Enhancing the Collaborative Learning by using Immersive Virtual Reality.

Ronan Jamieson¹, Priscilla Ramsamy¹, Adrian Haffegee¹, Nia Alexandrov¹,

¹Advanced Computing and Emerging Technologies Centre(ACET), The University of Reading, UK

Key words: Virtual Reality, Collaborative Environments, E-learning,

Abstract:

High performance Virtual Reality (VR) technology such as immersive projection technology (IPT) systems can provide an ideal platform that immerses students within the virtual world. Using such a system with educational applications that have been developed to contain an element of fun, would result in a powerful learning tool that students would enjoy using. Through the interconnection of multiple VR systems the learning environment can be distributed amongst multiple users at different locations. This work builds upon the use of VR as an educational tool and investigates how collaborative interaction between multiple parties can improve learning while also encouraging the formation of working relationships within the Virtual Environment (VE).

1 Introduction

The fast changing nature of technology means that the educational landscape has to rapidly change to integrate these new features into the classroom environment. As students are currently spending larger portions of their time on-line, a proliferation of virtual communities and environments are being developed to cater for these needs. This has forced many organisations; especially schools to adapt their methods of engagement reflect these new trends. This is especially apparent for the "console generation". Modern students expect to be able to use the latest technology in every aspect of their daily life from web-based learning to social networking (e.g. My Space) and entertainment (e.g. You Tube). Therefore, there is a need for continual development of novel, high-tech strategies to address the fast evolving needs and to engage the interest of today's youth. We believe that one such approach is through the incorporation of VR into this landscape. VR allows for the creation of virtual worlds that can address the entire social spectrum. It is a powerful technology that takes advantage of the mind's natural way of visualising and processing information and therefore can be a valuable teaching tool.

A major benefit of this rapid pace of technological advancement is that equipment that previously was only in the research or private domain are now within the reach of educational institutions. Investigations have shown that VR can be a useful tool to enhance the learning process; we feel that VR will have a growing influence on traditional teaching methods. VR utilises the latest advances in computer graphics, which allow us to generate 3D stereo scenes that simulate realistic environments, landscapes or models, this coupled with 3D virtual objects becomes a powerful educational medium. In this medium we can provide to its end-users the ability to create virtual representations of physical systems on a computer display or
in an immersive environment. These can range from a simulation of complex molecular docking through to an architectural walk through of ancient Rome.

By putting the learner in the active role rather than given the passive role computer generated environments can enrich and enhance retention and learning. When sharing a Virtual Environment, students can collectively participate in a shared experience. If tailored with an educational bias this environment can provide an almost boundless educational tool that is only constrained by the limits of the VR hardware. At a basic level, this could allow collaboration as the students share some common task. However, by tuning the applications the students could each be given different roles within these environments. This will further encourage teamwork as the students work together to reach their common goals.

The main VR system at Reading is a fully immersive back projected system, it is considered a CAVE[1] – like system. Also the authors have access to a large back projected screen and various desktop systems, which allows them to create a variety of different collaborative environment configuration. The rest of the paper is organised in the following manner, section 2 presents the related work in this area, section 3 will discuss why VR is an ideal medium for carrying out worked involving teaching and collaborative exercises. This is followed by section 4 which outlines our approach and completed work. Section 5 presents our conclusions where as section 6 discuss any future work under consideration.

2 Related Work

There have been many research-based systems that have aimed to demonstrate the enormous potential that VR has as a simulation tool, training tool and for modelling various different scenarios. The most current ones, that have incorporated the latest advances in VR technology for the purpose of education, are as follows. This is no mean an exhaustive list, but a mention of the more applicable ones. The NICE [2] project and the Round Earth project [3] for instance focuses on the potential of immersive displays (CAVE) to make the interface for the learning experience easier and more natural to use. Due to the fact that the CAVE can support more than one person at a time, each user can take part in the learning environment simultaneously. This research focused on providing an evaluative framework, with the purpose of accounting for usability and conceptual learning attributes. The main outcome of the study acknowledged that it is not a straight forward answer to the direct benefits that VR could bring to a learning environment, but that there was definite advantages to using such technology.

