Problem-based Learning in Virtual Worlds: a Case Study in User Interface Design

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Abstract
Problem-based Learning (PBL) is an educational approach that is based on student collaboration and self-directed learning. In PBL, students learn by addressing ill-defined and open-ended problems reflecting on their experiences. This paper aims to investigate the suitability of Virtual Worlds (VWs) as a platform for hosting PBL activities and to report on their strengths and difficulties in terms of usability, collaboration support and learning effectiveness. As a case study, the authors have set up a VW on the basis of open source software, developed a number of in-world supporting tools, and ran two PBL activities in the area of User Interface Design. Students were asked to collaboratively design and present the user interface of applications in various problem areas and platforms. Each group collected resources, presented and argued about concepts, and built together an interactive user interface prototype with explanatory annotations. The final prototypes were presented to the class. The learning activities has been evaluated and the results have revealed several strong points of VWs that validate their potential for PBL activities, but also indicated a number of problems to be tackled.

Key Words: Virtual Worlds, Virtual Environments, Education, Problem-based learning, User Interface Design.

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1. Introduction
Problem-based learning as a learning and teaching practice has been widely adopted during the last 20 years in both traditional and online educational settings. According to Boud and Feletti, PBL is a process of acquiring knowledge and skills through a staged sequence of problems: Clarification of the problem, identification of the needs to address the problem, individual learning/study and application of the newly acquired skills in order to solve the problem, are the main typical stages in a PBL situation. It is documented in scientific literature that collaboration and interaction are some of the critical factors for PBL success in both traditional and online learning settings. Therefore, it is not surprising that PBL has been characterized as one of the most appropriate learning methods in virtual
VWs provide great opportunities for both synchronous and asynchronous learning and are highly collaborative, interactive and persistent 3D environments. Instructors and educators can prepare learning materials as in-world tutorials and develop interactive learning scenarios, and students/learners are invited to interact with the world and become active participants in these scenarios.

Up to date there are only a few approaches attempting to realize PBL and other constructivist learning methods in VWs. Vrellis et al. used Second Life (SL) to implement a collaborative problem-based learning activity following a constructivist approach. Brown et al. demonstrated the suitability of SL for problem-based learning through the mapping of learning activities on to PBL goals as they have been stated in the framework of Hmelo-Silver. According to the findings it is supported that development of wider transferable skills can be realized effectively through virtual worlds such as SL. In another related study, findings from a case study with a strong PBL approach are reported, where students were tasked to create learning experiences within SL for external clients. It was found that SL can contribute to PBL as a pedagogical approach in several ways such as supporting the roles of tutors and students, facilitating their relationships, enhancing students’ motivation and ownership of the project, and easing the assessment activities by the tutors.

Collaboration and group interaction was a common denominator in the aforementioned studies. However much of the relevant research is still conceptual and information about empirical evaluation with regard to specific methods and practices is lacking. In this study we put much emphasis on the evaluation of collaborative learning activities according to the PBL philosophy. Our goals were to discover the extent in which VWs can support PBL activities, to evaluate the learning results of their use, and to unveil critical problems related to student collaboration and learning. We set up a complete activity in the problem area of User Interface Design, following the PBL learning cycle presented in the framework of Hmelo-Silver and we designed and implemented a number of tools to support collaborative and problem-specific tasks in the environment.

2. **A Virtual World for User-Interface Design**

The authors have set up a VW as a platform to host PBL activities in User Interface Design. The implementation has been based entirely on open source software. The world server was installed in a standalone PC using the OpenSimulator platform (http://opensimulator.org), and the FreeSwitch server (http://www.freeswitch.org) has been set up and connected to the environment to provide voice communication support.

The implementation of PBL activities in VWs poses strong requirements on the environment’s side concerning their affordances to fulfill
A necessary prerequisite to detect such requirements is to identify the
common student tasks during a session and to discover the collaboration
needs for each task. For our study in the area of user interface design we have
identified the following tasks in group-based PBL activities:

- In the early stages, students discuss about the problem, write down
  facts and reveal aspects for which further knowledge may be
  required.
- Then, they assign roles to group members, search for and share
  resources, and formulate, present and explain their ideas.
- Finally, they collaboratively assemble a final solution, refine it and
  present it to the class to be further evaluated.

