Designing a Collaborative Learning Activity in Second Life

An exploratory study in physics

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Abstract—Multi-user virtual environments (MUVEs) seem to have great potential in education. Current educational uses of MUVEs seem to exploit them more as group interaction platforms and less as worlds where users learn by interacting and modifying the environment in a constructivist approach. There is also a need for systematic research efforts that will lead to guidelines and principles for designing and evaluating effective learning activities in MUVEs. This paper presents preliminary empirical results from an exploratory study with university students. A collaborative problem-based physics learning activity was designed in Second Life® (SL), following a constructivist approach. Students (n=30) collaborated “in-world” in pairs assisted by a tutor, in order to solve the problem. Data were gathered using a questionnaire and session recordings. The study focused on issues related to educational environment design, collaboration and instruction. Results indicate that satisfactory, engaging and effective collaborative learning activities can be realized in SL.

Multi-user virtual environments; Second Life; environment design; collaboration; instructional design; constructivism; physics

I. INTRODUCTION

In just eight years after Dede described “‘Alice-in-Wonderland’ multi-user virtual environments interfaces” as a technology that would “shape how people learn” [1], Multi-user virtual environments (MUVEs) are already a trend in Computer Supported Collaborative Learning. MUVEs are welcomed with enthusiasm as environments that can provide rich learning experiences, enhance the sense of (social) presence of learners, allow multifaceted interaction, and support a constructivist approach to teaching and learning.

A number of MUVEs have been developed specifically for educational use. Some of the most cited projects are River City, a MUVE developed to foster inquiry-based learning in which students communicate with “computerized residents” in order to gather useful clues for their research [2], AquaMoose3D, a graphical MUVE for mathematics learning [3], and Quest Atlantis, a 3D multi-user learning environment which engages children in educational tasks [4].

General-purpose MUVEs are being used more widely and in a variety of educational settings and domains of subject matter. Second Life® (SL) seems to be the MUVE of choice for educators around the globe, while Active Worlds is also a popular environment. Especially in the higher education level, SL has attracted a great deal of attention, as over 400 academic institutions hold a virtual presence in it [5], more and more official courses are being offered “in-world” and classes are taught in architecture, English as a second language, science, engineering, law, computer science, history, arts, etc [6]. SL is a persistent (24/7) computer-generated virtual world the content of which is created by its residents. It is not a game and there are no “competitors” or a priori defined goals. Rather, it is a virtual world which constitutes a platform with open-ended possibilities which can be utilized to develop educational virtual environments and to design learning activities.

Despite the hype surrounding MUVEs and their role in education, little is reported on how educators design specific learning activities, with specific learning goals to be conducted “in-world” and even fewer data comes from empirical studies related to instructional design and pedagogy in MUVEs. To slightly rephrase Dalgarno and Lee’s claim about educational research on 3D virtual learning environments, much of what has been published about the educational uses of MUVEs in the last years is largely “show-and-tell” [7]. There is a need for systematic research efforts that will lead to guidelines and principles for designing and evaluating effective learning activities to be conducted in MUVEs.

Science has been reported as preferential domain for virtual learning environments because of the latter’s unique technological characteristics and affordances, mostly related to visualization [8]. However, most of the MUVEs used or related to science learning are places for exploration and inquiry. For example, Holmes [9] conducted an empirical study in Active Worlds that simulated a river ecosystem. Through their avatars, students were able to walk around the environment, chat with their learning partner, and perform various problem solving tasks. In River City, Ketelhut [10] designed a problem-based, student-centered project where students can gather evidence from the environment, based on the practices in which an epidemiologist might engage while investigating an outbreak of illness. Barab et al. [11] created the virtual “Taiga Park” that was facing a problem in that there had recently been a decline in fish numbers. Lim, Nonis & Hedberg [12], have studied a problem students faced at Atlantis coming from a disaster as a result of lost values and corrupt leadership.


There is a lack of studies in MUVEs where students interact with the virtual environment and its objects specifically in conducting scientific experiments and learning activities, with specific learning goals and outcomes, related to specific concepts and phenomena. Researchers seem to give emphasis on MUVEs as group interaction platforms and less as worlds where users learn also by interacting and modifying the environment in a constructivist approach.

This paper presents preliminary empirical results from an exploratory study regarding problem-based physics learning activities in SL. We wanted to gain experience in educational environment design issues (object manipulation, educational material presentation, tools, activity setting), collaboration issues (evaluation of environment affordances, tutor presence, non-verbal communication) and instructional issues (identification of scaffolding points).

This work is part of a broader research project that aims at designing learning activities in SL and comparing them with real world learning activities in terms of learning outcomes, collaboration and presence.

II. METHOD

A. Virtual Environment and Learning Activity

The virtual environment was designed and developed in SL. It refers to science learning and specifically to the reflection of light. The design of the learning activity was based on the seven principles of constructivism [13]:

1. Provide multiple representations of reality – avoid oversimplification of instruction by representing the natural complexity of the world.
2. Focus on knowledge construction not reproduction.
3. Present authentic tasks.
4. Provide real world, case based learning environments.
5. Foster reflective practice.
6. Enable context, and content, dependent knowledge construction.
7. Support collaborative construction of knowledge through social negotiation, not competition among learners for recognition.

