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Technology implementation in eLearning

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New technologies, such as computer based learning, wireless computing, internet2, online courses, distance learning, and in general multimedia applications are being implemented in the higher education sector in an increasing manner. However, these implementations are not coherent, and lack standards. However, one example of the existing standards is the development and implementation of the virtual learning environments. These technology tools help in delivering the eLearning objectives. There is a major initiative in Europe (eEurope action plan) in promoting eLearning towards creating a knowledge-based society. Technology implementation is the major driver for achieving the eLearning objectives. A two-year pilot project on implementing technology tools including virtual learning environment (VLE), video-conferencing, and simulation and visualization was carried out for providing a blended learning environment for undergraduate and graduate students in Mining Engineering (undergraduate) and Mineral Deposit Evaluation (M.Sc.) course at the Imperial College London. The pilot project was funded by the Imperial College Centre for Educational Development (ICCED). The project did contribute towards activities for creating an institute-wide eLearning strategy in line with the eEurope action plan.

Introduction

The concept of eLearning and its European focus is best described with the following quote:

'The eLearning initiative of the European Commission seeks to mobilise the educational and cultural communities, as well as the economic and social players in Europe, in order to speed up changes in the education and training systems for Europe's move to a knowledge-based society.' - http://europa.eu.int/comm/education/elearning/

However, a significant effort is required in implementing the standards and the relevant tools for delivering eLearning meeting the goals stated in the **eEurope Benchmarking Report** (http://europa.eu.int/information_society/eeurope/news_library/documents/index_en.htm). This report shows a wide variation in internet penetration and internet use (backbone of eLearning delivery) in the member countries in the Europe. A large number of additional documents on the eLearning initiative by the European Commission are also available at the website http://europa.eu.int/comm/education/elearning/doc_en.html. New technologies, such as computer based learning, wireless computing, internet2, online courses, distance learning, and in general multimedia applications are being implemented in the higher education sector in an increasing manner. However, these implementations are not coherent, and lack standards. A collaborative research initiative (http://www.imsproject.org) on eLearning standards is gaining strength. However, focus of this initiative is in developing and implementing of virtual learning environments. The need for eLearning standards and its implementation has been highlighted in an editorial (Grush, 2002) in the *Syllabus* journal (www.syllabus.com, April 2002). A uniform and well-researched implementation of the eLearning strategy is being pursued for effective implementation at the Imperial College partnering with the similar organizations in Europe.

Imperial College Centre for Educational Development (ICCED, http://www.ic.ac.uk/icced/) initiated a teaching development grant in 2000, and took a proactive view in implementing a common platform for eLearning at the Imperial College. Technology Implementation in Learning and Teaching project (TILT-phase 1) by Basu, Ganguli, and Sturgul (2002) was granted for the academic year 2000–2001 for implementing a VLE environment and utilizing video-conference in a standard teaching environment and within a normal course schedule. An extension of the project (TILT-II) was also funded for the academic year 2001–2002 for blending various tools including VLE, video-conferencing, simulation and animation. This paper addresses the various issues in implementing the technology tools, mostly at the second phase. A report on the first phase development has been addressed earlier (Basu, Ganguli, and Sturgul, 2002).

Mining engineering education is multidisciplinary and requires the learning of operational practices for engineering design, production planning and maintenance, in addition to the theoretical knowledge required in these areas. Moreover, the world-class operations are located in North America, Australia, South America and South Africa. The availability and development of current telecommunication technology merging internet, video-conferencing, and visualization tools provide a great opportunity to implement these tools in the learning and teaching environment at Imperial College for teaching the best practice in mining engineering operations on a global scale. This local project on integrating the technology tools is addressed in the context of global standardization requirements for effective delivery of the eLearning goals. Imperial College does have existing relationship with

TuDelft, ETH-Zurich, and RWTH-Aachen forming a group, IDEA League*, which promotes eLearning. Another European partnership exists in the form of European Mining Course and European Mineral Engineering Course (EMC and EMEC, http://www.emc-edu.org). The core partners are Imperial College, TuDelft, RWTH-Aachen, and Helsinki University of Technology. Other universities, Virginia Tech (USA), Queens University (Canada), and University of Queensland (Australia) participate as associate partners. However, the EMC and EMEC do not employ eLearning as a course delivery tool. Blackboard (www.blackboard.com), a VLE tool, is used for course management including evaluation of course modules.

