A Comparison of 3D Collaborative Virtual Learning Environments:
OpenSim vs. Second Life

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ABSTRACT

This paper focuses on 3D Collaborative Virtual Learning Environments, examining the state of the art in both open source and proprietary software. Issues pertaining to the use of open source Collaborative Virtual Learning Environments are discussed, rationalizing the choice of executing a collaborative learning scenario in Second Life. The scenario is then presented and evaluation results assess the appropriateness of the chosen platform with regards to its technical and pedagogical affordances. Finally, students' suggestions and reactions towards such a novel didactical approach are discussed.

Keywords: *3D Virtual Learning Environments, Collaborative Learning, OpenSim, Open Source Learning Environments, Second Life*

INTRODUCTION

Collaborative Learning (CL) is a general term used for the description of educational practices based on the simultaneous cognitive and mental effort of multiple students or/and educators. Students share a common goal, depend on each other and they are mutually responsible for their success or failure.

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Research (e.g., Vygotsky, 1962) has led to several educational theories, such as those of constructivism and social learning. Vygotsky, who is the main supporter of social learning theories, states in the basic principles of his theory that "learning and developing is a social, collaborative activity".

Contemporary research (i.e., Bruckman & Hudson, 2001; Dillenbourg, Baker, Blaye, & O'Malley; 1996), has proven the effectiveness of utilizing collaborative learning in specific situations in comparison to other educational practices (e.g., competitive or personalized learning). It seems collaborative activities centered on a cognitive goal and supported by experts, result in the more meaningful and efficient acquisition of knowledge.

The potential pedagogical benefits of collaborative learning, in general, are multiple and varied. Through this pedagogical approach, students can be stimulated to negotiate information such as abstract, ill-defined and not easily accessible knowledge and open-ended problems. Also, collaboration enables the discussion of complex problems from different perspectives and supports learners in the elaboration, explanation and evaluation of information in order to re- and co-construct new knowledge or to solve problems (Veerman & Veldhuis-Diermanse, 2001).

The main problem in the application of collaborative learning is the lack of engagement, which can be attributed to the absence of interactivity and challenge. Failing to stimulate learners, makes the collaborative experience unattractive and discourages progress. To counter this issue our main purpose is to exploit the advantages of Collaborative Virtual Environments (CVEs).

A CVE is a computer-based, distributed, virtual space or set of places. In such places, people can meet and interact with others, with agents, or with virtual objects. CVEs might vary in their representational richness from 3D graphical spaces, 2.5D and 2D environments, to text-based environments. Access to CVEs is by no means limited to desktop devices (Churchill, Snowdon, & Munro, 2001), but might well include mobile or wearable devices, public kiosks, etc.

From studying the pedagogical benefits of collaborative learning, we can surmise that the most important factor in designing a CVE is the catering for immersion. Immersion happens through four processes of engagement: interest, involvement, imagination and interaction (Burbules, 2004). For the digital generation, these four aspects are to some extent shaped by their engagement with technology and the media. Therefore, educators seeking to attract and retain student attention will have to learn from what makes those environments so appealing to contemporary students.

Compared to tools supporting traditional teaching methods, CVEs have many advantages (Bruckman & Hudson, 2001). In addition to supporting real time distance learning, advantages can vary from student motivation and amusement to the simplification of the development of cognitive models from complicated or abstract material. CVEs let users experience environments, which, for reasons of time, distance, scale, and safety, would not otherwise be available, especially to those with disabilities (Muller & Koubek, 2002).

In addition, CVEs could be useful for supporting Complex Learning approaches. According to Guglielman and Vettraino (2007), "Complex learning represents the hybridization of environments, languages and interaction in a learning community composed of the whole world wide web" (p. 1). The contribution of a CVE to this hybridization is the support of distance learning and collaboration services along with traditional lectures in a class of students.

This paper focuses on a specific category of CVEs that aims to support Collaborative Learning. We call these environments Collaborative Virtual Learning Environments (CVLEs). According to Bouras and Tsiatsos (2006), a CVLE can be defined as an environment in which:

- The users participating have different roles and privileges.
- The educational interactions in the environment transform the simple virtual space into a communication space.
- The information in the environment is represented in multiple ways, which can vary from simple text to three dimensional (3D) graphics.
- Students are not passive users but they can interact with each other and with the virtual environment.
- The system that supports the environment integrates multiple technologies.
- The possibility of implementing multiple learning scenarios is supported.

- Recognizable elements from the real world are visualized.

