

# USE OF VIRTUAL REALITY IN MINING EDUCATION AND TRAINING

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## ABSTRACT

*Education and training are of great importance to the Mining Industry in improving safety and productivity. Although there is no substitute for real life training, more and more people are using software and hardware technologies to shorten training times, improve training effectiveness and to reduce the cost of education. Virtual Reality (VR) is an evolving technology, which has the potential to revolutionise education and training in the mining industry.*

*This paper describes the development of a number of VR applications for mining education and training, including virtual mining method teaching modules, drill rig and Instron UCS rock testing simulations and a VR ventilation simulation of the University of Queensland Experimental Mine (UQEM). These simulations provide the user/student with the opportunity to navigate around virtual models, to carry out hazard identification inspections and to conduct a number of rock property tests in an interactive manner. These simulations make use of realistic 3D graphics and sound to create an engaging and realistic learning experience for the student.*

## INTRODUCTION

Education is a complex process in which both human and technical resources should be utilised in a carefully balanced way. Traditional teaching practice, learning methods and course content have all been affected by the introduction of computer technology. The challenge is to develop and use modern learning environments in education while the curriculum of university education is continuously evaluated and modified to both include new ideas, thinking and learning methods, and to eliminate redundant material.

Bell and Fogler (1995) state that students learn best when a variety of teaching methods are used. They further state that different students respond better to different teaching methods. When used in conjunction with contemporary teaching techniques such as class discussions, group projects and problem-based learning, multimedia and virtual reality based techniques have the potential to revolutionise education in the mining industry. The use of these techniques in education is more attractive to students as they are flexible, attractive and easier to understand - especially in mining where it can be difficult to demonstrate complex underground mining methods through the use of two-dimensional diagrams.

Training is becoming a high priority for the mining industry due to high injury and fatality rate (Quinlan, M. and Bohle, P. 1995, MCA 1998 and 1999). Although there is no substitute for real world training, VR offers the necessary tools to reduce the cost of training and improve safety. By using VR in the initial stages of training, personnel can be taught to use equipment in a controlled and safe (both for the personnel and the equipment) environment. In addition, equipment down time due to training and the risk of damage to expensive equipment during training are reduced.

## VIRTUAL REALITY SIMULATIONS DEVELOPED

Virtual Reality can best be described as “a way for humans to visualise and interact with the artificial 3D environments created using computer graphics”(Aukstakalnis and Blatner, 1992). VR systems are real-time computer simulations of the real world in which visual realism, object behaviour and user interaction are essential elements (Denby and Schofield, 1999; Filigenzi *et al*, 2000 and Schofield *et al*, 1994).

Although the concept of VR has been around for nearly half a century, it has taken recent advances in hardware and software to bring this technology to within the budgetary reach of ordinary users and researchers. VR is now successfully being used in the mining industry

Although Virtual Reality techniques have been around for a considerable time now, their use in the Mining Industry have so far been relatively limited. The VR research group at The University of Queensland, Mining

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Division has been involved in developing VR applications for the benefit of the mining industry since 2000 (Kizil *et al*, 2001 and Kizil, 2003).

This paper gives a brief overview of some of the VR simulations developed by The University of Queensland for use as training and education tool for students involved (or plan to be involved) in the mining industry.

### Virtual Mining Methods

Teaching mining methods to students is a challenge for many mining academics. The difficulty lies in representing three dimensional environments and constructions with two dimensional images and drawings (Previous approaches include the construction of bulky physical models). Since the purpose of VR is to intuitively convey three dimensional concepts and environments through three dimensional graphics and user interaction, it is the ideal solution to this problem.

As part of the mine planning teaching module developed with support from the Minerals Council of Australia (MCA)- Minerals Tertiary Education Council (MTEC), a series of six subsidiary teaching modules have been developed that outline various conventional mining methods (Kerridge *et al*, 2003). The methods featured are;

- Block Caving,
- Open Pit Mining,
- Strip Mining,
- Longwall Mining,
- Sublevel Stopping and
- Cut and Fill Mining.

While the teaching modules utilise traditional written text and graphics, it is the fully embedded three-dimensional animations (Figure 1) and interactive virtual models that will enable students to rapidly learn the design and production aspects of the featured mining methods (Figure 2).