Technology components in eLearning

Technology implementation is the key driver of eLearning. Availability of internet access is the core requirement for building an eLearning infrastructure. All the major higher educational institutions now have established internet resources and the current student generation actively participate in taking maximum benefit of these resources. Emails and web-based document delivery was the initial usage of internet in implementing eLearning concepts in a higher education environment. However, the gradual increase in hardware and storage capacity, availability of digital technology and mobile devices, such as Personal Digital Assistants (PDA)† and hand-held computers, are helping in developing and delivering more interactive mode of eLearning tools. However, the use of PDAs are still in an experimental stage and yet to gain full acceptance (Nybo and Orr, 2001).

The technology components available these days are:

- *Standard internet access*—LAN, Broadband, and Dial-up (still available, but more individual users are moving up to Broadband through cable and other forms of high speed access).
- *Wireless access*—in a higher education campus
- *Internet2* (http://www.internet2.edu)—Available to a number of universities. However, yet to be implemented for delivering a course.
- *Video conferencing*—gradual increase in introducing experts to the students from a far-away place.
- *Streaming video*
- *Virtual learning environment* (VLE)—this is the most common implementation of an eLearning tool
- *Immersive 3D visualization* and *virtual reality* applications—gradual implementation leading to an interactive learning environment (ILE).

An effective eLearning implementation will require a good blending of the technology components, and this blending would vary depending on the discipline and scope of eLearning implementation. Pittinsky 2002, (cited in *Syllabus,* 2002), Blackboard Chairman, identified three defining technology directions:

- *Immersion*—leading to virtual laboratories for doing simulated tests, teaching operational practices
- *Standards*—for better collaboration and share of content
- *Specialization*—will create discipline-based tools and pedagogical approaches.

This paper covers the author's experience in using a VLE system and video conferencing in delivering mining engineering courses to the undergraduate and graduate students. Moreover, a current effort is in the area of implementing immersive 3D visualization and discrete event simulation tools for introducing a hands-on interactive medium to teach and train operational activities, for example, material handling by off-highway trucks. Implementation of eLearning is highly dependent on technology and this is a very fast changing environment. Therefore, it requires a very high degree of commitment from the provider that the beneficiaries (students) have access to most current technology, hardware, software, and qualified personnel. Therefore, the higher educational institutions need to be aware of the investment cost in equipment and maintenance of an effective and continuously improving eLearning environment.

An Imperial example

A technology implementation initiative, Technology Implementation in Learning and Teaching (TILT) project funded by the Imperial College Centre for Educational Development (ICCED). The TILT project Imperial College was carried out in two phases:

- The first phase
  - -introducing a virtual learning environment tool within a standard curriculum
  - -video conferencing for introducing world experts to the Imperial students through a course delivery using live and interactive video conferencing
- The second stage
  - -Incorporating simulation and visualization for interactive teaching in an immersive mode.

Introduction of a Virtual Learning Environment (VLE) at Imperial College

The project's initial goal was to address the existing educational problems in teaching mining engineering and developing a strategy to overcome these problems. The educational problems encountered in delivering mining engineering courses at the Imperial College are:

- Lack of availability of local mining operations and relevant experts to cover the operational aspects
- Lack of student motivation (primarily in the undergraduate level) and interaction as they are not aware of the global picture
- Absence of a coherent on-line course delivery plan (internet is used on a regular basis, but there is no existing enterprise online delivery system in place).

The main aim of this technology implementation project was to reinforce the seven principles of good practice is highlighted by Chickering and Ehrmann (1996). This paper is also available at the website http://www.tlt group.org/programs/seven.html. The principles are:

- Good practice encourages contacts between students and faculty
- Good practice develops reciprocity and cooperation among students
- Good practice uses active learning techniques
- Good practice gives prompt feedback
- Good practice emphasizes time on task
- Good practice communicates high expectations

*IDEA (Imperial College, Technical University Delft, ETH Zurich, RWTH-Apache) League

†Personal Digital Assistant

- Good practice respects diverse talents and ways of learning.