Depending on the instructional methods employed, CVLEs can support constructivist learning, in terms of distributed and situated learning (Dieterle & Clarke, 2006). A virtual learning environment can distribute knowledge and cognition among various artifacts (such as tools and virtual objects), students (for example when collaborating to solve a problem, or when performing an experiment) (Perkins, 1992), and symbols. It introduces new possibilities for scientific thinking and representational methods through the avatar's existence in the virtual space. In other words, students learn while associating with other novice or experienced participants of the learning community (Barab & Duffy, 1998).

However, regarding CVLEs, there are many issues to be resolved. For example, many practitioners and researchers have concluded that totally free, unguided or unstructured collaboration does not necessarily result in productive activity or learning (Kreijns, Kirschner, & Jochems, 2003). Also, students perform better in a virtual environment with guided exploration, independent from their learning style (Zaharias, Andreou, & Vosinakis, 2010). This is a result that highlights the consequence of virtual world design decisions on learning outcomes.

Other main issues include:

- The selection of a suitable CVLE among the wide range of CVLE platforms. One of the strongest arguments against the use of virtual reality for education is that the software and equipment require technical expertise and skills beyond that of most teachers (Winn, 2002).
- The design of a CVLE on top of the selected process. Designing a Computer Supported Collaborative Learning (CSCL) environment is not just a matter of taking a technological tool, an instructional approach supporting collaboration and an approach to studying its effects and putting them all together. The challenges to instructional designers are creating motivating goals and tasks for students to perform and choosing educational topics and concepts where the 3D visualization and simulation have clear advantages compared to traditional presentation formats such as slides, articles and diagrams (Prasolova-Førland, 2008).
- The organization of an effective evaluation process not only to uncover usability and functional problems but also to assess the potentiality of CVLEs to support collaborative learning scenarios. At present a systematic approach to the design of CSCL environments is missing (Strijbos, Kirschner, & Martens, 2004). More research is required on the relationship between a theoretical framework and the educational design of a CSCL setting.

The main goal of this paper is to examine whether it is possible to implement traditional collaborative learning activities in a 3D CVLE by evaluating the issues that hinder collaboration. These issues are usually related to the functional and pedagogical characteristics of 3D CVLEs, which foster collaboration among students. In addition, we are investigating the suitability, in terms of functionality and usability, of multiuser 3D platforms for supporting the completion of a collaborative project by postgraduate and undergraduate students. Second Life and OpenSim are the multiuser 3D platforms on which the case studies took place.

Initially, this paper presents some open source and proprietary CVLEs and then analyzes the problems encountered in trying to implement a collaborative activity through their utilization. These problems rationalize our attempt to implement the collaborative activity in the Second Life platform. After we discuss the design of our collaborative e-learning environment within the chosen platform, we proceed to present its evaluation. Conclusions and future work are presented in the final section.

Presentation of 3D Collaborative Environment Platforms

In this section we present the state of the art in 3D collaborative learning environments. The presented CVLEs were chosen based on their popularity, proven educational and collaborative value (e.g., Bedford, Birkedal, Erhard, Graff, & Hempel, 2006; Ang & Wang, 2006), respective user testimonials and support of the generic features and advantages of current systems. Specific selection criteria for a 3D CVLE can be found in Tsiatsos, Konstantinidis, and Pomportsis (2009).

