

## Use of an Integrated Mining Software Package for the Training of Mining Technologists

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**ABSTRACT:** As computers become part of every engineering activity, it is essential that mining technologists and engineers be exposed during their education to specialised software and hardware. The field of mining engineering becomes more computerised every day. New computer programmes and algorithms are developed to solve the most difficult mining problems and at the same time, new hardware is produced to run these programmes faster and more efficiently. This paper describes how mining software is used at the Technological Education Institute of West Macedonia, Greece. An integrated mining software package is used as the basis for training mining students in the application of computers to geotechnical and mining works. The benefits and problems of this integration are analysed.

### 1 INTRODUCTION

#### 1.1 *Mining Industry and Computers*

The wide acceptance and application of computer software and hardware by the mining industry is common knowledge. The mining field is complex, involving many different sciences, and this is one of the reasons why computers are so widely applied in this field. Computers are involved at almost every stage of a mining project. From exploration and reconnaissance to ore processing and production scheduling, highly sophisticated software is used to ensure quality of work as well as speed and efficiency.

Twenty years ago, mining was at the beginning of a technological outburst as the specific needs of this field attracted the attention of the computer industry. Since then, a number of software companies providing specialised mining, geological, and environmental software and services have appeared. Universities and research institutes worldwide have dedicated large amounts of financial and human resources to the research and development of computer algorithms, which were then integrated into small task-specific computer programmes and large multipurpose software packages.

#### 1.2 *Introducing Computers to Mining Education*

As a result of all these developments, the educational programme of universities training mining technologists is changing to incorporate computers

as a subject and as a means for training. To meet the growing challenge of computerisation, education providers must integrate computer hardware and software into the classroom. There are several questions to be answered before this integration takes place. The most important one is probably, "What facilities and training are vital to the education of mining technologists?" Next, it must be decided how to best integrate this technology into current curriculum as well as introduce new courses which simultaneously stress engineering fundamentals and computer applications (Procanone and Cameron, 1985).

#### 1.3 *The Case of the Technological Education Institute of West Macedonia*

The Technological Education Institute of West Macedonia has been training mining technologists for almost fifteen years. The recently reorganised Department of Geotechnology and Environmental Engineering aims at the production of technologically educated engineers that receive the necessary knowledge covering the fields of mining and geotechnical works as well as the environment and its restoration. With the introduction of new courses such as GIS, remote sensing, geostatistics, geoinformatics, and the application of computers to geotechnical and mining works, the department moved towards the integration of specialised computer software in the training of its students.

Recently, the department purchased VULCAN, a 3D-software package covering most aspects of

mining, to form the basis of the course "Applications of Computers to Geotechnical and Mining Works" and complement other courses. The reasons that led to this choice as well as the concept of using such software in training will be explained. As it will be shown, there are great benefits from the use of such software in education.

## 2 EDUCATIONAL ENVIRONMENT

### 2.1 The Course

Before the discussion of the integration of VULCAN into the course, it is necessary to give a brief description of the facilities and organisation of the department relative to this course.

The course "Applications of Computers to Geotechnical and Mining Works" is lectured to third-year students of the department. Basic computer knowledge is a prerequisite, while the students are also exposed in previous semesters to geology, surveying, mapping, CAD, and other important subjects. The aim of the course is to train students in using computers for project management, mine design, optimisation, and scheduling, as well as financial management.

### 2.2 Facilities

In order to cover the engineering part of the course, the department purchased the VULCAN 3D Software package from Maptek/KRJA Systems Ltd. A number of VULCAN licenses were acquired and a laboratory was set up with PC workstations running the software, a plotter, and a wall projection system to be used during lecturing as shown in Figure 1.

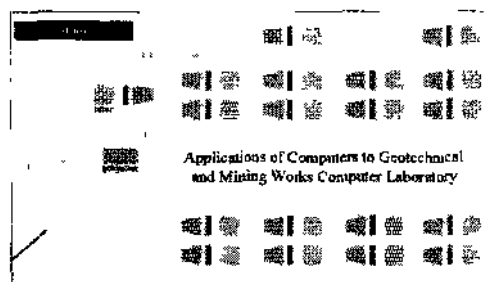


Figure 1: Plan view of laboratory arrangement for the course of Applications of Computers to Geotechnical and Mining Works.

The students form groups of twenty (maximum) to ensure that everyone gets hands-on experience. Each student will be using VULCAN at least four hours per week in a number of mining, geology, and environmental engineering tasks. Unfortunately, it is not possible to have free access to the laboratory as yet.

In principle, access must be as free and as unstructured as possible. A problem seen with many students is a feeling of unease when using computers. Utilisation of computer facilities allows one to become acquainted with their benefits and capabilities. It is one of the main considerations to find a way for the students to access the laboratory whenever they want while ensuring the safety of the equipment and software.

### 2.3 Lecture Notes

A set of lecture notes was prepared based on professional VULCAN training material from Maptek (McCallum, 1996) and related material from international sources (Badiozamani, 1988). Included in the notes are several tutorial exercises demonstrating various aspects of the use of mining software as well as basic principles of computer modelling and simulation. These notes are not meant as a replacement for other courses covering the theory behind mine design and process modelling. Computer analysis of a problem should not replace teaching design fundamentals in the classroom. Although such a course of action may make a student very capable at using the software, it can lead to deficiencies in the primary concepts vital to the engineering of a mining system.