Figure 1. Frame from an animation showing blasting and excavation in an open pit mine

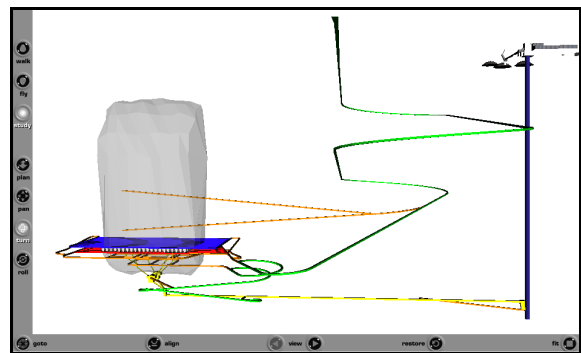


Figure 2. An interactive three dimensional VR model

Where appropriate each mining method module details the development, production and ventilation of a mine that uses the featured mining method. Equipment usage and method variations are also covered for each method. Each module is presented as a web based, multimedia document (Figure 3). It is planned that the mining method modules will be accessible as part of a virtual mining method website and as a CD-ROM distributed to each student.

### UQEM 3D Ventilation Simulations

The University of Queensland Experimental Mine (UQEM) has been used by students for practicals and experiments since 1956.

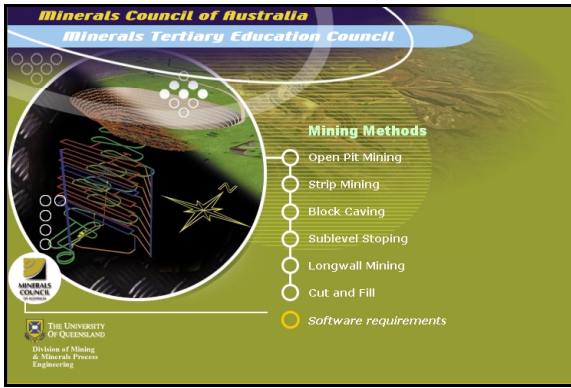


Figure 3. A screenshot of virtual mining methods website

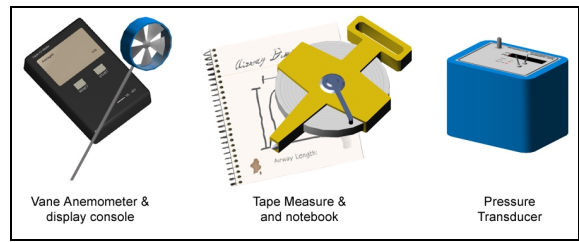


Figure 4. Three-dimensional survey equipment models

Two virtual reality computer applications have been developed to enhance the benefits of the UQEM to the students for the purpose of data visualisation, training and education in mine ventilation.

One of the applications provides virtual survey tools (Figure 4) for conducting pressure and quantity surveys while allowing the user to interact with different features of the ventilation system (such as doors and regulators) and witness the effect on the ventilation system (Figures 5 and 6).



Figure 5. Navigating around UQEM with a vane anemometer for conducting a quantity survey

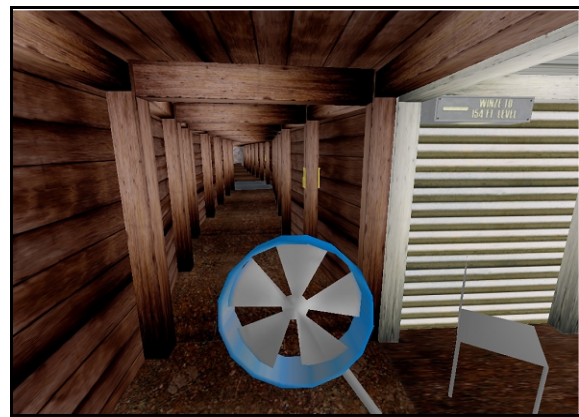


Figure 6. The user is able to close or open vent doors to measure their effects on ventilation

This program also allows the user to navigate around the mine and be immersed in an environment as close to the real world UQEM as possible.

The second application is capable of displaying the dynamic changes in airflow patterns in the UQEM using real-time sensor input. It is hoped that this program can be further enhanced for use as a real time visual monitoring system in an underground mine environment.

### CRCMining Drill Rig Training Simulation

Training is always high on the agenda of the mining industry due to the safety aspects and costs involved. As previously mentioned, the use of VR in training provides trainees with a safe and controlled learning environment, reduces equipment down time for training, and reduces the risk of equipment being damaged during training exercises. (Kizil and Joy, 2001). The BigTED virtual drill rig system is an example of such a training system (Figure 7).