- **Active Worlds:** In Active Worlds (http://www.activeworlds.com), users can visit 3D virtual environments, communicate with others and create their personal virtual space. The educational capabilities of Active Worlds have been explored by a learning community known as Active Worlds Educational Universe (AWEDU) which provides educators, students, educational institutions and individual programs with the Active Worlds technology. Through Active Worlds, educators can assess new ideas, learning theories and teaching methods and discover new paradigms in social learning. Institutions already using Active Worlds include the Boston Museum of Science, the San Jose Tech Museum of Innovation, the NASA Ames Research Laboratory and many others.
- **Croquet:** Croquet (http://opencroquet.org) is an open source cross platform 3D environment designed for rich interaction and simulation, with a combination of powerful graphics and multi-user collaborations (McCahill, 2004). Written in Squeak, an object and class based, reflective Smalltalk implementation, it's a combination of open source software and peer to peer network architecture providing an infrastructure for synchronous real time problem solving within shared simulations (Kadobayashi, Lombardi, McCahill, Stearns, Tanaka, & Kay, 2005). For Croquet's interface and architecture, its designers have incorporated many educational principles developed by Piaget, Papert, Montessori and Bruner.
- **Second Life:** Second Life (http://secondlife.com) is a very popular persistent 3D world which provides simple modeling tools and a scripting language (called LSL) for the creation of interactive objects and the alteration of the worlds' physics. In Second Life, educators can create real time interactive activities for the support of experiential, project-based and community service-based learning (Bedford, Birkedal, Erhard, Graff, & Hempel, 2006). Chatting with others and navigating the virtual world of the software is without charge, but creating permanent objects and buildings requires the acquisition of land from the developers or from other users. As mentioned before a CVE should feature recognizable elements from the real word, thus many companies, institutions and non-profit groups have setup virtual counterparts in the world of Second Life.
- **OpenSim:** OpenSim (http://opensimulator.org) is an open source server platform for hosting virtual worlds. Its main feature is the compatibility with the Second Life client. OpenSim currently uses the Second Life protocol for client to server communication. The modeling tools and the scripting language are the same as the ones in Second Life. Creating objects and importing things (e.g., textures) in OpenSim is without charge. Every user has private land on which they can create anything they want, without restrictions. Of course, this happens only when someone installs the OpenSim server on his/her own computer. Afterwards, any user can access the virtual world created by the administrator of the server.
- **Open Wonderland:** Open Wonderland (http://openwonderland.org) is a Java based open source toolkit for creating collaborative 3D virtual worlds. Within those worlds, users can communicate with high-fidelity, immersive audio, share live

desktop applications, and collaborate in an education, business, or government context. Wonderland is completely extensible; developers and graphic artists can extend its functionality to create entirely new worlds and add new features to existing worlds. The vision for Open Wonderland is to provide an environment that is robust enough in terms of security, scalability, reliability, and functionality that organizations can rely on it as a place to conduct real business or education. According to this vision organizations should be able to use Wonderland to create a virtual presence to better communicate with students, customers, partners, or friends. Individuals should be able to do their real work within a virtual world, eliminating the need for a separate collaboration tool when they wish to work together with others.
- **Pivote:** Pivote (http://www.pivote.info) is an open source virtual learning authoring system for virtual worlds. Initially, it was developed for training medical professionals in higher education but now it can be used for any sort of structured learning in virtual worlds. The key point of Pivote is that all the structure and information content of an exercise is stored on the web, not in the virtual world. This means that it is easy to create, edit and maintain courseware, independent of the virtual world. Therefore, since structure and content are separate, similar exercises with varying degrees of scaffolding, help and support can be facilitated.

The success, in terms of the very large user base, of these environments (for example in 2008, within sixty days 1.437.910 users had entered Second Life) (Beard, Wilson, Morra, & Keelan, 2009) is not difficult to explain: the freedom given to users to express themselves, to experiment, to configure their representation and to develop a kind of social life in the artificial environment have shown to be highly desirable (Herman, Coombe, & Lewis, 2006).

However, with regards to the comparison between open source and proprietary CVLEs, the main issue seems to be the cost of implementing a learning activity. There is no charge for creating a virtual learning world in an open source CVLE, whereas in proprietary software a fee is required in order to use a virtual space or some necessary features for the process.

According to Vosinakis, Koutsabasis, and Zaharias (2011), the main reasons for setting up a learning environment in OpenSim, instead of Second Life are:

- **Visualization and functionality:** There are no differences in graphics quality (both platforms use the same client), with OpenSim supporting most of the functionality of Second Life.
- **Cost:** Besides the cost for owing private land, Second Life places a charge for every image uploaded. On the other hand a limitless number of images can be uploaded in OpenSim at no cost.
- **Data Recording:** Using OpenSim all voice sessions can be recorded directly from the server. This would not be possible in Second Life, which allows only for the recording of public discussions at close range.

Furthermore, open source CVLEs are almost completely configurable and enable tuning and improvement. In an open source CVLE users can create as many virtual objects as they want, restricted only by computer resources. Also, virtual worlds are accessible by a theoretically unlimited number of users, utilizing local servers instead of paying a company.

Supporting a Collaborative Learning Activity Using Open Source Collaborative Virtual Learning Environments

Based on previous research (i.e., Konstantinidis, Tsiatsos, Terzidou, & Pomportsis, 2010; Tsiatsos, Konstantinidis, & Pomportsis, 2009) which assessed and compared the characteristics of state of the art open source CVLEs, OpenSim has been selected in order to examine its ability in supporting collaborative learning activities. The overall objective was to see whether environments such as this have gained the necessary maturity in order to allow for the implementation of effective collaborative activities. Meanwhile, our design objective included researching how the four aspects of immersion (i.e., interest, involvement, imagination and interaction) could be effectively utilized to transform a learning space into a learning place.