Implementation of a VLE delivery complemented by standard classroom teaching helps in meeting these principles. Technology implementation was limited mainly in utilizing a commercial VLE tool for complementing traditional classroom teaching. There are several available tools*, such as Blackboard (http://www.blackboard.com), eCollege (http://www.eCollege.com), and WebCT (http://www.webct.com). Imperial College does not have any such tool implemented yet. However, ICCED has just initiated a pilot study for implementing WebCT as VLE choice for the Imperial College. Therefore, initially a course site was developed using the free site option (this option is no longer available). The relevant websites for Blackboard and WebCT provides the options available to create a pilot site. Ganguli (2000), experimented with similar tools available at the University of Alaska, Fairbanks and is a collaborator for the current projects undertaken by Basu (2001). The main benefit of using such a tool is improvement in course organization. All the course materials and handouts could be stored in one central place, and the students can download the relevant information at their convenience. Moreover, the tool's communication centre provides email and discussion board options. A detailed coverage on this phase of implementation was provided in a recent publication by Basu, Ganguli, and Sturgul (2002).

Central to the building and managing the site is a module called Control Panel. It provides the course developer the tools to incorporate the various options and edit them as necessary. Figure 1 shows the control panel option. The Communication Center section provides email facilities, discussion board, and Virtual Chat. The Virtual Chat option is under-utilized. However, it may be used in place of office hours sessions with the students. The instructor can inform the time when he would go on live and the students can then ask any question during that session. The course delivery tool also provides features for linking relevant websites for additional information. In addition, it provides the instructor with course management tools such as student roster and online grading book. Another useful feature is Drop Box, through which students can submit their work. The instructor can then check the work and pass it back to the students using the course site maintaining all the necessary confidentiality issues. There is also an assessment tool for administering online quiz or tests. It was not used as the main mode of assessment. However, the feature was not tested for its effectiveness. It is a good feature, but requires more control for proper monitoring of the online test process.

The VLE environment (Blackboard) helped creating active participation by the students and increased student-instructor interaction. The Drop Box feature was extensively used in receiving student assignments, grading, and returning the graded assignment to the students. The

