breakout rooms, application sharing and Q&A, which help drive interactivity.

Recently however the evolution of technology let the educators add one more dimension to the synchronous e-learning process. Now the student is truly an actor of a virtual world, in which he does not only watch and participate, but also interacts. 3D Synchronous Learning, because of its truly immersive qualities, interaction is not disembodied and serial: it is embodied and parallel.

In [9] the notion of interactivity (I) and Immersion (I) to achieve Engagement (E) that compels learners and essentially teaches them the content is depicted by an equation

$$I*I=E$$

Then they are identifying seven sensibilities that differentiate the way 3D synchronous learning contextual learning experience is provided to the user: 1) Sense of Self, 2) the Death of Distance, 3) The Power of presence, 4) the sense of space, 5) the capability to co-create, 6) the Pervasiveness of Practice and 7) the Enrichment of Experience

Sensibility	2D Synchronous Learning	3D Synchronous Learning
Sense of Self	Emoticon	Avatar
Death of Distance	Same Time Same Website	Same Time Same Virtual Space
Power of Presence	Disembodied	Embodied
Sense of Space	Website/Slides	Virtual Space
Power to Co-Create	Document	Display

	Presentation	Building
Power of Practice	Exercises	Exercises Activities
Enrichment of Experience	Interaction	Interaction Immersion

Properties for Education in 3D Virtual Worlds

In the following we are analyzing some of the new properties when education is offered through a 3D virtual tool and finally how are introducing the notion of presence, and how the distance between the instructor and the student is minimized.

- *Shared Experience and Shared Learning*: As shared experience is defined the interactions of people from different places at the same world (time and place are the same for all users). As shared learning we define the engagement of multiple users in educational activities. Thus live Virtual 3D Worlds enable rapid knowledge sharing and instant access to information.
- *Co-creation and Collaboration*: Users can collaborate on the same document/file on the same time, as they were doing in real life. Social rules, such as who writes first, are similar to real life thus coordination is easier than traditional tools.
- *Social Environment*: 3D Worlds can be places were students and teachers can "hang out" and can exchange information while being at home. They allow users to establish interconnected communities and form an unlimited knowledge base. This concept converts the traditional online teaching methods to a social experience.
- *Innovation and Simulation*: the capability of co-creating and collaborating leads to the concept of virtual innovation. Students in a more flexible world can innovate and learn. They are capable of making simulations, getting feedback, demonstrating complex concepts and inviting others to participate in their scientific/artistic creations.
- *Incentives*: Participating in a 3D world is similar to participating in a social real time event. Socializing with other people may create incentive for students to learn and find people that have similar interests or find experts on a field of study.
- *Informal Learning*: VWs are the best places for a user to acquire knowledge randomly else called Informal Learning process and is defined as the learning process that takes place serendipitously, by random chance.
- *Use of Avatars*: Avatars are the Virtual People (the user's image on this world). Thus the learning experience is personalized and increases user's interaction and involvement.

Educational Challenges

Using VWs as a collaborative and socializing platform can provide great opportunities for the education of Distance Education students. However there are various challenges that the educators are going to face.

Technical Requirements and knowledge: 3D VWs require advanced graphic representations and thus the user PC must be equipped with the appropriate graphics processor. Similarly multimedia input/ouput devices (Speakers & Microphones) are prerequisites and have to be tested before beginning any session, course or lesson.

Internet Accessibility Issues: High Bandwidth Internet connection is also required. Especially for sessions with many people, Internet Bandwidth is an issue so that everybody can collaborate without significant lag.

Steep learning curves: Cooperation and co creation in virtual world may increase the learning curve to an unexpected level compared to legacy methods.

Dealing with troublemakers: Troublemakers can be divided into two categories, internal and external. Internal troublemakers are those people that are willing to help or are creating "noise" through e.g. an echo in their speakers, an open microphone, different technology perception level etc. External troublemakers are those people that participate in the session in which they do not belong (sometimes they can be eliminated by not providing access in a virtual place but there are also cases in which the instructor does not have the authority to lock a virtual room).

