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Mining Engineering Education Using the Internet

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ABSTRACT: An Internet connection with e-mail and web-browsing services can provide both students and teachers with a wide variety of learning tools, which can be used at any time, in any place, ad lib. This paper presents and discusses various aspects of Internet-based education with particular emphasis on mining engineering examples.

1 INTRODUCTION

There is no doubt that computing and automation have led to great changes in the mining industry, and these changes are mirrored in the undergraduate and graduate curricula of mining engineering departments, increased emphasis has been placed on computer training and applications, and it İs considered impossible for a well-educated mining engineer to graduate today without significant understanding and skills in this area.

Continuing education and technology programs become increasingly important for upgrading the education of practising engineers in specialized fields, including computer applications. Several departments are developing continuing education courses in a wide variety of fields, but more commonly continuing education is handled in-house by companies, in the form of specialized training for their engineers.

Conferences on numerous mining engineering topics and mining magazines are also important means for both students and engineers to improve their understanding of the "body of knowledge" that characterizes mining engineering.

The familiarity of students and engineers with computing, the "globalisation" of knowledge, and the need for frequent access to training, career-advancement tools and technical references at affordable cost has led to the development of an educational technology which is based on the use of computers and networks that convey knowledge from the teacher-instructor to the student-trainee.

This paper presents and discusses various aspects of Internet-based education with particular emphasis on mining engineering examples.

2 INTERNET-BASED EDUCATION

The influence of the Internet on personal and corporate lives is so great that our society is being virtually recreated. There is no doubt that we already live in an "electronic society" or "e-society", which covers almost all aspects of human activity. This is illustrated by the title of the 14th Bled Electronic Commerce Conference: "E-Everything", Bled, Slovenia, June 25-26, 2001. Among the conference's research track topics one can see: e-business, e-commerce, e-marketing, e-trade, e-education, e-strategy, e-behavior, e-households, and e-democracy.

Long before the World Wide Web (WWW) reached wide acceptance, the Internet was being used for educational purposes, mostly via mailing lists and bulletin boards. The tremendous growth of the WWW, its attractive educational features and its ease of use made it very quickly the main platform for potential educational applications, especially for open and distance learning.

The educationally attractive WWW features include:

- ability to obtain multimedia documents;
- hypertext/hypermedia capability;
- WWW networked basis, allowing for distance learning, ad lib;
- interactivity between the student and teacher; ease of use and system-open;

The importance of the WWW as an educational tool can be realized by the number of web-based courses that become available on a daily basis. The complexity of these courses varies from the simple posting of lecture notes on a website to more sophisticated educational elements such as animated graphics, simulations, virtual laboratories, etc. The

development of these sites using programming languages such as Java has made the courses more interactive, faster to execute and easily transportable to multiple platforms.

The Globewide Network Academy (GNA) is an educational non-profit organization in Texas, U.S.A., which develops distance-learning relationships and facilities for the public to use worldwide. The GNA's website <http://www.gnacademv.org> contains a comprehensive catalogue of distance-learning courses, as well as forums for distance learners and distance teachers. The catalogue lists (as of February 6, 2001) 23874 courses and 2508 programs, of various levels, of which 939 courses and 267 programs are on engineering topics.

According to JonesKnowledge.com <http://www. j onesknowledae. com>. a US-based company that provides end-to-end online learning solutions, students spent approximately $233 billion in direct costs on higher education in 1999, with $1 1 billion of that devoted to e-leaming. That figure is forecast to increase six-fold over the next ten years.

An article ("Taking over the world by degrees") published (January 5, 2001) on the Financial Time's website <http://www.ft.com>. describes some recent efforts to offer online education by British universities, and raises concerns about the future of distance learning. The U.K. government, through the Higher Education Funding Council, has established a joint e-university project with a budget of £400rn, and all U.K. universities are allowed to become members and hold shares.

Jones International University <http://www. jonesintemational .edu> is the first fully online accredited institution of higher learning whose campus is located in cyberspace and offers a variety of graduate, undergraduate, and certificate programs.

The apparent great interest in e-leaming projects has created the need for the development of adequate tools for the elaboration of web-based courses. These courseware development tools assist teachers with new course development and the move from traditional classroom pedagogy to an online format.

