Virtual Space as a Learning Environment: Two Case Studies

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Abstract
This paper addresses the issue of using virtual spaces as a learning environment. With the advances in e-Learning systems, the education community shows a growing interest in using online tools for educational purposes. The case studies presented in this paper demonstrate how a 3D Virtual Environment can be used as a learning tool by providing a virtual space that (1) allows people in different locations to interact, (2) gives users access to facilities not available physically, (3) enables activities that are not possible in physical settings, and (4) offers a variety of observation and measurement tools for performance evaluation and improvement. We demonstrate these advantages through two case studies that offer a framework for language learning for English as Second Language students and a simulated archaeological excavation site for History students, in the context of Carleton Virtual, a 3D virtual environment for Carleton University. Based on the results that show the advantages of using the virtual space as a learning environment, we argue that Virtual Space can be a new framework for learning.

1. Introduction

Providing universal world-class education and an innovative research environment, especially in a country as vast as Canada, requires prohibitive investment in resources to provide students and researchers with multiple physical spaces and environments suited for experimentation and collaboration. For example, physical facilities and spaces such as research labs and university campuses are location-dependent and only accessible to those in that geographical location. Likewise, some training and research activities require the development of complex simulated environments that are either too costly or impossible to arrange (e.g. training emergency personnel on handling major disasters). In addition, it has been recognized that innovative work requires collaborators to share tacit and explicit knowledge freely which requires the rich communication usually associated with face-to-face interaction, enabling people to transfer individually-held knowledge, and synthesize it to fashion new collective knowledge.

Digital media (i.e. computer-based systems) have been widely used to improve the educational and research experience by providing new means of processing and sharing information. However, while traditional information and communication technology (ICT) tools such as websites, email and messaging systems, have contributed to the speed of communication and dissemination of information, their ability to support knowledge creation and assimilation is still limited. Traditional ICT strips away the nonverbal cues that clarify messages, and does not provide the physical and linguistic “co-presence” that face-to-face communicators use to draw inferences about one another’s knowledge [1]. Traditional ICT tools are also limited in their ability to simulate real-world experiences, critical for the assimilation of complex concepts.

Three-dimensional virtual environments (3DVEs) are graphical environments resembling 3D spaces where users control computer-generated characters (avatars) that represent them, while interacting with the environment and other users, and possibly with computer controlled characters. 3DVEs can contribute to an educational and research system by facilitating communication, collaboration, and simulation. 3DVEs provide an electronic surrogate for face-to-face interaction and allow the creation of simulated environments and experiences otherwise not possible due to high cost, physical or logistics constraints. By providing a platform that closely resembles physical interaction, 3DVEs permit interaction with a computing environment and the work of other users, while creating the perception that one exists within the environment.
As discussed in the next section, various researchers have explored the advantages of 3DVEs as educational tools, but current 3DVE research and related technology still suffers from the lack of some particular features such as:

1. A thorough study of the advantages and applications of 3DVE technology
2. Advanced intelligent functionality such as dynamic content, integration with other tools, and performance evaluation tools
3. A new educational paradigm based on “virtual spaces”

In this paper, we present two case studies that together demonstrate general advantages of 3DVE technology. These two cases are a framework for language learning for English as Second Language students and a simulated archaeological excavation site for History students, both in the context of Carleton Virtual, a 3D virtual environment for Carleton University. We demonstrate that 3DVEs can be used as a learning tool by providing a virtual space with following advantages:

1. It allows people in different locations to interact.
2. It gives users access to facilities not available physically.
3. It enables activities that are not possible in physical settings.
4. It offers a variety of observation and measurement tools for performance evaluation and improvement.

The projects introduced here are part of a series of research projects that together try to address the three missing features mentioned above. We briefly introduce our framework which already provides some of those advanced functionality. We also discuss our initial ideas on the educational paradigm based on virtual spaces. In the next section we review some related work. The general structure of our framework and particular structure and results of two case studies are the topics of subsequent sections. Finally, we will provide a discussion and some concluding remarks.