A different approach was taken by the Human Interface Technology Laboratory (HITL) [4]. Their objective was to engage the students by enabling them to create their own virtual worlds and provide them with distinct hands on approach to developing their collaborative environment; this encouraged them to learn about VR by designing and constructing their own ideas. Students were deemed to be more motivated to learn the skills required to design and model objects, also they were eager to work towards their objective and demonstrated satisfaction with what they had achieved. The final completed virtual worlds were individual and highly original in both conceptualization and implementation. Collaboration between students proved to be highly successful, and this resulted in strong bonding between the team members.

Further research has been carried out at different stage in the education cycle from utilising a virtual environment to teach primary school algebra, Winn and Bricken [5] to teaching secondary school level chemistry, Byrne [6] with different levels of success. For teaching algebra VR proved to a promising educational tool. At the secondary school level, a study was
carried out by comparing interactive technologies namely VR, PC-based multimedia and passive video. The findings showed definite learning improvements when utilising interactive technologies and an improvement in performance which can be seen to indicate that interactivity encourages learning to a higher degree than passive viewing systems. These results were considered as preliminary due to the fact that there were several limiting factors that need to be addressed before the result can be considered as definite. These limiting factors included; the lack of experience in a virtual environment made it difficult to compare against the skills to work with a PC which is already highly developed for most students and also the short exposure time with poor graphics.

3 Virtual Reality in an Educational Context

From the previous section it has been shown that VR can enhance the users experience and should be incorporated into the educational landscape. As education is rapidly moving towards electronic methods of learning, e-learning is always seeking to integrate the next generation technology and by finding methods of integrating VR, we would embrace the fast moving digital revolution. This will enable e-learning to be relevant and not let it become potentially obsolete like the traditional textbook. The Educational Framework of the E-LANE project [7] provides a meta-model of how e-learning and how its inclusion in education should be implemented. In the context of this Framework VR can be used by extending and adding a new feature to the Digital Content and Technology component. The implementation and technology platform model from this Framework was considered when developing the two different collaborative environments mentioned in section 4.

VR can improve the learning process in the following ways [8] [9]:

- Strengthens motivation: Virtual worlds provide an engaging experience to end users by entirely immersing the student cognitively and effectively in the VE.

- 3D-interaction: Interaction with the virtual objects is more intuitive and realistic as students can manipulate and interact with VOs in a natural way.

- Supports individual learning styles: while permitting students to explore their surroundings it would increase their understanding of concepts and procedures. Knowledge will be based on their direct personal experience.

- Complexity levels: The virtual world can be programmed in such a way as to provide the users with different levels of complexity. This can be achieved by offering pop-ups or help tips that could be used be the students to successfully complete their task. The system could also automate some procedures at the very start enabling the students to concentrate on others and as the student moves form one level to the next degree of complexity can be increased or the amount of help could be minimized.

- Real-world modelling: VR has the possibility of offering educators the ability to simulate conditions where it would be dangerous, difficult, or costly to educate students in real world environments.

- Local or distance learning: VR can be used across different boundaries including those of time and distance. Students can work and collaborate distributed from remote areas.
• Monitoring and assessment: performance monitoring as a critical educational tool can be easily integrated with virtual educational settings.

Immersive systems also provide several features and characteristics that can enhance the education process including:

• Presence and Immersiveness: It provides the user with the highest sense of presence and immersion by displaying physical images at realistic sizes enabling better visualization and investigation. These systems would be suitably used where 3D spatial reasoning is required by permitting the end user to change his/her viewpoint and also by enabling him to manipulate and orient the object for a clearer understanding.

• Collaboration: more than one user can participate and interact in a CAVE-like session. This is beneficial when mutual discussions are needed.

• 3-D viewing: true 3D images can be viewed from different angles.

• Scale: due to the size of the immersive display the physical scale of images can be large enough for better visualization and investigation.

4 Current state of Development

The ACET centre has developed many different types of collaborative environments, they usually take one of two different structures, these being either a CAVE-CAVE collaborative environment or a multi-system collaborative environment (see Figure 1). The chosen structure depends on the requirements of the project. A variety of different hardware and software is used in the projects to create these collaborative environments. They are discussed in more detail in the next sections. Also discussed will be two different collaborative environments created for very different tasks.