3 INTERNET-BASED MINING EDUCATION

Just browsing through the web is an educational experience in itself. As very often happens, one starts browsing with something specific in mind^nd ends up diverted from the initial goal for a while, because one has found something interesting on the way which was not explicitly looked for. This type of learning, which happens at an unexpected moment about an unexpected subject, is called "accidental learning". A mining engineering student can easily "mine" the Internet. Good starting points are the following sites:

- InfoMine (<http://www.infomine.com/>)
- MineNet (<http.//www .microserve.net/--doug/> 1
- Mining Technology (<http://www.mming-technology.com/>)
- Mining Educators' website (<http://www.uidaho.edu/mining_school/>)

The last of these sites, developed and maintained by Prof. J.R. Sturgul at the University of Idaho, U.S.A., among other things, provides direct links to all the Mining Schools around the world

One of the unique features of engineering education is the combination of theoretical knowledge with practical experience. In conventional education, the former consists of lectures and exercises supported by handouts, lecture notes and textbooks, while the latter includes laboratory tests and fieldwork.

The web provides improved functionality in transmitting theoretical knowledge to students and possesses an effective mechanism to integrate multimedia tools into a single user interface.

Let's take as an example a mining engineering student located in Athens. Using his web browser he can attend a lecture on drill-and-blasting techniques, which is transmitted live from the Institute of Mining at the Technical University of Clausthal (TUC), Germany. A two-day event (26-27 January 2001) on drill-and-blasting was held at TUC and was audio-visually transmitted live via the Internet <http://www.bergbau.tu-clausthal.de/bus2001/BuS2O01.html>.

Then, in order to enhance his knowledge on these topics, he reads chapters: "9.1.3. Drilling" and "9.2.1. Blast Design" from the "Mining Engineering Handbook", published by the Society of Mining Engineers (SME), U.S.A. This comprehensive reference work, which distils the entire body of knowledge that characterizes minmg engineering as a disciplinary field, is available online at the SME's website <http://books.smenet.org/>.

Finally, he can read case studies, view state-of-the-art equipment, products and techniques and download the relevant literature from particular manufacturers' websites (e.g., from Atlas Copco's rock drilling equipment site <http://www.boomer-rig.com/> or for blasting products from Austin Powder's site <http://www.austinpowder.com/>).

R. Ganguli in his article "Online presentations aid classroom teaching" (Mining Engineering, Nov. 2000 <http://me. smenet. org/>) discusses elements of online pedagogy and information technology that are being used in the University of Alaska, Fairbanks, and the difficulties faced in the preparation and delivery of online mining engineering courses.

EduMine <http://www.edumine.com/> offers online courses on mining and geosciences. Its course catalogue includes online courses on: "Underground

Mining Methods and Equipment", "Risk Management İn Mining", "Geotechnical Data Collection for Excavation in Rock", "Practical Geostatistics, Modeling and Spatial Analysis", etc.

EduMine, which has partnering agreements with the Canadian Institute of Mining, Metallurgy and Petroleum and Svedala Process Technology, provides course authors with an authoring environment and tools for the conversion of existing course material into an online format or the development of new online material. EduMine's courses are based on the XML Internet standard, whose advantages include reduced bandwidth, intelligent processing, efficient management of content and greater client-side interactivity.

Practical experience in traditional mining engineering courses is gained through laboratory courses, and more often through visits and fieldwork in mines (the mining engineer's "Big Lab").

Mcintosh Redpath Engineering <http://www.mcintoshengineering.com/> provides online the "Rules of Thumb for the Hard Rock Mining Industry", which are practical guidelines and norms related more to the "art" and "praxis" of mining than to the "science" of mining.

Virtual Reality (VR) techniques have made it possible to establish shared "virtual laboratories" which are accessible via the Internet. The Cooperative Systems Engineering Group, Lancaster University, U.K., investigates the use of virtual reality in learning environments. The "DEVRL - Distributed Extensible Virtual Reality" project <http://www.comp.lancs.ac.Uk/computinp/research/cseg/proi ects/devri/> intends to provide distributed users with a number of cooperative virtual reality-based applications in order to experiment with a simulated set of physical properties.

The Virtual Reality Applications Research Team (VIRART), University of Nottingham, U.K., <http://www.virart.nottingham.ac.uk/> is involved in the specification, design, development and evaluation of virtual environments in both industrial and educational applications development,

The AIMS Research Unit, School of Chemical, Environmental and Mining Engineering, University of Nottingham, U.K., <http://www.nottingharn.ac.uk/ aims/> has done pioneering work in the development of mining and environmental management-related virtual reality applications. The user of these applications can interact with 3D computer-generated models of real-life systems and operate objects that respond to their actions in real time.