Learning spaces are spaces where creativity, problem solving, communication, collaboration, experimentation, and inquiry can happen. On the other hand, a learning place is a socially or subjectively meaningful space. As virtual spaces become familiar and significant, they become virtual places.

Design and Evaluation

In order to assess the OpenSim platform we have created an educational scenario. This scenario took place in a computer lab with the participation of seven postgraduate students consisting of four male and three female students. The use of OpenSim was within the context of the course "Virtual Learning Environments," taught during the spring semester of the second year, of the postgraduate studies program at the Informatics Department of our University.

The participants followed a collaborative scenario and created a presentation on a specific subject. After the formation of two groups (i.e., one group with four students and one with three students), each student had to use the features of OpenSim in order to collaborate with his/her teammates and create the presentation. At the end of the activity, students answered a questionnaire about the functionality of OpenSim, potential problems and the collaboration among them.

The educational scenario included the use of SLoodle in which users would present the deliverables they had been asked to prepare. The use of SLoodle was not proven to be very effective and eventually there was a problem in compatibility with OpenSim. Also, sound problems made the activity very difficult as the students had to use text chat to present their work.

According to the questionnaires answered by the students, the failure to use voice chat hindered the collaborative activity process. Another issue was the responsiveness of OpenSim. When the virtual space filled with virtual objects then the response from the server where OpenSim was installed was too slow for the students to work with ease. The problem was not due to the speed of the network connection as the activity took place in a local network and there was plenty of free bandwidth. We also used powerful computers for the OpenSim server and clients.

The next section presents the application of a collaborative learning activity in Second Life and discusses the differences regarding efficiency between this activity and the one in the open source CVLE.

Supporting a Collaborative Learning Activity Using Second Life

This section presents the methodology of the evaluation, carried out at our Informatics Department, with the participation of undergraduate students in a virtual collaborative learning environment implemented in the Second Life platform.

Design and Evaluation

The main goal of our evaluation was to determine whether Second Life overcomes the problems of the open source CVLEs, thus making it more suitable for the implementation of collaborative learning activities. The evaluation methodology we applied in our case study comprised of two phases. At the first phase the students have been familiarized with the virtual world, the means of communication and the use and building of virtual objects. During the second phase the educational scenario has been implemented, (as described in detail in the corresponding subsection, titled "Phase 2").

Subjects of the experiment were ten undergraduate students (i.e., consisting of eight male and 2 female students) attending the "Multimedia Systems" course of the undergraduate program of studies in Informatics at our university. It would be unsafe to assume that the characteristics of this specific group of students correspond to the general student population of this level, we can however comment on the homogeneity of our subjects. In order to assess the previous experience of our subjects to online collaboration, the students have completed specific questionnaires. According to the results, the majority of the subjects in the group were experienced in collaborating online through 2D interfaces. On the contrary, the majority of students were inexperienced in the use of 3D virtual environments for either education or entertainment.

With regards to the educational design we took into consideration that the term "learning space" denotes the idea of movement, activity and the possibility of discovering meaningful connections between the elements found within the environment. However, it does not capture the distinctive ways in which people can make a learning space familiar, turning it into a learning place. It is often the quality of a shared space that plays a crucial role in its development into a place.

A space becomes a place when we build into it enduring structures (Burbules, 2004). Architectures transform not only a space but the patterns of activity for those who occupy them. These patterns can be viewed along five polarities: a) movement – stasis, b) interaction – isolation, c) publicity – privacy, d) visibility – hiddenness, and e) enclosure – exclusion.

Phase 1

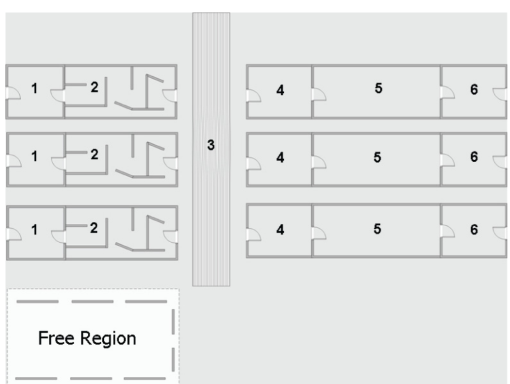
The goals of the first phase were to: a) allow students to familiarize themselves with the capabilities of the platform, and with the available collaboration and communication tools, b) gather information regarding students' previous experience, c) organize the students into pairs, d) gather first impressions and usability requirements and e) evaluate the previous experience of the users.