![Figure 1 - Different Collaborative Structures](image-url)
4.1 Hardware
The ACET centre at Reading University has a range of visualization systems such as the Trimension ReaCTor which is a CAVE-like system. This system provides the illusion of immersion by projecting stereoscopic computer graphics into a room sized cube composed of display-screens that completely surround the viewer. It is coupled with a head and hand tracking system to produce the correct stereo perspective and to capture the position and orientation of a three-dimensional input device. Audio feedback is provided by using a sound system. To navigate within the virtual world end users make use of a wand or can move freely within the cube.

The CAVE can blend real and virtual objects in the same space providing the user with an unobstructed view of themselves interacting with the virtual environment. The major advantage over desktop systems is that fully immersive systems will provide a greater sense of presence, offer a realistic mode of interaction and manipulation, and also provide a larger field of view hence increasing the sense of immersion.

4.2 Software
The application has been implemented using the VieGen framework as described in [10]. VieGen provides several libraries of tools and utilities that can be used to assist the development of Virtual Interactive Environments. Elements of this framework include the interface to the display hardware, a networking subsystem, scene management, environment simulation and accompanying utilities, all of which can be used or omitted as required.

4.3 Virtual House
This application environment uses the multi-system collaborative environment structure. One user is immersed (in the ReaCTor) whereas the other user is sitting in front of a desktop system. There are a variety of simple task to be completed collaboratively within this environment. One such task is associated with opening and closing the door of a virtual house. A picture of this can be seen in Figure 2, which shows a local user about to manipulate a moving door that has been opened by a remote user, represented through its avatar.

![Figure 2 - Virtual House Collaborative Environment](image)

4.4 Human Anatomy
This application was developed to allow either a single user (in the ReaCTor) to learn in a virtual environment by interacting with the 3D models in a multi-user learning environment where remote users can collaboratively learn, by interacting with the models but also with the benefit of discussion with other users, a picture of this can be seen in Figure 2. The user
should gain an understanding of this by examining the organs using the different techniques. The learning experience is achieved via the user identifying the organs correctly and then placing them in their respective position within a human skeleton. Afterwards the user should have a greater understanding of the size, shape, colour and position of the different organs.

Figure 3 - Human Anatomy Collaborative Environment

5 Conclusion

We have demonstrated the ability to use VR technology and software to create and test collaborative virtual environment. Two different possible approaches were implemented and demonstrated, this being a Virtual House environment and a Human Anatomy environment. Within these VEs created, the users had the ability to view, move and interact with various different VO’s, any actions in one environment was then transmitted to the other systems on the network. There it should only be a short step to expand these VE’s to allow a collection of students to utilise the environment in their studies. Further work needs to be undertaken in conjunction with interested educators. Therefore the objective of this paper has been fulfilled which was to stimulate debate concerning best practice to ensure all the relevant parties (i.e. students, teachers, parents) have a positive outcome.

From experience relating to using VR in other studies, an important issue that will need addressing will be improved manipulation and navigation within the virtual environment. These issues can be addressed in any future work to be carried out.

6 Future Work

A review of the training given to users prior to exposing them to the technology. Will be carried out. To further refine the different environment a broader range of test users varying in age and educational background would be used. Other emerging technologies will also be evaluated and integrated to enhance the virtual environment, for example Augmented Reality (AR), haptics devices, audio cues or video streaming.

References:


Author(s):

Ronan, Jamieson, Mr
University of Reading, ACET Centre
School of Systems Engineering
Reading, Berkshire, RG6 6AY
United Kingdom
r.jamieson@rdg.ac.uk

Priscilla, Ramsamy, Ms
University of Reading, ACET Centre
School of Systems Engineering
Reading, Berkshire, RG6 6AY
United Kingdom
p.ramsamy@rdg.ac.uk

Adrian, Haffegee, Mr
University of Reading, ACET Centre
School of Systems Engineering
Reading, Berkshire, RG6 6AY
United Kingdom
a.m.haffegee@rdg.ac.uk

Nia, Alexandrov, Mrs
University of Reading, ACET Centre
School of Systems Engineering
Reading, Berkshire, RG6 6AY
United Kingdom
n.s.alexandrov@rdg.ac.uk