Difference between real and virtual collaboration: Participation in a virtual session tests the ability of the students to socialize and interact through a different world than the reality. Some of the social rules alternate and thus the students and the instructor must have identified them in order for the session to be successful.

How to Design Experiments in Virtual Worlds

Through our applied trials we have identified that as part of the initial step most of the session problems can be eliminated by providing a tutorial of VW functionalities and by defining the rules of the participation in the session.

VWs learning environment is not only based on what the students absorb from the instructor during the session, or during a virtual exercise, but also on the engaging experience. So when designing sessions and exercises in VWs, it is of primary importance, that the learner is leaded to an optimal flow to assimilate the desired by the instructor experience. To understand this better, we have to identify two worlds that are now interacting with the user. Since the environment of the Distance Education Student is not controlled (as in classroom) there are interactions with the real world (e.g. door bell, loss of connectivity), and interactions of the virtual world (e.g. a friend is chatting during the session). The sessions and exercises have to be designed in such a way that even if the flow is interrupted the learner has the capability to reengage with the learning process.

Another interesting aspect is the well known learning curves. Now learning curves have been transformed into “experience curves” and the challenge for the instructor is to identify the “experience curves” of each student separately since they tend to differentiate from user to user. These curves are now based on how well the student is interacting, socializing and acting towards the defined goal, also on how the student is overcoming from a failure to finally achieve the learning outcome.

So the main parts of designing these experiments are:

- Provide a VW social tutorial before the experiment
- Specify the right virtual environment and the limits
- Allowing small group interactions and collaborations (social networking)
- Encouraging co-creation or demonstrations in the VW
- Build in inceptives

Some other tools could be creating a protocol that should be followed and set surveys to assimilate the students opinion and identify the “experience curves”.

Comparison of Virtual Worlds

A. Second Life [1]

Second Life is 3D Virtual World developed by Linden Labs, in which everyone can create an account and participate in a VW where people socialize, educate, listen to music, shop and generally follow virtually everyday habits. Second Life (SL) is said to be the biggest and most profitable VW, where thousands of people sign in everyday and millions of dollars are spent in each marketplace (SL translates US dollars to Linden dollars as virtual currency). The following table maps numbers its social and market base.

Statistics (June 2007):

- **Total accounts:** over 7.2 million
- **Active users:** approx. 720,000 (10% of total)
- **Premium (paid) accounts:** approx. 90,000
- **Peak concurrency:** approx. 47,000
- **Average concurrency:** approx. 30,000
- **New signups a day:** approx. 26,000
- **Age:** average is 30 (was 37 in 2006) with approx. 16% over 55
- **Gender balance:** 57% are men, 43% are women
- **US$ spent every 24hrs:** approx. $1.7 million

The great advantage of SL is the market and social acceptance (all the known brands have a VW department in SL and 720,000 people co-participate in this world and generate new content). SL has an easy tool to create objects and write scripts for the performance of these objects. A great library of the educational perspective of SL can be found in [3]

Education Point of View

Non-Engineering Courses: SL can be an excellent tool for those courses that are based on socialization, innovation and cooperation through the use of basic application material (Presentations/Documents*).

Engineering Courses: SL can be hardly used by engineering courses since the users cannot share their own desktop applications; simulations are not also able to run through SL. Another main drawback is the Server Dilemma, which limits the computation capability of SL, as mentioned in the Appendix.

B. Protosphere [4]

Protosphere is a product offered by Protonmedia. For our trial settings we used the demo version that is provided in their webpage. The concept that Protosphere was created is different than that of Second Life. It is a commercial product specifically for education/business collaboration and for that reason does not have the social acceptance of Second Life since it is addressed to other group of people. Socialization is done in a smaller scale but has a very robust tool called AppShare, in which every application of one computer can be shared among the peers. The other peers can grant control of the instructor's computer and use all of its resources. Protosphere can be a very valuable tool, for accessing central powerful mainframes where simulations are run, such as the VCL.