With these virtual reality models, the user can visualise new designs, techniques and methods, handle hazardous situations without actually putting himself at risk, and take training courses on how to use complex equipment in a safe and cost effective environment.

Information collection and analysis activities. which involve students collecting, compiling and comparing different types of information on a topic of interest, are an integral part of education, particularly at postgraduate level. Numerous papers are available on websites maintained by mining engineering departments (<http://www.uidaho.edu/mining school/>) or in electronic libraries (e-Iibraries), e.g., the ScienceDirect® of Elsevier Science B.V, (<http:// www.sciencedirect.com/>). Leading mining journals are available over the Internet, including:

- Mining Engineering (<http://me.smenet.org/>)
- Engineering & Mining Journal (<http://www.e-mj.com/>)
- Coal Age (<http://industryclick.com/>)
- World Mining Equipment (<http://www.wme.com>)
- Mining Environmental Management (<http://www. mining-ioumaI.com/osindex.htm>)
- Mining Journal (<http://www.mining-iournal.com/osindex. htm>)
- Mining Magazine (<hrtp://www.mining-journal. com/os İndex.htm>)

Finally, regarding student guidance, Question-and-Answer, and Ask-the-Expert services, these can be easily implemented via the Internet through e-mailing, mailing lists and forums. Internet-connected specialists from universities, businesses, organizations, etc. can serve as electronic mentors to students who want to explore specific study topics in an interactive format (e-mentoring). In the Mining Educators' website <http://www.uidaho.edu/mining school/> there is a list of Email Experts on various mining topics and a Mine Simulation Discussion List. Gibbs Associates maintains the MINGEOL mailing list for a discussion group on mining, geology, and earth science software.

Mining forums are maintained by MineNet <http://www.niicroserve.net/~doug/forum.html> and Trans Tech Publications <http://www.bulk-online.com/>.

4 WEB-BASED MINING SYMPOSIA

MineSim '96, the First International Symposium on Mine Simulation via the Internet, was organized by the Department of Mining Engineering and Metallurgy of the National Technical University of Athens (NTUA), Greece and the Department of Metallurgy and Mining of the University of Idaho (Ul), U.S.A. It was held in "cyberspace" on 2-13 December 1996. (<http://www.metal.ntua.gr/msslab/MineSim96/>)

The symposium was run using a web pages arrangement, set up and maintained by the Mining

Systems Simulation Unit (MSSLab) at NTUA. İt was the first such symposium for any area of mining and mining-related topics, and it appears to be the first such full-scale international symposium on any topic.

The success of any symposium is, primarily, based on the quality of the papers presented, but in the case of web-based symposia, and in addition to the papers' quality, the success depends heavily on issues not common in conventional symposia, such as hardware and software, and network availability, capability and reliability, not to mention programming skills. MSSLab was responsible for the planning, development and management of this "virtual" symposium.

The basic concept in designing MineSim '96 was to "model" a conventional-type symposium, so that a participant that had ever been to a conference would find no difficulty in participating in MineSim '96. The design principles for the web pages were: easy navigation, functionality and speed.

Registration was non-compulsory and a registration fee was not required. However, a short registration form was provided for the symposium's site visitors for the purpose of creating an automatically updated list of participants, allowing purchase of the proceedings at a reduced price and the distribution of personalized symposium badges. At the end of the symposium, 406 participants from 35 countries were listed, while the symposium's home page had 2188 "hits'*.

The symposium's Call for Papers attracted 111 abstracts and 82 papers, representing 24 countries, which were arranged and presented in ten sessions, namely (the number of papers is given in parentheses): Simulation - Open Pit Mining Operations (7); Simulation - Underground Mining Operations (6); Simulation - General Topics (10); Virtual Reality (4); Expert Systems - Genetic Algorithms (9); Neural Networks (4); Mine Safety - Training (3); Modeling, Planning and Production Scheduling (24); Rock Mechanics (7); Mine Equipment (8).

By clicking on a paper's title, the participant was ready to read the presentation of this particular paper. Following the presentation, as in a regular conference, there was a "Q&A time". A navigation bar at the top of each paper facilitated dialogue between participants, asking questions or making comments, and the paper's authors, replying to questions and defending their theses. Each paper had a Discussion List associated with it and an e-mail address in the form: PaperCode@www.metal.ntua.gr. Both participants and authors communicated by sending e-mail messages to the paper's Discussion List. For each paper, messages could be viewed sorted by thread, date, subject and author.