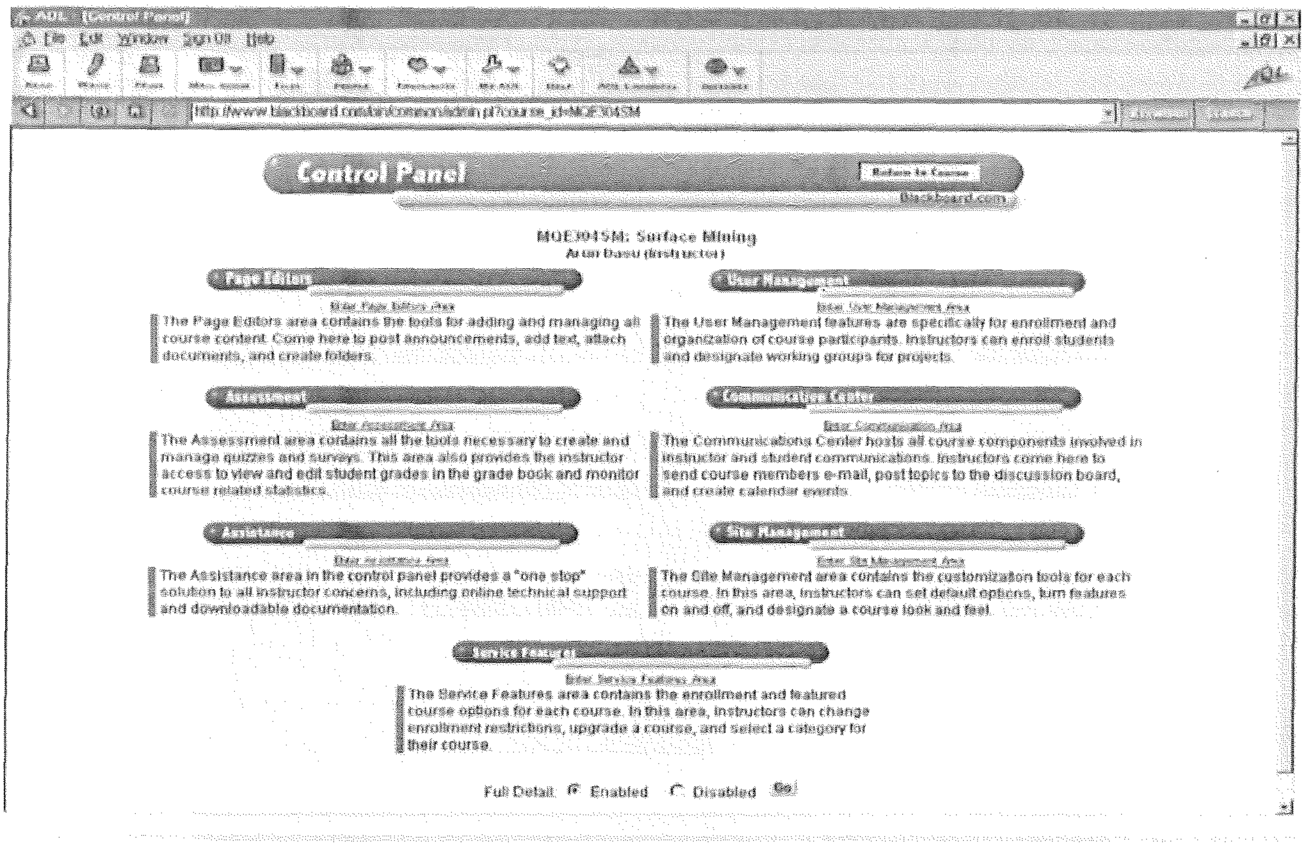

Figure 1. The control panel screen

[3]A website http://www.c2t2.ca/landonline/evalapps.asp provides comparative reviews of 56 VLEs. However, Blackboard and WebCT software are most commonly used

current generation university students are familiar to use standard internet tools and accepted the VLE as a natural extension of internet infrastructure in a higher educational institution. The following section covers the use of video conferencing facility at the College.

Video conferencing

Video conferencing is now accepted as a mainstream technology. A low end use using a PC and a web camera on internet is very common for a home/family type video conferencing. The high end use is seen on a daily basis in the Television news coverages. However, its use in classroom teaching has just started. It is also a very good tool for offering distance learning in synchronous as well as asynchronous modes. A number of video-conferencing sessions were organized in 2001 and 2002. The sessions were designed to bring in an expert delivering a standard 2-hour lecture to the undergraduate and the graduate students. The sessions were on Surface Mining (mainly strip mining) practice in North America. Dr Tad Golosinki from University of Missouri-Rolla, an expert in surface mining offered two sessions on strip mining and also a session on maintenance. Another expert (Dr G.T. Lineberry) in mine plant design and haulage offered a session on hoisting and rope selection. The sessions were taped and also now available as a streaming video from the websites: http://streaming.ic.ac.uk/umr1.asx—Surface (strip) mining operations

http://streaming.ic.ac.uk/umr2.asx—Maintenance (mining engineering) planning and operations

http://streaming.ic.ac.uk/kentucky.asx—Rope selection and hoisting.

Video conferencing sessions were live and realtime. Students could interact with the presenter in the same manner as a face to face lecture. It was an example of synchronous mode of learning. However, the streaming videos will be used as on-demand source of information for asynchronous learning. It is a very effective mode of eLearning and being used at a number of places. Burnett, Maue, and McKaveney (2002) provide an useful resource on planning and implementing instructional video. They list a number of relevant websites including, among which the following may be of the readers' interest:

- e-learning and Teleconference Magazine (www.elearningmag.com)
- eMEDIA Magazine (www.emediamag.com)
- Streaming Media Magazine (www.streaming media.com)
- Real Networks/Real System iQ, Real Server, Real Producer, Real Slideshow (www.real.com)
- Video Conferencing Cookbook (www.vide.gatech. edu/cookbook2.0)
- Streaming Media World Video (www.streaming mediaworld.com/video)

Figure 2 provides a view of a live video conferencing showing that the students are actively participating in such a session. The body language including the facial expressions of the student audience shows the level of interaction achieved through a live video conferencing session.