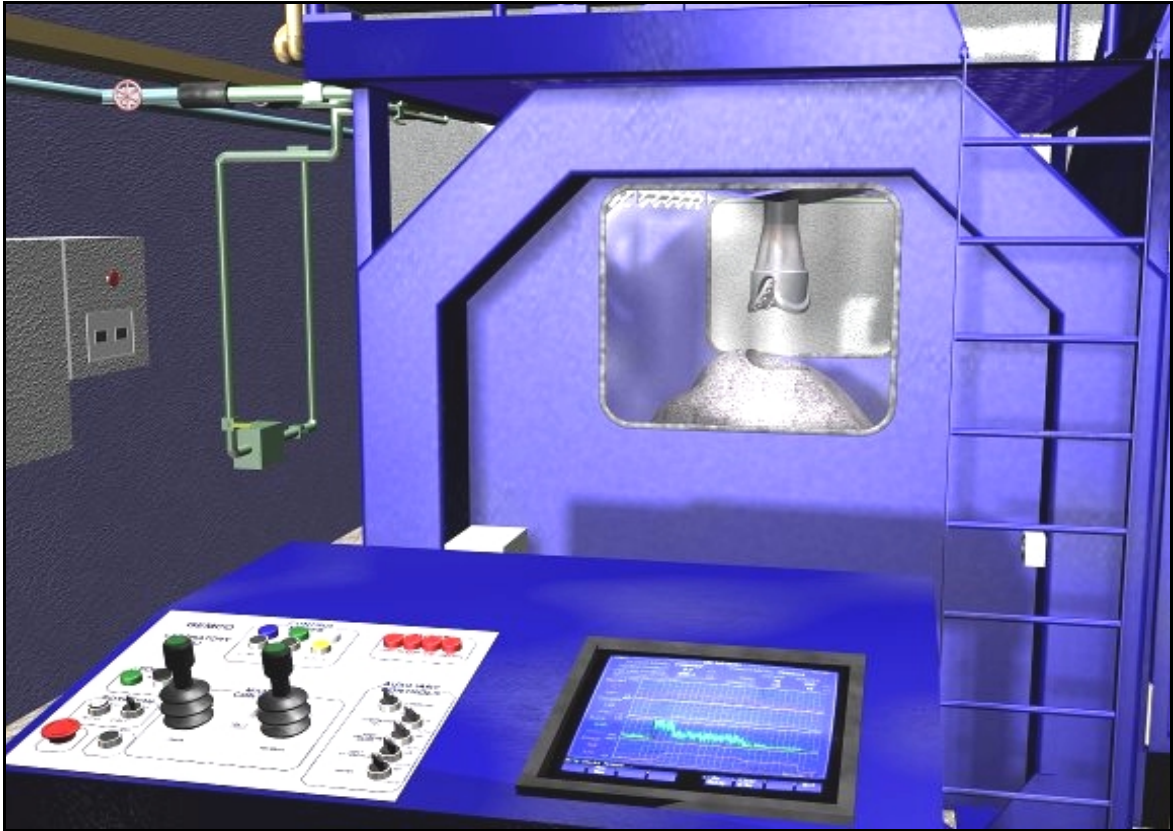


Figure 7. BigTED drill rig training simulation

BigTED has a fully functional control system which can be used to operate the rig, hazard identification exercises, with detailed 3D models and realistic surround sound (Kizil *et al*, 2001). The simulation is made to emulate, as closely as possible, the actual drill rig.

BigTED has a number of components which are replicated in the VR simulation. These include the drill rig itself, the power pack, the associated control panels, the mains power board, the air compressor, and the rig's water, compressed air and hydraulic piping system. The BigTED model was developed in a three-dimensional CAD package and assembled in SafeVR. SafeVR provides real-time user interaction in a simulated virtual environment, and is a revolutionary new tool that may be used to create training applications quickly and simply on a PC. This powerful software has been developed by the AIMS Research Unit at the University of Nottingham, UK.

BigTED combines two different simulations:

- Equipment inspection and
- Operator training.

In equipment inspection mode, the user navigates around the lab and inspects the rig, pipes, cables and sensors for any damage. The user is assessed based on the number of hazards identified and correctly dealt with (Figure 8).

In the operator training mode, the user is allowed to operate the rig in the same manner as in real life. The operation of the drill rig involves turning on the power, air and water supply in the right order and positioning the drill bit on the rock sample. The machine responds to any mistakes made by the operator with pop-up text messages providing instructions on the correct procedures.