2. Related Work

Researchers have studied these virtual environments for education and health care. Davis et al. [2] proposed a community building approach for cancer patients, while Curran et al. [3] describe the Town of Mirror Lake, a virtual community for educating nurses and medical staff. Most of these researchers have noted that virtual communities have become more and more popular thanks to the familiarity of users, particularly younger generations, with digital online media. Second Life (http://www.secondlife.com) is a 3D virtual environment that has been widely used for social, educational, and commercial purposes. Twinity (http://www.twinity.com) and IMVU (http://www.imvu.com) are two other examples of virtual environments that target reconstruction of real cities and creating social meeting places, respectively. Boulos et al. [4] have provided a good review of potential uses of Second Life and other 3D virtual environments for health and medical education. They argue that 3D environments provide an immersive realistic experience that can combine communication, entertainment, training, and access to a variety of data types. On the other hand, serious and educational games, and the effect of story-based learning and empathic virtual characters have been studied by different researchers such as McQuiggan et al. [5] and Kenny et al. [6]. Other researchers [7] have tried to focus on the issue of community members and how they can differ based on gender, age, and race, and require different treatments.

Callaghan et al. [8] also report the use of Second Life for technology education. They notice the need for some simplifications (for example in teaching engineering equipments) which can be a problem but also mention partial integration with a content management system (Moodle) which is a considerable advantage. Danilicheva et al. [9] explore the educational values of 3D virtual worlds but from a storytelling point of view. Their work points to the value of artificial intelligence and also uses stereoscopic 3D to increase immersiveness.
The common conclusion seems to be that virtual communities may provide a more flexible and accessible learning experience, empower users (students, professionals, patients, etc) and enhance coordination of education/care services. Eysenbach et al. [10] on the other hand have argued that the advantages and disadvantages of using virtual communities for health and education still need to be studied. It should be noted that although very interesting and relatively successful in achieving their targets, none of the above mentioned approaches take advantage of all properties of digital media and provide an immersive virtual world with data collection features required for a quantitative analysis. Full audio/visual immersion and quantitative analysis are major missing parts in most of the existing approaches. Some other shortcomings are integration with web applications and real-time content update and web access from within the environment.

3. Carleton Virtual Framework

The cases studied and presented in this paper have been performed within the context of a web-based 3D virtual environment called Carleton Virtual (CV), designed for Carleton University (CU), Ottawa, Canada. Fig. 1 shows some views of our virtual environment, built using the web.alive technology (http://www.avayalive.com) by Avaya (http://www.avaya.com), which itself is based on web technologies and the Unreal Engine (http://www.unrealengine.com). As shown in this figure, CV provides spaces for lectures, various presentations, collaboration, social interaction and special activities. CV was designed to resemble the actual Carleton University campus. The design keeps some of the characteristic features and elements of the campus but allows modifications to improve the space usage and customize it for the virtual activities.

Fig. 1. Sample Views of Carleton Virtual
The content presentation is done through surfaces (screens) that can show videos, images, presentation files (supporting PowerPoint and PDF), and real-time web pages. This will allow instructors and other participants to easily access content and update it in real time while in the environment. The system allows 3D spatial audio. The sound level can be independent of distance (e.g. for speakers in the lecture hall) or change based on avatars distance (for local talks). At any time, users can know who can hear them, and also can control different audio features such as temporary mute. Different “areas” can be defined to simplify environmental control (e.g. private meetings) and behavioural monitoring (e.g. who goes where, etc).

General activities like lectures and collaboration involve tasks like presenting content in different forms, meetings, and social interaction. They are used in both case 1 and case 2. Special activities are those not commonly used by educators and students. The primary example is the excavation site discussed in case 1.

The implementation of this solution is broken down into three parts: (1) content, (2) telemetrics, (3) integration and deployment. The content is a set of 3D assets generated using standard software tools and environmental controls such as events, triggers, scripts, and volumes, defined using web.alive editor (which also serves as the tool to put together all the assets). Web.alive is based on the Unreal Engine by Epic Games (http://www.unrealtechnology.com) and supports a variety of different asset types. An overview of the telemetric instrumentation and data collection methodology is provided in the next subsection to give insight into current and future potential of the system. Integration and deployment is done through web.alive server side tools in a web-based format.