MineSim '96 was supported by a pool of sponsors, 13 organizations and 22 industrial sponsors, and through links to their respective websites, they presented their products, services and brochures.

The "sightseeing" program of the symposium included a "virtual tour" to the Acropolis of Athens and the monasteries of Mount Athos.

MineSim '96 proposed a new way of organizing symposia on specialized topics in which the Limited interest does not justify the organization of a regular symposium due to the high costs involved on tine part of both the organizers and the participants.

From 1-12 December 1997, a similar event, the "First International Conference on Information Technologies in the Minerals Industry - via the Internet" (MinelT '97), was organized by the Department of Mining Engineering and Metallurgy of NTUA, and run using a web pages arrangement set-up maintained by MSSLab. (http://www.metal.ntua.gr/ mssIab/MineiT97/). Following a number of requests by participants and members of the International Organizing Committee, the conference period was extended till the end of the year. During the course of the conference mere were 1683 "hits" and 296 registrants, from 35 countries, submitted a non-compulsory registration form.

During this period, the conference's website provided a forum for the presentation, discussion and criticism of state-of-the-art and emerging information technologies applied in the minerals industry, covering a wide spectrum of applications from orebody modeling to training and reclamation.

Forty-six papers, from North and South America, Europe, Australia, Africa and Asia, were accepted for presentation and arranged in six technical sessions: Exploration - Orebody Modeling; Mine Planning - Mining Operations; Rock Mechanics - Excavation Engineering; Mine Equipment; Mine Safety - Training; Reclamation - Environmental Issues. Several interesting case histories were offered, while high quality 3D colour graphics and animations supported many papers.

MinelT '97 was sponsored by O&K Orenstein and Koppel Inc., USA.

The proceedings of both symposia, the permanent record of the "virtual conferences", were published by A.A. Balkema Publishers, Rotterdam, Netherlands (<http://www.balkema.nl>) in hardback with a companion CD-ROM.

5 EDUCATING WITH RITAS

RITAS (Remote Interactive Training Ad-lib System) is a web-based environment developed by the Mining Systems Simulation Unit (MSSLab), NTUA, to facilitate remote learning and training using the Internet.

In its present state of development, RITAS aims to offer an on-line course for final year students of the Department attending the class "Mining Systems Simulation". It is expected that in the near future RITAS will include additional mining classes.

RITAS is accessible 24 hours a day via the Internet, by directing a web browser to: <http://kimolos.metal .ntua.gr/ritas/>. Instructions are provided both in Greek and English.

The Mining Systems Simulation course is based on the GPSS/H discrete-event simulation language, developed by Wolverine Software Corp., U.S.A., and therefore RITAS provides students with the ability to run simulations on the web browser, using the GPSS/H Student Version Release 3.0. The student version of GPSS/H İs a full functioning version of GPSS/H, but has certain limitations regarding the size of the model one can run.

RITAS includes four main sections.

The *Help Section* provides students with online tutorial material, which describes the philosophy, the structure and the way that GPSS/H functions. In addition, the syntax of all GPSS/H language code-statements is available online, m tables that present the code name, operands, and description with examples. Using this section, students are able to retrieve quickly information regarding the language syntax when practising on simulation examples or working with exercises.

The *Example Section* instructs students how to simulate an underground mine transportation system using GPSS/H. The conversion of the real system into a GPSS/H model is analysed step by step using both text and animated pictures (Figure 1).

The aim of the *Model Section* is to familiarize students with the "fundamental nature" of a simulation study, i.e., the ability that a simulation has to answer "what if?" questions. The student can simulate different operating scenarios of a "loader-truck" mining system, by changing the values of the tabulated operation and cost input data and running the simulation model. The simulation output is provided both in the form of tables and charts, from which the student can realise the effect of each scenario on the system's output, operating cost, etc.

In the *Source Section,* which is the "heart" of RITAS, the student can develop, using GPSS/H, his own simulation models of the systems he studies. This can be done by either writing the GPSS/H code in a text window provided, or by uploading the GPSS/H source file written with a text editor. The simulation-run results are provided either in the GPSS/H Standard Output format or a more simplified and ergonomie "Quick-View" format.