The platform we have employed for our study provided inherent
support only for part of these tasks. We have therefore implemented a
number of additional tools that were available to students during the study in
order to overcome these obstacles and to enhance the collaboration
affordances of the environment. The implemented tools were:

- **Resource**: an object that links to external web resources. It can be
  used by the teacher(s) in order to provide some initial resources to
  the students (guidelines, design patterns, templates, etc.) to aid them
during their tasks, and by the student groups in order to share and
organize the resources they found in their self-directed learning
activities.

- **Comment Recorder**: a tool to record and playback user messages.
  It can be used to take notes from conversations during the early
  collaboration stages and also as a tool to record viewer comments
during the final evaluation stage.

- **Annotation**: an object that contains a written message. Annotations
can be used for the asynchronous collaboration between group
members (e.g. in the form of comments, notes about things to be
done, role descriptions, etc.) or they may be attached to the user
interface prototype as further notes or explanations of design
choices.

- **Interface Element**: an object with scripted behavior that can be
  used as a user interface component in the working prototype.
  Students can combine and configure copies of the “Interface
  Element” object in order to design buttons, windows and image
  containers during the final stages of the learning activity and
  collaboratively construct an interactive user interface prototype.

The aforementioned objects were provided to each student on
initialization and they could insert multiple copies of them inside the
environment. Fig.1 presents a screenshot of the four tools.
3. User Studies

A. Laboratory study

The first study was an exploratory laboratory experiment that simulated the use of VWs for user interface design. The participants were ten students, who had considerable experience in user interface design, since they had all attended the courses of: human-computer interaction, interaction design and multimedia design. The participants were allocated in three equivalent groups in terms of their experience in VWs and their user interface design skills and they communicated with an audio link and text chat, thus simulating a remote collaborative work situation.

The problem-based learning activity was given to the participants in the following statement of a ‘design brief’: “Design the user interface of a multimedia kiosk system for browsing available rooms to let in the island of Syros. The intended users are tourists (Greeks and foreigners), who can access the system from the harbour of Syros. You should take into account usability guidelines for multimedia presentations and information seeking. You should design the 5-7 most basic screens of the system, in wireframes”. In addition, the participants were presented with an abstract work plan that included several tasks that they could choose to follow with indicative times for completion.

The learning goals of this intervention were: a) to discover the usability and accessibility requirements of touch screen interfaces, b) to understand the differences in the design of such interfaces compared to other, more conventional cases, and c) to apply this knowledge in a specific practical context.
The learning intervention lasted for a total time of 6.5 hours. The first 2 hours were devoted to the tutorial about the use of the VW. Then, a total of 3.5 hours were devoted to the activity of user interface design, presentations (Fig. 2) and follow-up; a total of 1 hour was allocated to the breaks. Participants were asked how much time they would need to carry out the user interface task in a 'face to face' situation and deliver at the same quality: some of them answered about the same time (3.5 hours), others said about an hour less. This is a quite interesting result considering other time consuming activities in face to face situations like for example time and space arrangements.

Figure 2. Group presentation inside the VW

The main positive aspects of the experience were identified as follows: (a) “Shared space”: Participants felt engaged with the shared space and motivated to work towards their common goal. (b) “Persistence”: Also, they highlighted that they could log off or postpone some of their activities in the world (especially when they performed self-directed learning) and that seeing the world as they had left it was extremely convenient to mentally focus fast on their task. (c) “The VW promotes problem-based collaboration”: It was fairly easy to discuss about the task since that they had all material uploaded on the shared space, to compare design ideas and comment on others’ work. (d) “Fun, engaging and immersive”. Despite the long time in the
lab, all participants were kept occupied in the VW (e) “Awareness of others’ work, activity and progress”, mainly as a motivating factor to one’s own work.

The main problems identified are as follows: (a) “Focus on the VW environment, not on the task”: some users’ attention was for long on the difficulties of using the environment. (b) “Hard to perform organizational tasks”: the teams did not manage to keep track of their decisions. (d) “The roles of participants were not mapped to their appearance” (e) “More 2D functions”: e.g. the possibility to embed applications from their desktop environment to the VW. (f) “Familiarity with the environment”: this was perhaps the most important constraint for this study: none was proficient with the use of a VW, despite some had limited expertise. They felt that if they were more familiar, the final result would be much better.