Establishing a video conference link is in principle no different from making a normal telephone call—it is simply a dial-up procedure to the location one wishes to be connected to. This method uses a system called ISDN, the Integrated Services Digital Network and is available in most countries world wide. The Imperial College facility accommodates about 10 people seated around a conference table, with cameras to capture the presenter as well as a document camera that can zoom into anything the presenter wishes to show. The facility is also equipped to show 35 mm slides and replay videotape. A simple remote control allows for one camera or the other to be active, and for zooming to occur. When using ISDN, well over 30 countries (see map) can be reached and the number is

Figure 2. Participating students attending a course lecture from an expert in USA

increasing all of the time. The facility can run in one of two ISDN modes using POLYCOM VIEWSTATION 512 equipment: 128kbit (2x56k or 2x64k) and from 128k to 512kbit (Bonded) both operating within the H320 specification (http://www.lib.ic.ac.uk/av). In most cases it is possible to show diagrams and drawings to each other, making use of a zoom facility if necessary to show detail or to show small objects. Depending upon the facilities at the site where you're located, one may also be able to show slides and videotape sequences. Most locations will have a room big enough to accommodate several people, all of whom can see and speak to each other. There are, however, certain images which might suffer as a result of the ISDN 'compression technology' used. An example is computer graphics, another is very high speed movement. But rest assured that, under normal uses, the images are very impressive, particularly from overseas (using ISDN). Figure 3 shows a session with University of Missouri-Rolla (Dr Golosinski is delivering a lecture from Rolla, Missouri to the students receiving the live broadcast at the Imperial College video conferencing facility). University of Missouri-Rolla is using the video conferencing tool successfully in an online M.Sc. course in Mining Engineering (http://www.umr.edu/~mining/ME.html). More information on this initiative is available in recent publication by Golosinski (2002).

Internet2 and video conferencing

Internet2 implementation was not completed. It is still not available at the Imperial College. However, a meeting was conducted with the University of Idaho officials in charge of Internet2 projects. It was observed that the full potential of internet2 is still under-utilized. It would be a very valuable tool to deliver a video rich course content. A trial of internet2 for such activity took place at University of Alaska, Fairbanks, which showed the potential of internet2 in offering live, real-time distance learning capabilities (Ganguli, 2001).

Simulation and visualization

The application of discreet event simulation has matured in modelling manufacturing systems for production analysis. This simulation tool was used in studying a number of mining operations, especially material handling processes. The study of Truck-Shovel operation including equipment matching, selection, and production estimation utilized the discrete event simulation for providing valuable decision-making information.

The sophistication of the available simulation tools grew over time, and simulation driven animation was used to facilitate the validation and visualization of the simulated system. This form of visualization enhanced the simulation use in planning and analysing mining operations (Sturgul, 1996). First of all, it provided a communication medium to transfer information to the non-technical managerial personnel as a better decision-making tool. Moreover, the animated visualization provided a validation tool to check the working of the simulated system and interaction among its components. Most of the visualization is done using a 2D graphical interface. Figure 4 shows a snapshot of a 2D visualization (animation) of truck haulage in an open pit mine (Basu, 1999).

Current development in 3D visualization and animation tools provides a great opportunity for incorporating 3D visualization for improved user interaction and understanding of a system and its components. Implementation of this tool will lead to visual simulation where a user would interact with the simulation engine using the 3D visual interface. The end use would also lead to develop systems for providing operational training to the equipment operators for improved health and safety.