The problem presents an authentic task in a “real” world environment. Students had to collaborate in order to shoot an apple down from a tree using a laser beam and a plane mirror (Fig. 1). They had to calculate the correct angle of the mirror in order to reflect the laser beam to the apple. Students were not allowed to use a trial and error approach. Instead, they had to use trigonometry for the calculation of the correct angle before shooting.

The following “in-world” tools were available to the students:

- Two virtual rulers for the measurement of horizontal and vertical distances.
- A poster presenting the law of reflection.
- Three posters presenting the trigonometric functions and values for sine, cosine and tangent.
- An interactive whiteboard where students could draw sketches. The whiteboard had also a help button that presented a graphical model of the problem (Fig. 2).
- A virtual calculator.

To solve the problem, students had to calculate the rotation angle of the mirror (θ) (Fig. 2). To do so, they had to recognize that θ = POA/2. The angle POA could be calculated through its tangent. So, firstly they had to measure the distances PO and PA by correctly positioning the rulers. Then, they had to divide the distances in order to find the tangent. Finally, by using the trigonometric tables, students could find the angle POA and thus θ.

B. Subjects

Participants were 30 students (22 women, 8 men) of the Department of Primary Education, the University of Ioannina, Greece. Their ages were 18-25 (Mean=19.7, SD=1.44). They all had experience in SL since they had attended a class on SL and its potential educational uses. Their participation was voluntary, motivated by a small bonus in their marks. The participants registered in pairs for the collaborative activity.
C. Procedure

Initially, two pilot sessions were conducted and technical problems such as sound quality and session recording were identified and solved.

The empirical data was gathered from 15 sessions with 30 students. In each session, a pair of two students and a tutor (always the same person) participated.

The three participants were physically located in three different rooms and collaborated only through SL. The duration of each session was approximately 40 minutes. Before the session, each student answered a questionnaire on demographics, computer and 3D-VR games experience, tendency to become involved in activities and previous knowledge related to the learning activity.

Participants logged in SL using their own accounts and were asked to teleport to the sandbox of the Educational Approaches to Virtual Reality Technologies Lab’s island in SL (Earthlab Education Island). There, they met the tutor who guided them to the activity’s setting. They communicated via the SL voice chat using a headset. During the session, the screen, microphone and webcam of each participant were recorded.

Before the collaborative activity, a brief lesson was given by the tutor in a virtual classroom, reminding the law of reflection and basic trigonometry (Fig. 3). The lesson also included the use of educational material in the form of posters and external html links. In the classroom, students familiarized with the use of the virtual laser, rotating mirror, whiteboard, and calculator. The laser could be switched on and off by clicking on its power supply. The mirror could be rotated in steps of 1° by clicking its upper or lower ends. The value of θ was always visible close to the mirror. Participants had also the choice to display the normal to the mirror. Finally, participants were familiarized with the use of the rulers, by manipulating them either by the 3D arrows on their ends, or by a dialog menu.

After the lesson, the tutor asked the students to walk outside the classroom, where the activity setting was located. There, the tutor informed the students about the problem they had to solve collaboratively and that he would be available for any assistance.

After the end of the activity, the students answered a questionnaire on educational environment design issues and sense of presence, and took part in a debriefing interview with the tutor.

III. Results

A. Educational environment design issues

One of the characteristics of virtual environments is the direct and intuitive manipulation of virtual objects. In our activity, the students had to move the two rulers in their correct places. 93.3% of the students considered that the most obvious way of manipulation was using the 3D arrows, and 90% of them found this way handier. Students also preferred the educational material presented “in-world” in the form of posters (93.3%) instead of external links. “In-world” material has the advantage of being always visible to all participants during the activity, fostering collaboration and social negotiation. Likewise, 83.3% of the students declared that the “in-world” calculator was handier than the windows calculator. It seems that students prefer “in-world” intuitive object manipulation, educational material and tools instead of “out of world” dialogue menus, browsers and tools that could distract their attention from the environment and learning activity.

Another design issue concerned the degrees of freedom of the virtual objects. Allowing many degrees of freedom not only demands a considerable programming effort, but also could distract participants from achieving the activity goals. In our experimental setting the laser and mirror were in fixed positions allowing students to control only the mirror rotation. This restriction had no negative effects on achieving the activity’s goal, since most of the students did not want to move the laser or the mirror. It seems that not all the technological affordances are necessary in an educational context. Of course, the degrees of freedom depend on the specific instructional design and educational scenario.

Usually, a learning activity takes place in a classroom or a lab. In our case the students had the opportunity to deal with the learning activity both inside a virtual classroom and in an open-air setting. Even though the students were not interested in choosing the activity’s setting, 86.7% of them found the open-air setting more suitable for the activity. A plausible explanation would be that students want to leave conventional educational settings in favor of more task-relevant environments, in accordance with the constructivist approach to learning, but the result could be further investigated.