In selecting the web.alive tool, the project gained access to a sophisticated and verbose logging system as well as a preconfigured set of analytic data and tools. In addition, the raw data affords the future potential of immersive learning focused analytics to help increase the overall effectiveness of education both within virtual environments and in real classrooms. Data is collected by the system on both the server as well as the client. For privacy reasons, the data collected on the server is limited to data which is typically collected over the World Wide Web today such as source Internet Protocol (IP) address, user supplied name and action performed. On the client side, detailed logs are collected about encounters that occur within the environment – from individuals walking within listening radius of each other (an encounter) to two or more individuals speaking to each other within listening radius at the same time (a conversation).

4. Archaeology Case

4.1. Background
The prototype immersive archaeological experience is built on the results of a 2003 excavation conducted by Shawn Graham (Carleton University) and Andrea Bradley (Institute for Field Archaeologists, UK) in Shawville, Quebec (Bibliographie de l’inventaire des sites archéologiques du Québec MCCQ 3453, rapport inédit). That excavation was conducted in the context of a community revitalization project, and was designed to introduce high school students to their community’s heritage as a summer field school in archaeology. The excavation was directed with the intention of discovering the functional layout and extent of this brickyard on the property slated for development. We took the results of that excavation, and simulated one of the 2m x 2m trenches in the Carleton Virtual environment, creating soil layers, features, and artefacts in their relative correct positioning.

4.2. Task
In our initial assessment of the excavation, we wanted to explore whether or not the system made sense intuitively: if, in interacting with it, some appreciation of how archaeological knowledge is created was developed. A second aim was to understand how engaging it was, and what worked, or did not work, for the students in this regard. None of the student volunteers had any archaeological experience, aside from
one introductory lecture on archaeological landscapes. The students were divided into two groups. One group was introduced immediately to the 3D simulation; the other group interacted with a 2D simulation developed by the Friends of Bonnechere Parks. The 2D simulation was selected for comparison as it is a well-developed example of archaeological outreach and a teaching tool expressly meant to address the same issues as our own prototype.

Both groups of students were given graphing paper and recording sheets, and instructed to talk aloud as they sought to understand what the site they were looking at represented. Afterwards, they were asked to complete a questionnaire, in order to enable cross-project comparability. These questions were assessed on a 5 point Likert scale, where the respondents indicated their degree of agreement with various statements:

4.3. Results
These results can be considered no more than anecdotal, of course. However by focusing our design on engagement, we seem to be reaching our initial group of use-testers at the level that we desired. The design of the simulation and the affordances of immersive virtual experience seem to be promoting the kind of emergent learning about archaeology that we should wish to promote to a wider public. When things broke in the excavation, or the students pursued a blind alley, they could hit the ‘reset’ switch, and start again. It was safe to fail, and thus promoted exploratory and constructivist learning. Both kinds of simulation had their strengths and weaknesses (see tables), but the 3D simulation seemed to elicit stronger agreement from our use testers when asked if it helped develop understanding; it also seemed to be a better environment for fostering group learning.

Table 1. Average Students Rating for 2D and 3D Archaeological Simulation

<table>
<thead>
<tr>
<th>Questions were answered by rating from 0 (strongly disagree) to 4 (strongly agree)</th>
<th>3D</th>
<th>2D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel that I have learnt something by using this system.</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2. The excavation simulation reveals believable information.</td>
<td>3.6</td>
<td>2.8</td>
</tr>
<tr>
<td>3. I found it difficult to find out information about the archaeological site.</td>
<td>1.4</td>
<td>2.6</td>
</tr>
<tr>
<td>4. The quality of the material presented was consistent.</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>5. I feel that using this system helps develop my understanding of fieldwork methods and techniques.</td>
<td>2.8</td>
<td>1.2</td>
</tr>
<tr>
<td>6. I found the system educationally stimulating.</td>
<td>3.4</td>
<td>0.8</td>
</tr>
<tr>
<td>7. I was easily able to identify material culture.</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>8. Tools provided allowed me to practice the theory relating to how archaeology creates knowledge.</td>
<td>2.4</td>
<td>1.8</td>
</tr>
<tr>
<td>9. Working in a group helped me understand the excavation process.</td>
<td>3.8</td>
<td>0.8</td>
</tr>
<tr>
<td>10. I found it useful to be able to identify where finds were located within the site.</td>
<td>2.8</td>
<td>1.8</td>
</tr>
<tr>
<td>11. The descriptions of the artefacts I found were reasonable.</td>
<td>3.2</td>
<td>1.4</td>
</tr>
<tr>
<td>12. I was able to find the tools and information I needed to maintain my context sheets.</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>13. I would have preferred to work individually using the system.</td>
<td>0.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Average</td>
<td>2.7</td>
<td>1.6</td>
</tr>
</tbody>
</table>
5. Language Case