To gather the required information regarding students' previous experience, students answered a pre-test questionnaire which inquired about facts such as previous experience with 3D CVLEs.

In order to give students the chance to familiarize themselves with the virtual world, we created a special training corridor (Figure 1) where students passed through various stages of training.

To achieve this, we placed presentation boards in every room of the corridor where students could watch video tutorials about a specific subject. First, students learn about com-

Figure 1. Three replications of the training corridor



munication in Second Life using voice and text chat. Next, there is a maze where students have to learn to navigate and fly in the environment, with the guidance of an assistant. Afterwards, the video tutorial shows students how to use the camera of the environment independently of avatar movement. The next room related to avatar appearance in Second Life, since the students would have to wear specific clothes differentiating the collaboration pairs. The last room was about creating objects in Second Life and how students can use them in order to achieve application sharing functionality in the virtual world.

After the familiarization session, students were divided into pairs, because in the next phase they would work collaboratively in order to achieve the specified goals of the educational scenario.

Phase 2

The goals of the second phase included: a) the specialization of students in specific tasks, b) the gathering of requirements concerning usability, communication and pedagogy, and c) the support of collaboration between pairs of students in order to answer specific worksheets.

In order to implement the second phase we created a special classroom which included a central place for discussion and smaller collaboration rooms for each pair of students (Figure 2). Also, it contained a library where students could access information from relative websites which were linked to virtual objects. Finally, there was a room with lockers, where students could obtain clothes which could be used to differentiate the collaborating teams. This had emerged as a need from previous evaluations in open source CVLEs.

A worksheet was assigned to each pair of students which contained questions related to the course under which the activity took place. The worksheet could be collected by the students from the special library that was created to serve this purpose, but they also had the opportunity to see the worksheet from the web browser in every room (Figure 3).

The presentation board in the central room contained the work requirements for the students. Searching for answers to the questions in the worksheets required use of the web browsers which existed in each collaboration room. The members of the pairs of students exchanged views with each other through VoIP and by using Second Life notes. If necessary, they also had the opportunity to utilize application sharing, in order to facilitate collaboration. The whole process was supported by four assistants.

After completing the assigned task, each pair had to present the information they had retrieved. The presentations took place in the central area of the classroom where there was a presentation board in which the assistants had

Figure 2. The central classroom area and the collaboration rooms

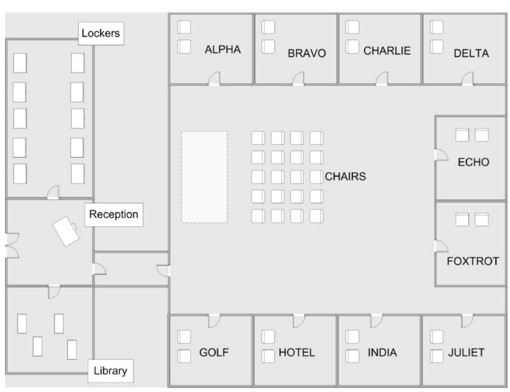
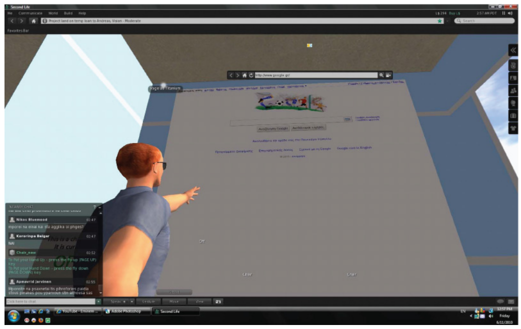


Figure 3. Students using the built-in web browser to search the Internet for information



loaded the projects of all pairs of students on a Moodle environment.

At the end of this final phase of the scenario, each student had to answer an online questionnaire recording his/her experience and suggestions.

Results

This section presents the evaluation results as revealed by analyzing the questionnaires submitted by the participating students. Furthermore, we discuss and compare these results in order to derive to conclusions.

Despite some obvious advantages of open source CVLEs, as mentioned in a previous section, the problems described above led us to implement a collaborative activity in Second Life. It had become obvious that the restrictions which existed in open source CVLEs would not allow the implementation of a collaborative activity in an efficient manner. Therefore, we tend to agree with Vosinakis, Koutsabasis, and Zaharias (2011), regarding the problematic issues encountered within the OpenSim platform:

- Collaboration is hindered when there is a lack of voice communication.
- Lack of familiarity with 3D virtual environments, led to users focusing more on mastering the user interface and less on concentrating on the assigned collaborative task.
- The collaborating teams and the roles of the participants where difficult to distinguish from one another.
- Lack of 2D functions and embedded shareable applications obstructed the scenario.