## Development of the Drill Rig

The aim of the project was to create a three dimensional model of the CRCMining's laboratory drill rig and consequently create a VR simulation with the model. The simulation was to include the basic operating principles of the rig and some hazard identification situations. The simulation is to be used in training users to operate the rig and all associated equipment. This involves starting up the rig and its power systems, basic operation of the rig using its control panel, and turning off the system when drilling is completed. The computer system involved with automatic control of the drill rig was not to be simulated as its complexity was beyond the scope of this project.

## Operation of the Rig

The operation of the drill rig, if done correctly, is quite simple, a key is turned, buttons are pressed in the right order, and the power pack turns on (Figure 9). More keys and buttons and the rig is in manual control mode. The drill bit is moved into position, and automatic drilling is commenced. This process sounds simple, and it is. The problem occurs when things are done in the wrong order, which in some cases may damage the machine or its components. To make a realistic simulation model every combination of actions must be thought of and the consequences must be understood and implemented in the model. This is not only time consuming, but also involves knowing the subject of the simulation well and being able to determine "what if" scenarios.

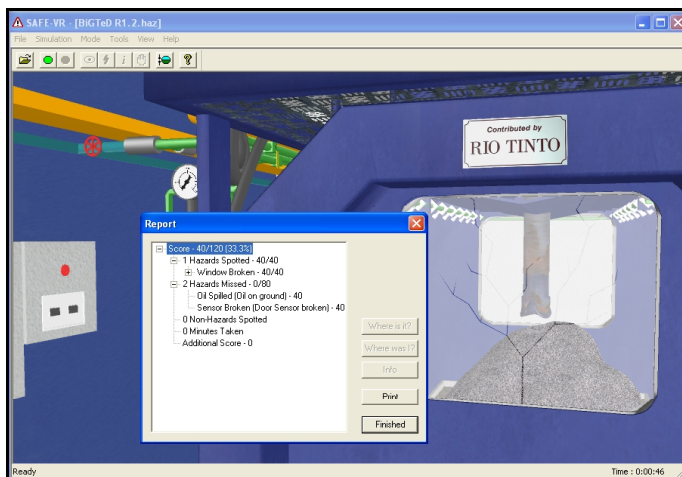


Figure 8. BigTED's hazard assessment report



Figure 9. Control interface of power pack

Another aspect of the operation of the rig is the moving parts. In the rig, most of the large part's positions and rotations are related to one another. To capture this, synchronous movement equations can be derived describing the position of each moving or rotating object with respect to a reference point or object. This is complicated, but if done correctly, quite effective. The user may move around the simulation environment using the mouse and/or keyboard and may interact with objects by clicking on them with the mouse or pressing set hotkeys. Actions can be carried out on objects in this way, just as hazards can be identified and objects can be moved around the world (if movement of the object is permitted).

The simulation is made to emulate, as closely as possible, the actual lab drill. While a model could be made to emulate exactly every movement of the rig, this model would be very complex (mainly due to the bending of flexible pipes) and currently could not be exported to SafeVR. The model in the simulation is easily recognisable as that in the lab, but has much simpler movement (no bending of parts, and no rotating of the tri-cones on the drill bit). Minor details may often be left out if they do not affect the purpose of the simulation.