B. Field study
The second study was based on the rationale of the first study but it was more like a field study rather than a laboratory study. Again the main purpose was to use VWs for the task of user interface design. The participants were forty students at the Computer Science Department at University of Cyprus, who were following the course in human-computer interaction in the fourth year of studies.

![Figure 3. A user interface prototype designed by the students and presented in-world.](image)

This experiment, which was part of the exercises in the context of the course of ‘Human Computer Interaction’ was more “longitudinal” and
lasted for a couple of months. The participants formed eight groups and each group had to design interfaces for various interactive systems. The experiment consisted of two distinct phases: in phase I a series of introductory tutorials on Second Life were conducted (i.e., how to configure an avatar, how to create objects, etc.), while in phase II, groups of 3-4 students were assigned to design and develop an interactive system utilizing the VW. Different interactive systems (e.g., Realtor’s Agency, Online Game Shop, University’s Management System, Smart Home Management System, etc.) were allocated to each group. The interface design of each system was based on the Logical User-Centred Interactive Design (LUCID)\textsuperscript{11} methodology. Some indicative tasks the students had to undertake throughout the design/development cycle were: i) literature review on similar systems, ii) determine the typical users of the system, iii) analyse the interface’s design, following the Hierarchical Task Analysis (HTA) methodology, iv) design and develop the system’s interface prototypes (Figure 3), v) design users’ navigation model.

Regarding the main outcomes of this study, the main positive aspect was that the vast majority of the students felt that the VW provided the means for a fruitful collaboration. Students claimed that the environment functioned as a shared space where processes such as discussion and exchange of ideas, creation of new ideas and brainstorming were promoted in an effective and efficient way. For some of the students participation in this study provided a new way of communication and collaboration especially for those that didn’t have similar experiences with others VWs before. Some of the students noted that the VW provided the opportunity for them to “prove their communication skills”. Some of their comments are very expressive:

- “The VW helped us to share ideas for the design process”.
- “I found the environment very useful while testing the interfaces we created”.
- “Comments from teammates facilitated the learning process. Comment listener and chatting were the tools that helped me the most”.
- “The VW helped us in the process of work allocation”.
- “It helped me to be more patient with the other members of the team”.

They also pointed out the affordance of persistence of the VW, which was a highly motivating factor to go on for a period of two months. Additionally they emphasized the ability to see the work and the progress that other groups had achieved. Such kind of transparency was unprecedented for the most of the students, which led to a greater engagement and positive feelings despite the several technical problems.
The main problems identified were very much alike as the ones found in the first study. There was a strong focus on handling technical problems that aroused. In addition students stated that they would need more 2D functionalities such as the possibility to embed and share applications from their desktop environment to the VW, to co-edit documents etc. Another problem that was common between the two empirical studies was the issue of familiarity with the environment. The majority of the students did not have previous experiences with such VWs, while some of them claimed that VW would have to be more “authentic” in terms of representational fidelity.

4. Discussion

The results of the user studies were rather encouraging and they indicate that VWs seem to have a potential as constructivist learning environments. Students were engaged in the medium and, despite the difficulties, managed to complete their tasks in a highly collaborative and constructive process. However, the problems identified were sometimes critical and required interventions from the instructors. These findings suggest that VWs are still not mature enough as learning environments, and further research is needed to improve their usability and effectiveness.

One critical issue discovered during our studies were the technical problems that the students encountered during their experience in the VW. Inexperienced users find it difficult to navigate and manipulate elements in 3D and the large number of available commands and parameters needed to make full use of the environment made the user interface quite complicated. Therefore, in-world support by experienced users should be available during the learning activities in order to assist new users to overcome such difficulties. Furthermore, PBL activities are based on student collaboration and there was a notable lack of collaborative tools in the VW. Elements such as shared documents and sketchboards would be useful during these activities. Ideally, as some students suggested, these tools should be interfaced with well known desktop applications that they are familiar with, such as word processing and image processing programs. Finally, VWs are also lacking tools and metaphors for organizational awareness, e.g. means to visualize work progress, task dependencies, user roles and assignments. To overcome these issues, VWs should adopt well known methods from traditional CSCW applications and include them in their user interface using intuitive metaphors.

Bibliography


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