Moreover a 3D visualization-based maintenance system would enhance production efficiency. Current work in modelling 3D objects and animation has been limited to building an animation model of a Caterpillar truck 793 from the information available in a manufacturer's catalogue. Continuum Resources (http://www.continuum-resources.com.au), Australia, a research partner in the current project helped in building a realistic animation of an off-highway truck operation in an open pit mining environment. Work is in progress in linking a discreet event simulation code (using GPSS/H) for creating an interactive model for studying open pit haulage. A pilot work is in

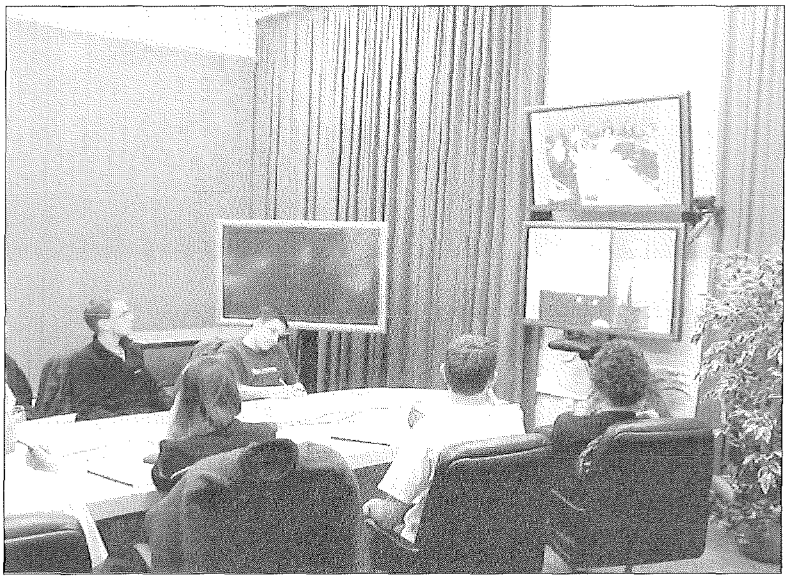

Figure 3. A live real-time (interactive) video conference with University of Missouri-Rolla

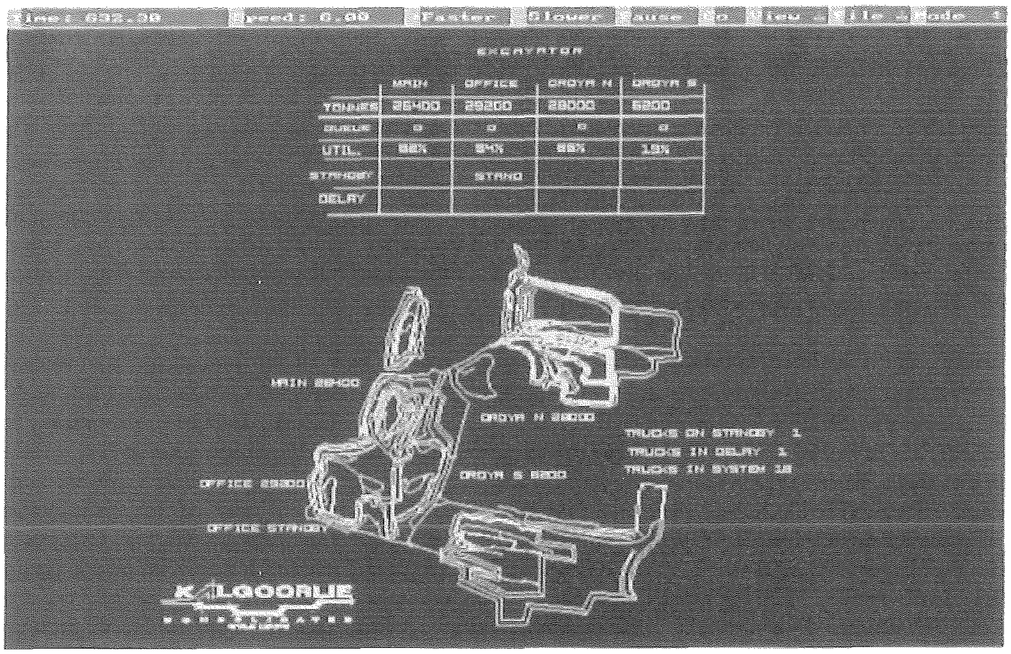

Figure 4. An example of a 2D discrete event simulation (Basu, 1999)

