USING VIRTUAL REALITY IN TEACHING SECONDARY SCHOOL PHYSICS

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Abstract

The use of Virtual Reality (VR) in education has been depicted as an interesting and promising area where constructivist learning theory can be put into practice. This paper describes a work-in-progress project attempting to take advantage of the current VR technology for constructivist learning practices in the teaching of secondary school Physics.

The project involves the creation of 3D VR environments for use on the World Wide Web where learners are exposed to virtual physical environments. These environments incorporate rich and meaningful physical phenomena and relationships so that learners can navigate and explore freely, view from different perspectives and visualize the various physical concepts and relationships which otherwise can be difficult to visualize using traditional teaching material in the form of texts and graphics.

This paper also discusses the initial reactions from learners as well as colleagues teaching on the subject.

Introduction

The central tenet of Constructivism is that knowledge of the world is constructed by the learner (Boyle 1997). Constructivism proposes that courseware should be designed in such a way to provide an environment conducive to the construction of knowledge by the individual, rather than supplying knowledge directly. Constructivism also emphasizes collaborative learning and personal introspection into one's learning process (Brooks & Brooks 1993, 1996). It has been viewed by many (e.g., Moore 1995; Osberg 1997) that virtual reality (VR) offers promising grounds for creating and developing learning environments that promotes constructivist learning.

VR refers to computer-generated 3-D interactive environments in which the learner is an active participant (Bricken 1991; Bricken & Byrne 1992). The learners interact with and act directly upon the virtual environment and influences the variables in the environment (Moore 1995). Although some comment that the VR technology is still in a relatively rudimentary stage of development, it is our opinion that what is currently available can already be applied in teaching.

In secondary school Physics where many topics to be studied, for example, those in Mechanics, involve cognitive visualization of distance, direction, inclination and speed and intricate relationships between these elements, it is our belief that VR can play an effective role in creating 3-dimensional virtual environments that promotes learning.

Rationale

The traditional Physics class is predominantly filled with experiments with which students observe physical phenomena, record data, analyse data and the relationships they exhibit in order to verify established or current theories. While doing experiments promotes the principles of the Scientific Method, the drawback of conventional classroom experiments is that it is difficult to allow learners to design their own learning curve. In fact, under the constraints of the physical settings of a school laboratory and the apparent authority of teacher instructions, learners typically pursue in their experimental work outcomes that are expected of the experiment, either by the teacher or by the textbook. The individual differences in learners are rarely addressed and individuals rarely have the opportunity to develop unique ways of experimentation.

Moreover, the typical secondary school physics laboratory is simply not sophisticated enough to meet many learning needs. Observation and visualisation of complicated physical phenomena is a virtual impossibility. The collision of gas particles in the micro world, the circular motions of celestial bodies in the macro world, perfectly elastic collisions, frictionless environments are some typical examples.

To teach concepts and theories related to these physical phenomena, teachers often depend on 2-dimensional chalk and board or textbook-based descriptions and explanations. To learn them, students have to rely on their own creative imagination to construct in their mind a 3-dimensional space. Blackboard descriptions, and by the same token textbook descriptions, only allow the learner to view phenomena from a single rather than multiple perspectives. The use of static images to teach ideas involving motion is an understandably difficult task. What learners have constructed in their imaginary 3-dimensional world can differ tremendously from one another, and can deviate phenomenally from what the teacher is attempting to describe. This typical scenario presents great barriers in learning and makes in-depth classroom discussion and further exploration very difficult.

This project attempts to break through this barrier by constructing an interactive web-based VR environment in the secondary school Physics teaching classroom. This environment is created with a PC-based 3D virtual reality technology. In the initial stage of this project, the following areas targeted at Form 4 secondary school students have been selected:

1. Relative Motion: Ships in the Sea ; Sun Rise; Rotation of Planets

2. Pressure and Collision of Particles

3. Gas Pressure against Gravity

4. Periodic Motion: Simple Pendulum; Pendulum of 2; Pendulum of 5

Building and using the VR

To build the interactive environment, which we call *3D Physics World*, the following software has been used:

- Superscape 3D Webmaster (Evaluation version)

- Microsoft Frontpage

3D Webmaster allows users to create virtual reality environments called Worlds. In its *Drag and Drop Warehouse*, different 3D models including buildings, cars, plants and animals are available. Users can create their own models or modify from ones available. Most of the models used in this project were created by modifying the primitive objects in the *Drag and Drop Warehouse* using the *Shape Editor* provided. By assigning these objects in different initial positions and setting different initial velocities for them, a VR simulation was thus created.

Learners when working in this virtual world can observe the physical phenomena from any perspective and any frame of reference. The navigational controls provided by 3D Webmaster are intuitive enough for secondary school learners to grasp with ease in a couple of minutes. Once feeling comfortable with the navigational tools, the learner can view the physical phenomena from a perspective of his own choice. He can then initiate movements of objects by dragging and dropping and observe the motion created in different settings. He can also pause all motions to observe more closely for as long as he likes, or return to the initial settings at his discretion to start all over again. This kind of experience is not what traditional 2-dimentsional texts and graphics alone can produce.

Initial Observation and Feedback

The material developed in this project was used with a group of Form 4 students in the 1998-1999 academic year. Students seemed to be greatly impressed with the possibility of being able to control and explore with objects in a VR environment. There was an obvious surge in interest in the subject and in the motivation to learn. Many were excited by the hands-on experience and expressed the opinion that it was fun to learn compared with a situation where only the textbook and blackboard would be used. Peer discussion and share of experience among learners was also seen to increase as excitement about the different observations mounted.

Colleagues teaching on the subject also expressed positive comments after trying to use *3D Physics World* in class. They felt that the lesson was conducted with less teacher talk and resulted in better understanding of the subject being taught. Some commented on the need to design follow-up activities to go with the Web material in order to maximise learning.

Conclusion

It is believed that this project represents initial attempts by front-line secondary school teachers taking advantage of the available VR technology in teaching. It is hoped that the project could be further developed in the following lines:

- Extension to other topics

- Post-VR activities

More structured research can be carried out to study learner reaction, and learning outcomes as compared with the more traditional chalk and board approach. It is our hope that teachers teaching on the same topics will attempt to use *3D Physics World* posted on the World Wide

Web (http://i.am/3dphysicsworld/) and give us their comments and suggestions for improvement.

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