3D LEARNING ENVIRONMENTS IN TERTIARY EDUCATION

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Abstract

Recent advances in desktop computer graphics hardware and associated software have made 3D environments feasible for mainstream educational use. This paper examines the potential applications of 3D environments in tertiary education. Characteristics of a 3D Virtual Chemistry Laboratory currently under development are described in order to illustrate the ideas discussed. The paper concludes by identifying key research questions that need to be addressed.

Keywords

3D, virtual environment, virtual reality, simulation, microworld, visualisation

Introduction

In recent years, teachers in a variety of educational settings have begun to make greater use of information and communication technologies in their teaching. Such technologies have the potential to make learning resources more accessible, to allow a greater degree of individualisation and to make the learning process a more active one. Recent developments in desktop computer hardware and software have made feasible a new application of learning technologies, the 3D learning environment. It is argued in this paper that such environments can situate learning to a greater degree than traditional multimedia learning resources and can facilitate individual knowledge construction through new types of learner-computer interaction.

Background

Virtual Reality and Virtual Learning Environment have become increasingly ambiguous terms in recent years. For example, Moore (1995, p.91) states that “Virtual reality falls into three major categories: text-based, desktop and sensory-immersive VR”. Text-based VR, of which MUDs and MOOs are examples, is outside the scope of this paper. The term Virtual Learning Environment has begun to be used to encompass any Internet or Web based learning resource with associated discussion tools. The term 3D environment has been chosen to focus on a particular type of virtual environment that makes use of a 3D model.

Specifically, the main characteristics of a 3D environment are as follows:

- The environment is modelled using 3D vector geometry, meaning that objects are represented using x, y and z coordinates describing their shape and position in 3D space.
- The user’s view of the environment is rendered dynamically according to their current position in 3D space.
- The user has the ability to move freely through the environment and their view is updated as they move.
- At least some of the objects within the environment respond to user action, for example doors might open when approached and information may be displayed when an object is clicked on.

Additionally, some environments include 3D audio, that is, audio which appears to be emitted from a source at a particular location within the environment. The volume of sound played from each speaker depends on the position and orientation of the user within the environment.

Much of the early 3D environment research focussed on physically immersive environments, which require expensive hardware such as head-mounted displays, rather than desktop environments, which use standard computer hardware. The focus of this paper is primarily on desktop 3D environments. Recent advances in the capabilities of standard desktop computers allow highly complex 3D models along with 3D audio to be delivered at realistic frame rates and with very fast response times (Kelty, Beckett & Zalcman, 1999). Robertson, Card and MacKinlay (1993) argue that desktop 3D environments can be easier to use than immersive environments because people are already familiar with the desktop computer, and do not subject the user to the physical and psychological stress often associated with immersive environments. Additionally, the development and proliferation of the Internet, has made possible the development of distributed 3D environments which can be explored by multiple learners together, from separate locations. Although physically immersive environments may be more suitable for some educational applications, for example applications that focus on sensory motor skills, it is argued in this paper that desktop 3D environments have potential across a range of discipline areas.

3D Environments and Learning

3D environments have the potential to situate the learner within a meaningful context to a much greater extent than traditional interactive multimedia environments. The sophistication in the rendering of objects, the independent behaviour of objects within the world, and the degree of interaction available, allow for situated tasks that are both meaningful and intrinsically motivating for learners. This section looks at existing educational applications of 3D environments and applications that have been suggested in the literature.

A frequently discussed application of 3D environments is the exploration of places that cannot be visited, such as historical places, outer space or the ocean floor. For example Alberti, Marini and Trapani (1998) describe an environment modelled on an historical theatre in Italy. A related application is the exploration of models of microscopic objects, such as molecular structures (Tsernoglou, Petsko, McQueen & Hermans, 1977, cited in Wann & Mo-Williams, 1996).

By allowing the learner to manipulate objects within the environment in addition to being able to move around, there is potential for the learner to develop a much greater level of understanding of the situation modelled. For example, in the discipline of physics, students are expected to understand how objects will respond to forces. By exploring an environment that allows for specific forces to be applied to objects and for the resultant object behaviours to be observed and measured, a learner is likely to improve their conceptual understanding.

Another application of 3D environments is in situations where the learner needs to master some skill. It is particularly appropriate to use 3D environments in situations where the tasks being learned are very expensive or very dangerous to undertake. For example, 3D environments have been used to train nuclear power plant workers in Japan (Akiyoshi, Miwa & Nishida, 1996 cited in Winn & Jackson, 1999). Another example is the use of such environments to train astronauts in how to repair a space telescope (Psotka, 1994 cited in Moore, 1995). However, 3D environments may be of value for any tasks that cannot be conveniently carried out by learners as often as they need to or at a convenient time.

Winn and Jackson (1999, p.7) suggest that 3D environments “are most useful when they embody concepts and principles that are not normally accessible to the senses”. For example, they discuss the modelling of concepts such as justice. They use the term “reification” to describe the representation of phenomena that have no natural form. An example is the 3D environment for developing learner’s understandings of geometry described by Kaufmann, Schmalstieg and Wagner (2000).

Hedberg and Alexander (1994) emphasise the ability of virtual environments to situate learning within a meaningful context. Because a 3D environment can provide a level of visual realism and interactivity consistent with the real-world, it is possible that ideas learned within the environment will be more readily recalled and applied within the corresponding real-world environment. This is a logical corollary to the theory that knowledge can be internally anchored to experience. This theory is supported by research carried out by Baddeley (1993) suggesting that information learned by divers under the sea is better applied while diving than information learnt on land. It is also supported by Brown, Collins and Duguid's theory of Situated Cognition (1989) and by the Cognition and Technology Group at Vanderbilt's theory of Anchored Instruction (1992).

Virtual Chemistry Laboratory

The Virtual Chemistry Laboratory is an accurate model of a chemistry laboratory used in teaching at Charles Sturt University. The initial version has been designed to allow a learner to become familiar with the layout of the actual lab, as well as to find out information about procedures to follow in using the lab. It has been developed using the Virtual Reality Modelling Language (VRML) and is accessed through a web interface. Learners can explore and manipulate items of apparatus within the lab, and by selecting an item can view information about the use of that item. The contents of the introductory chemistry laboratory manual is also accessible from within the lab. The current version can be explored online (Virtual Chemistry Laboratory, Online).

Figure 1: The virtual chemistry laboratory

The next phase of development will focus on facilitating the learning of fundamental concepts in chemistry through the undertaking of virtual experiments. A feature of the simulated experiments will be an option allowing the learner to zoom in to the molecular level. As well as visually simulating the experiments, the enhanced virtual laboratory will include logging of student activity and context-sensitive pedagogical guidance. It is intended at a later stage to enhance the environment so that each learner present within the laboratory is represented by an avatar and to include a facility to allow learners to communicate with each other. This would allow, for example, learners to undertake virtual experiments together as a group, under the supervision of laboratory demonstrators.

Conclusion

This paper has discussed the potential educational applications of 3D environments. Although the potential of 3D environments as learning resources is clear, there is still a great deal of work to be carried out before designers can be sure about where 3D environments should appropriately be used and about how best to design them. There is now a growing body of literature describing examples of educational 3D environments. However, there is a notable lack of published data from formal evaluations of their effectiveness. There is also a need for research that investigates the degree to which 3D environments do in fact assist in 3D cognitive encoding, and the degree to which such encoding aids in understanding, recall and application of knowledge. Additionally, if such environments are to become widespread, they need to be easy to use, and consequently work needs to be undertaken to derive useability guidelines for designers.

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