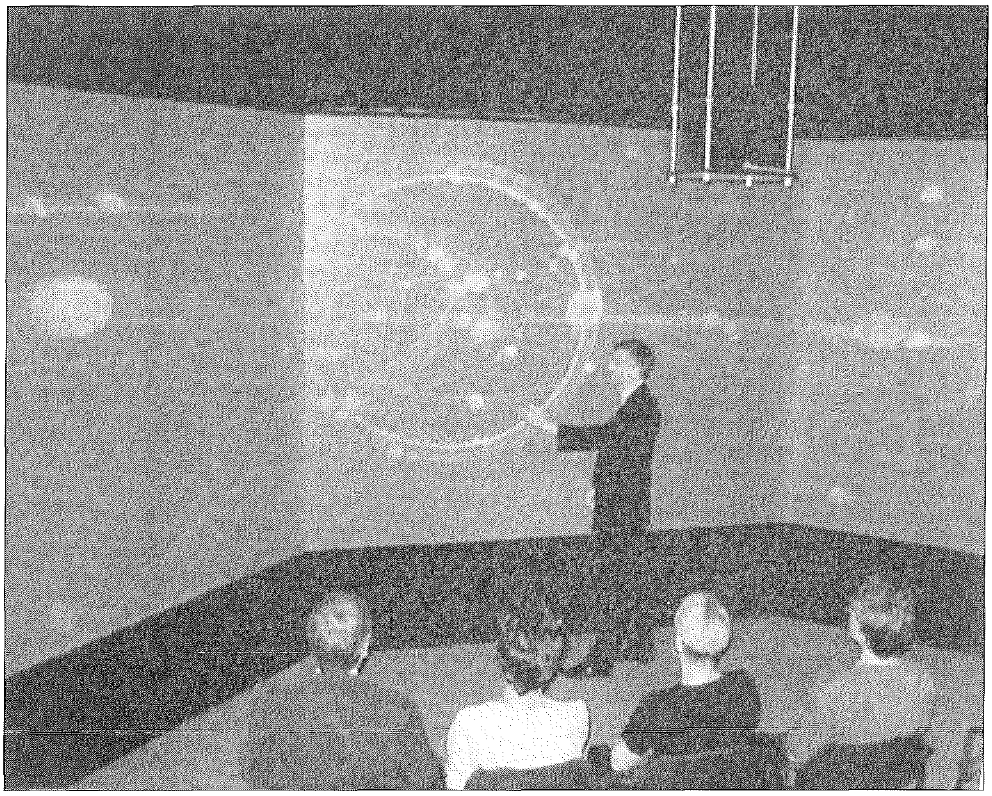

Figure 5. Immersive Visualization Centre facility at Imperial College

progress with the participation of the AIMS research group, University of Nottingham (http://www.nottingham.ac.uk/aims/Aimshome.html). Moreover, such an interactive model could be utilized in an immersive environment for an enhanced interactive session. Imperial College has access to a visualization centre as shown in Figure 5.

A future plan is to implement the haulage simulation of 3D off-highway truck model in the immersive mode. This pilot scale work currently in progress would lead to create a more realistic material handling system, and carrying out teaching and training students on those systems. A dissemination workshop in collaboration with the ICCED was organized at Imperial College (London, UK) in August 2001. The collaborators from the University of Idaho, Moscow (Prof. John Sturgul), and University of Alaska, Fairbanks (Dr Rajive Ganguli), were present and made contributions to the dissemination workshop. Visits to the Video Conferencing facility and the Visualization Centre at the Imperial College were arranged for the workshop delegates. Simulation and Visualization implementation is being carried out during the current project phase (2001–2002) and will be reported in the near future.