Second Life is one of the most popular virtual worlds and provides an opportunity to use simulation in a safe environment to enhance experiential learning, allowing individuals to practice skills, try new ideas, and learn from their mistakes.

The implementation of the collaborative learning activity in Second Life gave us the opportunity to overcome some serious issues, which hindered the collaboration between the students in previous attempts. In Second Life, there were no problems in voice chat communication. That was very important since it was described by students in previous activities as a necessary feature.

The problems we had encountered, concerning system response time in OpenSim, were completely resolved. This gave students the opportunity to interact with each other and with the virtual objects without problems. Each pair of students had at its disposal special clothes, which were very useful as it was easy for everyone to recognize who belongs to which pair.

In general, the students could change their appearance as they wanted and users could now also use gestures to communicate with each other, utilizing either those that the Second

Life platform inherently had or those that we had created.

In general, it seemed that in Second Life there were no usability and functionality problems and more importantly, there were no problems that hindered the collaboration among students, which was the main point we wanted to investigate.

Students were asked to comment on the general advantages and disadvantages of using 3D CVLEs for collaboration. The most important advantages of this pedagogical approach were considered to be spatial and temporal flexibility, innovation and originality of method (e.g., 83% of students entered the environment out of the educational process in order to simply explore the new environment) and the provision of enhanced communication and collaboration tools. On the other hand, disadvantages included lack of face to face interaction, increased technological dependency and the learning overhead imposed by the new tools.

With regard to other collaboration methods, the Second Life 3D CVLE is competing against more traditional approaches of 2D VLEs (or Learning/Content Management Systems) and core face to face interactions. Based on questionnaire results, Second Life is considered the most interesting (73%) and entertaining (80%) approach, incorporating the best collaboration tools (66%). On the other hand, it is also acknowledged as the least effective, direct and useful approach to collaboration. Thus, it becomes apparent that 3D CVLEs cannot compete with a traditional learning environment but they can assist the educational process in case of blended learning or when it is impossible to carry out a face to face collaborative activity.

Moreover, students commented that the Second Life platform hindered their ability to share information sources with their colleagues, and thus obstructed the collaboration process as a whole. Other issues, mentioned by students, included lack of desktop sharing and average graphics quality. Furthermore, the absence of a user friendly control scheme hindered the efficient use of the inventory system, as well as the appearance editing mechanism. Finally, a bug in the platform allowed the sound from video playback to be heard irrespectively of distance from the source, confusing and disorienting users.

Despite complications, students judged several aspects of the platform positively. According to the evaluation results, students enjoyed the 3D environment, finding it an interesting and immersive experience. One student commented that: "...it makes you want to stay online longer." Furthermore, students considered the Second Life collaboration process easier and more relaxing than a teleconference, taking pleasure in the feeling of presence of their peers.

Finally, with regard to specific functionality, students found the ability to move their camera independently of the avatar very useful and commented on the value of multiple communication channels: "…I could ask questions without interrupting." The majority of students were enthusiastic regarding the possible future use of the Second Life platform for collaborative activities, lectures and socializing.

Recommendations for future implementations are the following:

- **Application sharing through the built-in browser:** Most students believe that application sharing through the Second Life environment would enhance its collaboration capabilities, simplifying the scenario execution.
- **Extended periods of familiarization and collaboration sessions:** Users had limited time in which to familiarize themselves with the interface and complete the collaborative scenario. The majority of students believe that the educational process would benefit if the virtual environment was run in parallel, but not concurrently, to the face to face sessions, in consistency with the context and content of the course. It seems people who work together over a series of sessions develop what has been termed a "collaborative working relation" (Baker, 2010), as they progressively share

more extensive mutual knowledge and an enhanced ability to coordinate.

- **Increased publicity with the goal of attracting more students and defining a virtual social space:** Contemporary students are already skilled users of social software and Web 2.0 tools. Modern pedagogy, through 3D CVLEs, should exploit these abilities, by altering the context, medium and evaluation criteria of educational material.

CONCLUSION AND FUTURE WORK

Researchers have proven both the effectiveness of collaborative learning as an educational practice and the use of computers in aiding the acquisition of higher level cognitive and problem solving abilities. Combining the two, CVLEs exhibit many advantages compared to traditional teaching methods, including student motivation and the experience of unique environments.