The development of this final section, which is based on Client/Server architecture, was implemented by using web-based programming techniques (HTML, JavaScript, Perl, CGI, ISAPI). Figure 2 shows the task-flow to run a GPSS/H simulation model via the RITAS website.

RITAS has been used as the sole student-course interface for teaching Mining Systems Simulation in the Department of Mining Engineering & Metallurgy for the last two academic years (1999-2001). More than 30 students each year attended the class and worked with RITAS either from the Department's PC Lab or by using PCs at home. The feedback received from the students was very positive, while their constructive criticism led to certain "ergonomie" modifications of the RITAS web page layout

6 CONCLUSIONS

At a time when people will redirect their careers 5-7 times before they retire, and jobs requinng higher education have increased by 86% f<http//www.jonesknowledge com/higher/about.html>). society is paying more and more attention to education, including continuing education, career-advancement short courses and training m specialized topics.

Computing and network technology have been introduced into the educational community in order to enhance learning, communication and teacher-student interaction. Web-based services and tools are widely available, allowing educators to easily develop and implement instructional material online to supplement classroom-teaching methods, or to deliver distance education courses.

Online learning (e-leaming) is a powerful medium that gives educational establishments the opportunity to deliver lifelong learning to millions, with no time zone or distance barriers, and offers the potential for long-term revenues.

However, education, apart form being a process of information transfer and problem solving, is primarily a process of enlightening students so that they absorb ideas and ways of thinking, preparing Üiem for life. This requires extensive social interaction, tuition and mentonng.

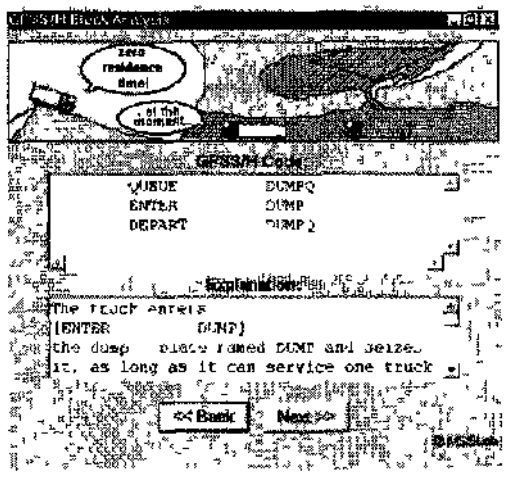

Figure 1 Analysis of conversion of the real system into a GPSS/H modei ustng both text and animated pictures

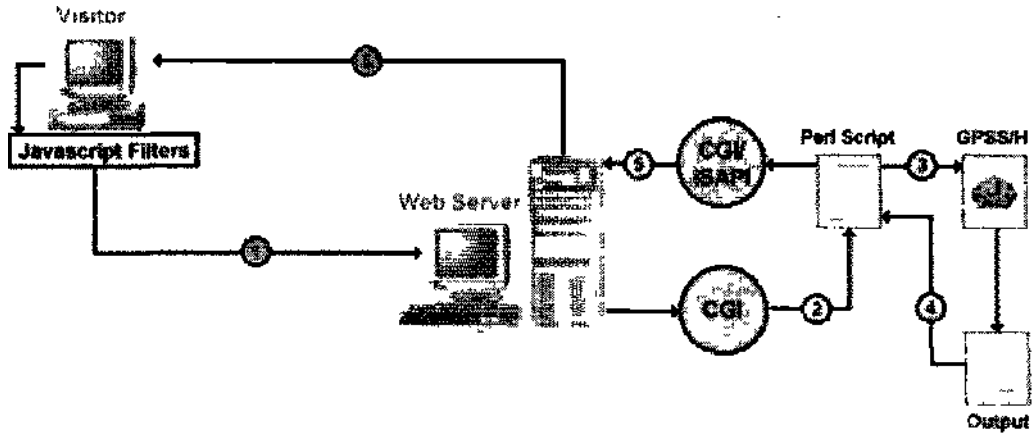

Figure 2. Task flow to run a GPSS/H simulation model via the RITAS website.

A good educational scheme should take into account the background of each student and tailor its material to the student's capabilities. In addition, it should provide appropriate remediation to students who experience difficulties with some concepts.

Certainly, the Internet, thanks to its attractive educational features, İs an excellent vehicle for the delivery of online learning materials to the international community, including the widely dispersed mining communities, but it is unlikely to replace the human education element provided by classroom teachers.

REFERENCES

All references are available online URLs are provided within the paper's text