Conclusions

The phase 1 (2000–2001) of the technology implementation demonstrated the benefit of using course delivery tools in parallel with traditional teaching. Moreover, linking with the internationally reputed professionals and educational experts in mining engineering through the video conferencing tool provides case-based instructions to the mining engineering students. However, the current internet technology limits transmitting of high volume of video transmission. Further development and introduction of internet2 would help in more efficient delivery for online and distance education. The overall marriage of the technology and the case-based learning would enhance students' perception and understanding of the course material. The phase 2 (2001–2002) involved simulation and visualization applications producing interactive learning environment to study a production system.

Evaluation of technology implementation was carried out by informal feedback from the students. The general comment was positive. The availability of such a tool increased the level of student-instructor interaction. The video conferencing sessions were also received very well by the students. The live interaction with internationally recognized experts provided the added value. A formal survey-based evaluation will be carried out in the current academic year on the technology implementation. Simulation and visualization development evaluations will be carried out during the rest of 2002, and expect to receive evaluation on the acceptability of the interactive learning environment will be reported in the future dissemination process. Other published material on assessment and evaluation, such as by Miller (2001) will also be looked at for implementation.

Current trends are limited to implement eLearning within the framework of traditional in-class learning and teaching. However, a fundamental paradigm shift is necessary for a flexible, interactive, and media-rich learning environment implementing the asynchronous technical interface (Sonwalkar, 2002). He also emphasized in reinventing pedagogy for the new interface including multimedia enhancements (video, animation, and simulation), and establishing standards for the educational media. Initiatives by Imperial College and its IDEA League partners are in line with these directions of global eLearning targets and establishing an institution-wide eLearning strategy.

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References

BASU, A.J. Simulation of a Large Open Pit Mine Operation in Australia, *Mineral Resources Engineering*, Imperial College Press. vol. 8, no. 2, 1999. pp. 157–164.

BASU, A.J. Technology Implementation in Learning and Teaching (TILT). *Presented at the IDEAL : E-Learning Forum of the IDEA League*, RWTH-Apache, Apache, Germany, 27–28 September. 2001.

BASU, A.J., GANGULI, R., and STURGUL, J. Technology Implementation in Learning and Teaching, *Mineral Resources Engineering*, vol. 11, no. 1, (Educators Forum section) in press, Imperial College Press. 2002.

BURNETT, A., MAUE, D., and McKAVENEY, E. Planning and Implementing Instructional Video, *Syllabus*, vol. 15, no. 11, 2002. pp. 34–38.

CHICKERING, A. and EHRMANN, S. Implementing the Seven Principles: Technology as Lever, *AAHE Bulletin*, October, 1996. pp. 3–6.

DOMINICK, J. Wireless on Campus, *Syllabus,* vol. 14, no.4, 2000. pp. 18–23.

European Commission. Communication from the Commisssion to the Council, The European Parliament, The Economic and Social Committee and the Committee of the Regions., *eEurope Benchmarking report*, eEurope 2002. 19 pp.

GANGULI, R. On-line Presentations Aids in Classroom Teaching. *Mining Engineering*. November. 2000. pp. 42–44.

GOLOSINSKI, T.S. Online Mining Education: A Reality. *Mineral Resources Engineering*, vol. 11, no. 1, 2002. pp. 137–146.

GRUSH, M. Editor's Note, *Syllabus*, vol. 15, no. 9, 2002. p. 3.

MILLER, S.B. How Do You Measure Success? Lessons on Assessment and Evaluation from the LEAD Center. *Syllabus*. February. 2001. pp. 11–13.

NYBO, V. and ORR, R. Case Studies Will Handheld Computers Work in the Classroom?, *Syllabus*, 2001. vol. 15, no. 4, pp. 36–37.

RIELLY, D. Personal communication, information on Association for learning technology— http://www.alt.ac.uk. 2001.

STURGUL, J. Simulation and Animation Come of Age in Mining, *Engineering and Mining Journal*, vol. 6, no. 2, 1996. pp. 38–42.

Syllabus: The Interactive Campus: Administration and Course Management System Vendors Take Up the Challenge, *Feature article*, vol. 15, no.4, 2002. pp. 16–18, 42–43.