Educational Features

- Application Share tool (called AppShare)
- Whiteboard
- Live Match (a search tool that can find peers working on the same subject and connect in Protosphere)
- Organize courseware

Fig.1 Using a Network Simulator on a VCL blade through Protosphere

C. Qwaq [5]

Qwaq is based on Croquet which is an Open source 3D immersive platform. It features a peer-based network architecture that supports communication, collaboration, resource sharing, and synchronous computation between multiple users on multiple devices without the need of a central control. Croquet's time-based synchronization capabilities enable real-time, identical interactions between groups of users while dramatically reducing the need for server infrastructures to support virtual world deployment.

Qwaq architecture makes it easy to develop deeply collaborative applications without having to spend a lot of effort and expertise in understanding how replicated applications work. The Qwaq application is very simple in its use and does not suffer from the client server model, since all the computations are done locally on each computer. Qwaq's unique fine-grained sharing control (called Qwaq Multi-Share™) allows multiple users to edit a document or use an application GUI in an intuitive manner at the same time. All users see interaction with the application in real-time.

Fig. 2 Network Performance Research Group Laboratory Room on Qwaq

<u>Educational Features</u>

- Can share most of the well known file formats both as 2D and 3D type
- Data encryption: all traffic between peers is encrypted to ensure privacy
- Build-in webcam support

- **Drag and drop content import.** Share Microsoft Office documents created with Word, PowerPoint and Excel; Adobe PDF files, images, and even 3-D content by dragging from local folders into a Qwaq Forums space.

	Second Life	Protosphere	Qwaq
Avatar Customization	Y	Y	N (only photo)
Application Sharing	N	Y	Y
Application Collaboration	Not applicable	2D (only Full Screen)	2D & 3D
Free to use	Y	N (Free Demo 30d)	N (Free Demo 30d)
P2P architecture	N	N	Y
Presentations	Y (JPEG)	Y (PPT)	Y (PPT)
Servers Dilemma	Y	Y	**N**
Simplicity to use	M	M	H
Text Chat	Y	Y	Y
Video (WebCam)	N	N	Y
Voice	Y	Y	Y
Uploading Files	Y	N	Y

Y: Supported N: Not Supported

L: Low M: Medium H: High

VCL over 3D collaborative tools

Our main objective was to transform the Virtual Computing Lab (VCL [6]) from a static reservation scheme, to a collaborative platform in which multiple users can access the same machine at the same time. Thus single reservations for single persons will be transformed to single reservations for multiple people. During our course we showcased to the students how they can collaborate through Protosphere in a Remote Desktop machine. A 2hour session was followed in which every student could participate in a simulation example through VCL.

However crucial questions are emerging related not only to efficient and scalable use of resources but also with respect to the best way to enable social interactions for collaborative work among and between students and faculty. Collaborative social computational environments such as virtual worlds and the networking capabilities that support them, present an entirely new way for users to interact and work together. How exactly people will collaborate and work effectively within collaborative simulations and virtual worlds is poorly understood. We expect that the progression from static two-dimensional Web 1.0 technologies to dynamic collaborative simulations/virtual worlds and Web 2.0 and 3.0 technologies will transform the nature of collaborative work. In the following figure we showcase our vision of the web evolution closely correlated to the next version of VCL.