5.1. Background
This project was designed to give students in an Academic ESL class a unique opportunity to practice speaking and collaborating with their classmates using a common linguistic reference (English) in a risk-free environment. The 3D Carleton Virtual environment allowed students to collaborate in a space that was mutually convenient to the participants in terms of time and accessibility. This immersive learning opportunity made use of the existing Carleton Virtual (CV) framework. In particular, students collaborated in designated library rooms and final presentations were held in the Azrieli Pavillion.

5.2. Task
This project was piloted with an advanced English as a Second Language Academic (ESLA) class. To begin, students were introduced to the concept of virtual worlds and virtual environments through several assigned readings. This content helped them to understand basic issues and challenges associated with learning virtually or online. Additionally, these readings established some core academic and topic related vocabulary such as “virtual” and “immersive”. Students later attended a “virtual workshop” wherein they experienced firsthand the CV environment. Next, students were asked to choose between a more traditional group project and presentation or a virtual group project and presentation. Student groups then chose to compare two non-governmental organizations or two virtual learning platforms (these sub-topics related to broader course themes). Students in the traditional groups had to arrange to meet and plan on campus and the final oral presentation took place during a regularly scheduled class. Conversely, students in the virtual groups committed to meet, collaborate and present exclusively in Carleton Virtual. All presentations included a reflective component and were evaluated.

Success of a virtual learning task depends on the task itself and the tools available within the immersive environment. As CV physically replicates a university classroom space, tools are not all that dissimilar to those tools students would normally use to work on traditional academic projects. But, what makes this experience unique is that the students can perform under the persona of their avatar anywhere and anytime.

The option to personalize one’s avatar was also appealing to many students as they could alter such traits as hair, skin and eye color. This simple act of fictitiously representing oneself (through a personalized avatar) generated spontaneous language production and even humour as group members commented on each others’ changing appearance from day to day. Students liked the “game-like” scenario.

5.3. Results
The most positive outcome was seeing how student groups embraced this opportunity with new-found enthusiasm and energy (this project was introduced towards the end of term and so motivation was beginning to wane); this enthusiasm resulted in professional and well executed group oral presentations. Content was strong and delivery was well rehearsed as evidence in their formal stage presence, authentic and “true-to-life” avatar mannerisms, and well-timed delivery. In addition to increased motivation and task engagement, some learners in the virtual groups appeared less reticent presenting to other non-native speakers and actually demonstrated more initiative and problem solving skills than had been observed during group work in the traditional classroom. The 3D environment afforded students freedom and flexibility which motivated them to work more collaboratively in a “fun”, risk free environment and consequently perhaps speakers were more comfortable speaking than in a traditional language classroom.

While student feedback was generally positive, there were some challenges. Overall learners liked that CV was more active and technologically attractive, and that communication was more similar to face to face communication compared to in other learning platforms. Challenges included technology and internet access, which were not always compatible or working.
It is important to note that this task was executed and piloted during a short period of time and at the end of term. Preliminary observations suggest that ESLA learners can benefit from immersive environments like CV, because they are fun, autonomous and relevant providing the task is challenging and generates opportunities for language production.

6. Conclusion

In this paper we have presented the results of two case studies on the use of 3D Virtual Environments as virtual learning spaces. The paper demonstrates how a 3DVE can be used as a learning tool by providing a virtual space that (1) allows people in different locations to interact, (2) gives users access to facilities not available physically, (3) enables activities that are not possible in physical settings, and (4) offers a variety of observation and measurement tools for performance evaluation and improvement. Each one of our two cases show a subset of these features. While the ESL course relies on interaction of people in different location and presentation of content virtually, the archaeology course is a good example of offering activities otherwise not available.

Further research is required to make better use of telemetric and analysis tools, and measurement data, in order to enhance the learning experience. Other types of educational activities such as science lab and also interaction with artificial intelligence-controlled characters are also among future objectives of our research.

References