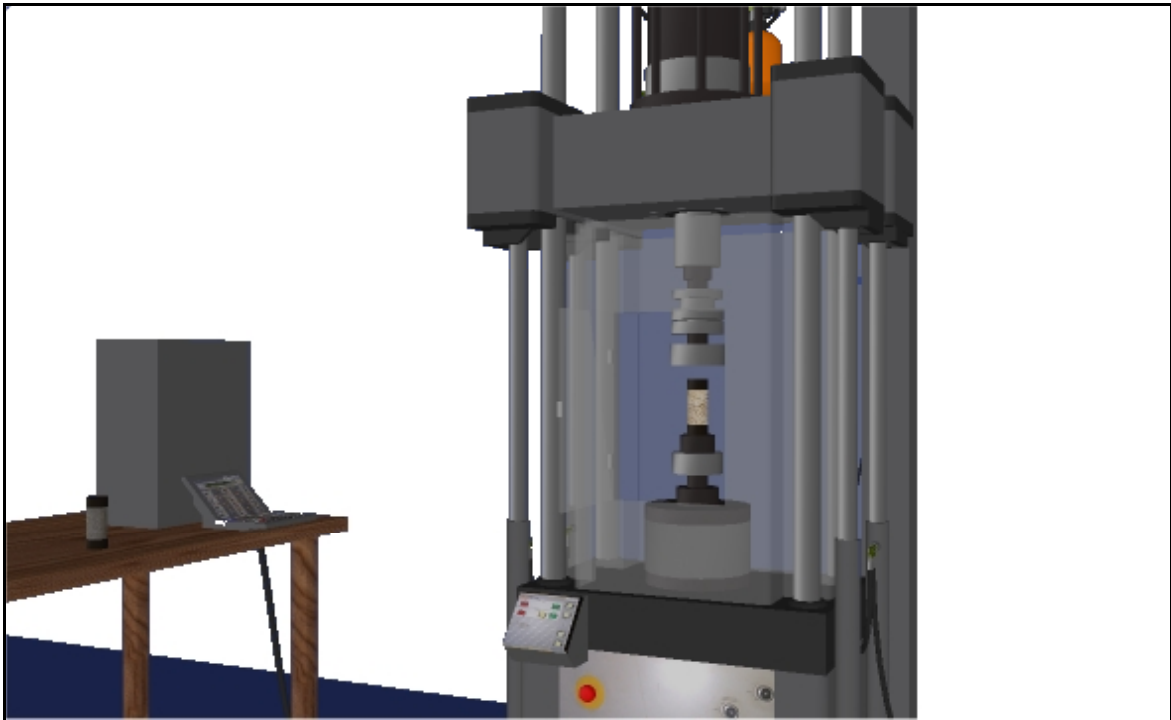
### *Hazard Identification*

Hazard identification is a large part of the SafeVR package, it can be very useful in training personnel in equipment and site inspections, basic workplace health and safety issues, and in a variety of other safety training exercises. In SafeVR the user must first identify which object has a safety hazard associated with it. If an object with a hazard is selected a list will be given asking them to identify what the hazard is.

The user can then be asked how the hazard should be dealt with, what the consequences of this problem are and what the probability is that it will occur. Marks can be allocated to correct answers and deducted for incorrect answers, for instance; identifying hazards where there are none present. As the CRCMining lab drill simulation is mainly focused on training the user on how to operate the rig, only basic hazards were included. It is entirely possible to do a full risk assessment on a piece of equipment and build it into the simulation.

### **Instron UCS Testing Simulation**

InstronVR has been developed to simulate the Uniaxial Compressive Strength testing practical using the Instron rock testing machine at the University of Queensland. The aim of this simulation is to let students perform Uniaxial Compressive Strength test on a number of rock samples from the relative comfort of their computer laboratory (Figure 10). The simulation allows students to individually operate the equipment and perform the tests as opposed to the traditional approach of students observing a demonstration of the machine at the UQEM.



*Figure 10. InstronVR and virtual rock samples and control panel*

Currently implemented in the project are UCS tests for sandstone and marble, and a post peak behaviour test for a sample of coalcrete (a concrete and coal mixture). During the practical the machine is already set up to perform the test, so set-up of test conditions using the control panel is not required. The students are required to turn the Instron machine and its computer on and then choose a sample for testing. The test process cannot start until all the safety and operational requirements are met. After the test, the simulation produces a result file in Excel format, which students can save to a floppy disc for further analysis and interpretation in their practical report (Figure 11).

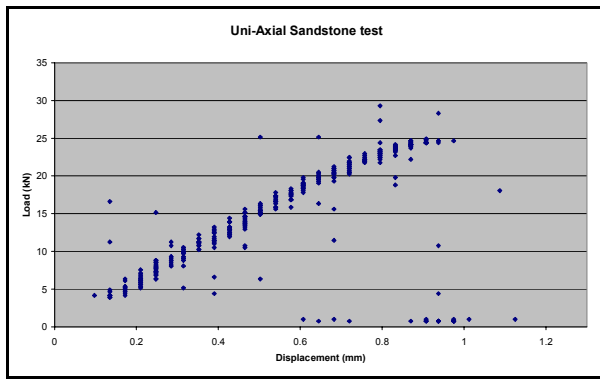


Figure 11. An example of the results

## CONCLUSIONS

The use of VR simulations in education and training in the mining industry will become more widespread in coming years, as the hardware required to run a virtual reality system becomes more affordable and readily available. This technology has already proved to be effective and beneficial in terms of cutting the cost of training and providing the students a better understanding of the system simulated.

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