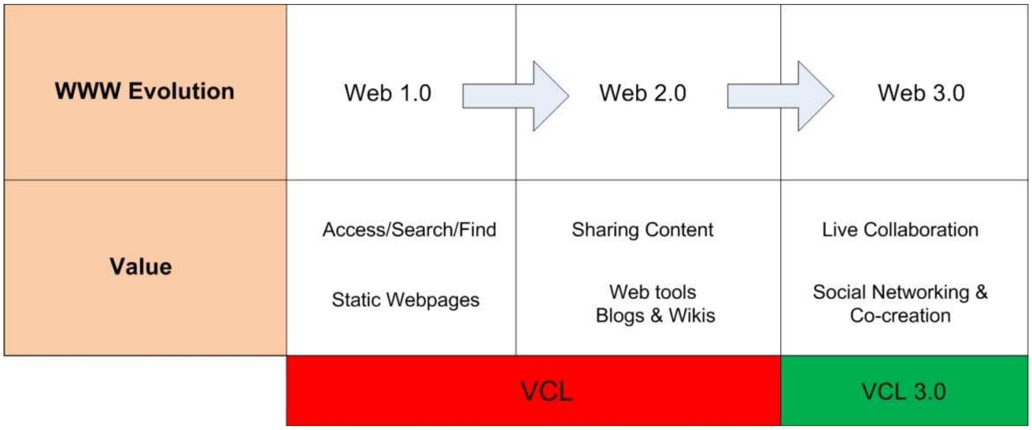

Fig.3 Our vision towards the evolution of VCL

Future Perspective

With our virtual trials we initially set this technology pace of transforming the future internet education. As a future perspective, we are going to investigate a multi-disciplinary research approach to understand the requirements of virtual environments, and their enabling network infrastructures, to support deep collaboration, scientific exploration, and discovery within virtual organizations. From the technological point of view it seems that education through 3D environments will use more and more materials from Virtual Reality, artificial intelligence and mobile wireless networking. We also believe that the integration between traditional synchronous learning systems such as WebEX, Centra, Adobe Connect, Citrix and 3D Avatar-Mediated platforms is not far away.

Conclusion

Our experience through this integration is that 3D VWs provide an engaging and entertaining learning experience. Students are faced with a variety of real-time situations in which they can make their mistakes and be guided correspondingly. This enhances their ability to project themselves into the activity, and goes belong traditional ways of learning. In our study, we investigated new challenges for the educators, the new characteristic of these environments we compared three prevailing 3D virtual worlds and provided to the Distance Education students a collaborative solution with the aid of VCL.

References

[1] http://secondlife.com/

[2] Article Second Earth, MIT Technology Review, July-August 2007

[3] http://sleducation.wikispaces.com/educationaluses

[4] http://www.protonmedia.com/

[5] http://www.qwaq.com/qwaq_forums.html

[6] vcl.ncsu.edu

[7] “E-learning concepts and techniques”, Ebook from Institute of Interactive Technologies, Bloomsburg University of Pennsylvania, USA, 2006
http://iit.bloomu.edu/Spring2006_eBook_files/ebook_spring2006.pdf

[8] http://www.study-center.com/welearn.asp

[9] “Escaping Flatland”, Karl Kapp, Tony O’ Driscoll, Guild Research 360 Report on Synchronous learning systems.

Appendix

The Servers Dilemma (From [2])

This reimagining of the real world can go only so far, given current limitations on the growth of Linden Lab's server farm, the amount of bandwidth available to stream data to users, and the power of the graphics card in the average PC.

According to [Cory] *Ondrejka* [Linden Lab's now former CTO]*, Linden Lab must purchase and install more than 120 servers every week to keep up with all the new members pouring into Second Life, who increase the computational load by creating new objects and demanding their own slices of land. Each server at Linden Lab supports one to four "regions," 65,536-square-meter chunks of the Second Life environment--establishing the base topography, storing and rendering all inanimate objects, animating avatars, running scripts, and the like. This architecture is what makes it next to impossible to imagine re-creating a full-scale earth within Second Life, even at a low level of detail. At one region per server, simulating just the 29.2 percent of the planet's surface that's dry land would require 2.3 billion servers and 150 dedicated nuclear power plants to keep them running. It's the kind of system that "doesn't scale well," to use the jargon of information technology.*

But then, Linden Lab's engineers never designed Second Life's back end to scale that way. Says Ondrejka, "We're not interested in 100 percent veracity or a true representation of static reality."