This paper does not argue the superiority of the technological over the traditional face-to-face approach. Each domain has its own unique qualities and advantages. For this reason we did not focus on the matter of "Which is better?" but on "What is the distinct capability of 3D CVLEs to support immersive learning experiences?"

However, not all CVLEs are suitable for carrying out educational activities. There are problems both in terms of function and support of collaboration among learners. Dickey (2010) compared Second Life with Active Worlds, in a case study that did not include collaboration, and derived to the conclusion that both environments offered similar, as well as different, affordances and constraints. The main goal of this paper was to examine whether it is possible to implement collaborative learning activities in a 3D CVLE by evaluating some issues that hinder collaboration. This was accomplished within the context of comparing open source CVLEs to proprietary software.

The implementation of collaborative activities in open source CVLEs was not very effective and resulted in significant problems that prevented collaboration among students. The evaluation of the activity in OpenSim revealed that most of the students were left unsatisfied with the platform. The sound problems didn't allow students to collaborate efficiently as it was very difficult to communicate with each other and present work using only text chat. Also, delayed system response time made navigating the environment a complicated task.

Based on the above observations, our next attempt was to implement a collaborative learning activity in Second Life. The use of Second Life gave us the opportunity to overcome previous problems, which hindered collaboration between students.

The functionality and capabilities of Second Life allowed us to transform the virtual learning spaces we designed into meaningful virtual learning places by guiding the dynamics of interest, involvement, imagination, and interaction in ways that are judged to be educationally productive. Through this approach, the learning space becomes immersive and the students are engaged, actively relating to the subject-matter, seeing and feeling its importance.

The evaluation showed that the students worked without encountering any serious problems and without restrictions from the environment. Everyone submitted the deliverables which had been requested within the time frame that was set.

As a final conclusion, it becomes apparent that open source CVLEs are not mature enough yet to accommodate collaborative activities and allow educators to utilize them effectively. There are several problems seeking solution.

For example, bad system responsiveness due to the use of a different data transmission protocol disappointed students and the lack of voice chat hampered communications. It should be noted that sound problems can be addressed and overcome by utilizing a standalone voice chat application that runs in parallel with the virtual world's server and client. However, this complicates the collaborative process and ruins immersion. There are many other issues that also need to be addressed, including the avatar's appearance editor, navigation and orientation.

Future work will include the attempt to resolve the issues identified during assessment. Solving these problems will allow open source CVLEs to exploit the advantages of proprietary platforms and therefore be competitive in the facilitation of collaborative learning activities. Furthermore, future work can focus on developing approaches and designs which make learning spaces immersive, since immersion is an essential educational resource which can facilitate engagement and motivation for active student learning.

REFERENCES

Ang, K. H., & Wang, Q. (2006, December 6-8). A case study of engaging primary school students in learning science by using Active Worlds. In *Proceedings of the First International LAMS Conference: Design the Future of Learning*, Sydney, Australia (pp. 5-14).

Baker, M. (2010, May 18). Relations between two qualities of collaborative dialogue: Knowledge co-elaboration and affective regulation. Workshop: Analysing the quality of collaboration in task-oriented computer-mediated interactions. In *Proceedings of the 9th International Conference on the Design of Cooperative Systems*, Aix-en-Provence, France.

Barab, S. A., & Duffy, T. (1998). From practice fields to communities of practice. *Learning*, (1), 1-33.

Beard, L., Wilson, K., Morra, D., & Keelan, J. (2009). A survey of health-related activities on Second Life. *Journal of Medical Internet Research*, *11*(2), e17. doi:10.2196/jmir.1192

Bedford, C., Birkedal, R., Erhard, J., Graff, J., & Hempel, C. (2006, August 20). Second Life as an educational environment: A student perspective. In *Proceedings of the First Second Life Education Workshop*, San Francisco, CA (pp. 25-27).

Bouras, C., & Tsiatsos, T. (2006). Educational virtual environments: design rationale and architecture. *International Journal of Multimedia Tools and Applications*, *29*(2), 153–173. doi:10.1007/s11042-006-0005-7

Bruckman, A., & Hudson, J. M. (2001, March 22-24). Disinhibition in a CSCL environment. In *Proceedings of the Conference on Computer Support for Collaborative Learning*, Maastricht, The Netherlands (pp. 629-630).

Burbules, N. C. (2004). Rethinking the virtual. *Learning, 1*(2).