B. Collaboration

One of the goals of the exploratory study was to evaluate the affordances of SL for implementing collaborative learning activities. The questionnaire used, utilized a 7-point Likert scale (1=not at all, to 7=very much) and the results regarding collaboration are summarized in Table I.

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Figure 3. In the virtual classroom.
Students found participating in learning activities conducted in SL very important for their education. Most of them evaluated positively the presence of the tutor in the activity, but did not seem to care about having some other form of on-line help available.

Most of the students evaluated their collaboration in the environment as very satisfactory and the activity as pleasant and interesting. They also felt that they could interact with the other participants and most of them evaluated their experience as interactive and sociable.

A basic characteristic of SL is being a persistent (24/7) world. The students evaluated this characteristic positively since they found it important to be able to conduct a learning activity any time of the day and to be able to repeat it whenever they wanted.

Concerning the non verbal communication capabilities of SL, the students were moderately satisfied. They stated that they would prefer their avatar to be able to reproduce their facial expressions and body movements. These results indicate that students prefer to collaborate through richer communication channels that do not filter out important non verbal communication signals.

Finally, it is worth mentioning that all students (100%) found voice chat to be more useful that text chat for communicating in SL. This result is rather expected since voice chat is more direct and does not require typing, leaving hands free for navigation and object manipulation. Furthermore, it allows rich non-verbal components of the human voice to pass through.

C. Instructional issues

While supervising the collaborative activity, the tutor was able to identify certain points where scaffolding was necessary in order to help students to achieve the goal. These points of difficulty (cognitive obstacles) which were overcome with tutor feedback and prompting are described below.

1) Identifying the basic model (triangle). To solve the problem, students had to identify the imaginary triangle POA (Figs. 2, 4). Most of the participants were able to identify a triangle, but incorrect positioning of the rulers indicated that they did not have a clear picture of it. Indicative errors in ruler positioning included the positioning of the horizontal ruler in a height different than that of the incident laser beam (PO) and the positioning of the origin of the rulers on a point different than P. Some students also made incorrect measurements either by taking into account the width of the rulers or by reading false values due to parallax error, an error that also occurs in real experimental set-ups.

In order to help students identify their errors and overcome difficulties, the tutor intervened asking questions and prompting the students to explain their choices, guiding them to reflective processes.

2) Identifying the optimal trigonometric function. After having measured distances PA and PO, the students had to identify the next optimal step, which would be to calculate the tangent of angle POA by dividing PA by PO. Instead, most students intuitively came with the idea to use the Pythagorean Theorem to calculate the hypotenuse. Even though this approach is not wrong, it leads to a more complex solution and unnecessary calculations.
In this case also, the tutor asked the students to justify their approach, thus triggering reflective processes which led to the optimal solution.

3) Finding the relationship between $\theta$ and POA. The final step was to identify that $\theta = POA/2$ (Fig. 2). The most common mistakes made at that point were $\theta = POA$ and $\theta=2*POA$. Students seemed to assume the relationship of the angles rather intuitively. In many occasions, they rotated the mirror to the angle they thought was correct and tried to estimate the direction of the reflected laser beam. For instance, if they rotated the mirror by an angle $\theta$=POA, they could see that the normal of the mirror would point to the apple, thus the reflected beam would aim much higher.

The above cognitive obstacles may have occurred because students had to deal with a task in a “real” context, out of the traditional educational practice in science teaching.

Another interesting observation is that most of the students did not want to use the special help button on the whiteboard. This indicates a high degree of engagement with the activity, showing the potential of MUVEs in designing highly motivating tasks.

All student pairs solved the problem with more or less intervention by the tutor.

IV. CONCLUSIONS

In this paper we presented a problem-based physics learning activity in SL and empirical results from an exploratory study with 30 participants. Findings so far indicate that:

- Object manipulation seems to be more intuitive using other “in-world” objects than dialogue menus.
- Educational material seems to be more appealing when presented “in-world” than in a browser.
- Learning support tools like calculators seem to be handier when offered as “in-world” objects compared to external applications.
- Implementing all available degrees of freedom on objects is not always necessary in order to create an engaging learning task.
- Open-air setting of the learning activity was preferred over the traditional classroom setting.
- Persistence of MUVEs that leads to “always available” learning environments seems to be important for learners.
- Voice-chat is a very important feature of MUVEs for collaborative learning activities and is preferred over text-chat.
- Learners found that non-verbal communication is moderately supported by SL currently, and would like more non-verbal cues to be communicated.
- Learners found the presence of a tutor useful.
- Pedagogical methods of constructivist approach like scaffolding can be implemented in SL through properly designed problem-based learning activities.

We believe that satisfactory, engaging and effective collaborative learning activities can be realized in SL. Even though, MUVEs like SL may never replace traditional labs and classrooms, they provide powerful and flexible alternatives that do not have the temporal and spatial restraints of the former, making more learning opportunities available 24/7.

Our study continues by processing the empirical data in order to get results on the sense of presence in SL. Future work also includes the enhancement of the non-verbal communication capacities through real time motion capture in order to increase social presence and the quality of collaboration among the participants.

REFERENCES