Churchill, E., Snowdon, D., & Munro, A. (2001). *Collaborative virtual environments: Digital places and spaces for interaction*. London, UK: Springer.

Dickey, M. D. (2010). The pragmatics of virtual worlds for K-12 educators: Investigating the affordances and constraints of Active Worlds and Second Life with K-12 in-service teachers. *Educational Technology Research and Development*, *59*(1), 1–20. doi:10.1007/s11423-010-9163-4

Dieterle, E., & Clarke, J. (2006). Multi-user virtual environments for teaching and learning. In Pagani, M. (Ed.), *Encyclopedia of multimedia technology and networking* (2nd ed., pp. 1–11). Hershey, PA: Idea Group. doi:10.4018/978-1-60566-014-1.ch139

Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). The evolution of research on collaborative learning. In Spada, E., & Reiman, P. (Eds.), *Learning in humans and machine: Towards an interdisciplinary learning science* (pp. 189–211). Oxford, UK: Elsevier. doi:10.1007/978-1-4020-9827-7_1

Guglielman, E., & Vettraino, L. (2007). *Complex learning: A new approach for the age of knowledge* (pp. 1-6). Retrieved from http://eguglielman.tumblr.com/post/656537103/complex-learning-a-new-approach-for-the-age-of

Herman, H., Coombe, R. J., & Lewis, K. (2006). Your Second Life? *Cultural Studies*, *20*(2-3), 184–210. doi:10.1080/09502380500495684

Kadobayashi, R., Lombardi, J., McCahill, M. P., Stearns, H., Tanaka, K., & Kay, A. (2005, December 8-10). Annotation authoring in collaborative 3D virtual environments. In *Proceedings of the International Conference on Augmented Tele-Existence*, Christchurch, New Zealand.

Konstantinidis, A., Tsiatsos, T., Terzidou, T., & Pomportsis, A. (2010). Fostering collaborative learning in Second Life: Metaphors and affordances. *Computers & Education*, *55*(2), 603–615. doi:10.1016/j.compedu.2010.02.021

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls of social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior*, *19*(3), 335–353. doi:10.1016/S0747-5632(02)00057-2

McCahill, M. (2004, January 29-30). Design for an extensible croquet-based framework to deliver a persistent, unified, massively multi-user and self organizing virtual environment. In *Proceedings of the Second Conference on Creating, Connecting and Collaborating through Computing*, Kyoto, Japan.

Muller, K., & Koubek, A. (2002, November 16-20). Collaborative and virtual environments for learning. In *Proceedings of the ACM SIG Conference on Mobile Computing and Networking*, New Orleans, LA.

Perkins, D. N. (1992). *Smart schools: Better thinking and learning for every child*. New York, NY: Free Press.

Prasolova-Førland, E. (2008). Analyzing place metaphors in 3D educational collaborative virtual environments. *Computers in Human Behavior*, *24*(2), 185–204. doi:10.1016/j.chb.2007.01.009

Strijbos, J. W., Kirschner, P. A., & Martens, R. L. (2004). *What we know about CSCL: And implementing it in higher education*. Boston, MA: Kluwer Academic. doi:10.1007/1-4020-7921-4

Tsiatsos, T., Konstantinidis, A., & Pomportsis, A. (2009, June 8-13). Collaborative educational virtual environments evaluation: The case of Croquet. In *Proceedings of the Workshop on Intelligent and Innovative Support for Collaborative Learning Activities, Computer Supported Collaborative Learning*, Rhodes, Greece.

Veerman, A., & Veldhuis-Diermanse, E. (2001). Collaborative learning through computer-mediated communication in academic education. In *Proceedings of the 1st European Conference on Computer-Supported Collaborative Learning*, Maastricht, The Netherlands (pp. 625-632).

Vosinakis, S., Koutsabasis, P., & Zaharias, P. (2011). An exploratory study of problem-based learning in virtual worlds. In *Proceedings of the Third International Conference on Games and Virtual Worlds for Serious Applications* (pp. 112-119).

Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: MIT Press. doi:10.1037/11193-000

Winn, W. (2002). Current trends in educational technology research: The study of learning environments. *Educational Psychology Review*, *14*(3), 331–351. doi:10.1023/A:1016068530070

Zaharias, P., Andreou, I., & Vosinakis, S. (2010, September 23-26). Educational virtual worlds, learning styles and learning effectiveness: An empirical investigation. In *Proceedings of the 7th Pan-Hellenic Conference with International Participation ICT in Education*, Korinthos, Greece (pp.1-6).

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