### 2.4 Course Organisation and Student Assessment

Lecturing is organised in two-hour sessions twice a week. During this time span, the students are presented with a task and the primary data necessary to complete it. At the same time, the basic steps and principles in solving each problem are explained. The students need to comprehend the problem they need to solve and the approach to its solution using computer software. They also need to get familiar with the software-specific operations necessary to carry out the task. This is not one of the aims of the course but a necessity. The primary objective of the course and of the introduction of sophisticated computer software is to make students capable of using their knowledge of the physical behaviour of systems to solve problems and implement new designs and not to become experts in using the particular software package. It is impossible, though, to achieve this objective without some knowledge of the use of the software.

The students are assessed by means of a short oral examination involving the use of the software and its application to one of the tutorials from the course. During this examination, the students are marked for their understanding of the underlying processes, their ability to handle and visualise 3D data, and their ability to use data creatively to reach the solution.

### 3 CHOICE OF SOFTWARE

#### 3.1 *Single Package vs. Multiple Programmes*

The choice of the most adequate software package to train mining technologists is not the easiest of tasks. The first decision to make is whether it is going to be a single package covering many different aspects of mining or a number of different smaller programmes each specialised in one area. From our point of view, the single package covering as many applications as possible is preferable. This is the case for several reasons. Firstly, students will only have to learn one user interface as all programmes of the single software package behave in a similar way. In this way students can move between the various programmes and applications without having to learn yet another environment. Learning the user interface of a particular computer programme is not one of the educational goals. Another reason is that it becomes easier to combine results from different applications, and there is no need for file conversions and similar time-consuming procedures.

#### 3.2 *Degree of Sophistication*

The degree of sophistication of the software probably contributes little to the overall education of an engineer. There is no need for undergraduate students to be exposed to the latest and most sophisticated software during this course. However, in the case of mining software, the degree of sophistication usually shows the degree of usability and determines the range of applications covered. Thus it is critical to choose a software package that will meet the educational goals of the course. Choosing a sophisticated software package is important if the same software is to be used for research by graduate students and lecturers.

#### 3.3 *Computer Graphics*

Nowadays, software is also judged on one very important issue: 3D graphics. Computer graphics have developed rapidly over the past decade. The computer industry provides the hardware necessary to run software generating advanced 3D graphics in real-time mode. Advanced 3D graphics allow the precise visual representation of engineering designs and improve communication among people involved in the same project. In the case of education, this means better communication between lecturer and students and less effort from the latter to understand complex designs as well as the intermediate stages leading to them.

#### 3.4 *Maps and Reports*

Generation of maps and reports is another area of consideration when choosing mining software. It is essential for students to be able to see the results of their work printed on paper and to an appropriate scale. Reports from various calculations are also important, as they are necessary during tutorials and for the write-up of project reports. Both maps and reports give students a feeling of how things happen in a real professional working environment.

#### 3.5 *VULCAN 3D Software*

Maptek's VULCAN 3D Software has been chosen as the software used during lectures and tutorials for the course. VULCAN is one of the leading software packages in the field, providing great functionality and covering a very wide range of applications, including:

- all aspects of geology and mine planning
- open pit and underground mining
- modelling of metals, coal and industrial minerals
- surveying
- environmental management
- urban planning
- civil engineering
- road design
- 3D GIS
- oil & gas
- defence applications

VULCAN enables the translation of complex data into visual information. This visual information enhances students' understanding of complex mine designs and their ability to understand three-dimensional objects, particularly underground.

The various phases of a mining project can be clearly explained through a number of tutorials based on the advanced capabilities of the package. During the exploration phase, for example, students can see how information is collected from different sources, such as:

- exploration drilling
- assays (soil samples, drill core)
- surveying instruments
- geophysical and geochemical surveys
- digital terrain models
- scanned historical maps
- aerial photography

During the course, students get exposed to VULCAN-supported modelling techniques such as triangulations, grid models, block models and contours. They also get a taste of different numerical techniques used to estimate values when calculating grids and block models such as Delaunay triangulation, polynomial trend analysis, kriging, inverse distance, and nearest neighbour.

VULCAN's user interface is easy to learn even for students with no prior computer knowledge. When familiarising them with the system, most time is dedicated to manipulating the view and projection of models on the screen rather than learning menus and commands. Playing with the projection, zoom, pan and rotate tools in VULCAN's 3D graphical environment improves the students' ability to understand three-dimensional images and computer graphics. It also enables them to be productive during the tutorials as they can manipulate various models and other visual information fast, leaving time for more important modelling work.

Naturally, there have been some problems found during the course. As the software is quite sophisticated, there are numerous menus and functions that discourage students with little knowledge of computers. Most of the dialogue boxes and the various panels contain many options and tick boxes, all with titles and explanations in English. Some of the students have problems understanding them, meaning that the tutor has to put extra effort into explaining and translating the text in order for the tutorials to be carried out by all students. However, there is no guarantee that translating all this mining terminology into Greek would be particularly helpful as undergraduate students are not fully familiarised with mining terminology anyway.

## 4 HARDWARE REQUIREMENTS

### 4.1 Workstation System

The heart of the laboratory is a number of Intel-processor-based PC workstations. They use the Pentium II & III processors able to run VULCAN software at acceptable speed. The software requires large memory resources; therefore, a minimum of 128Mb of RAM is set as the standard. The large surface and solid models produced by VULCAN also require large amounts of virtual memory and, therefore, fast and high capacity hard disks are absolutely necessary. The workstations are networked via Ethernet to allow easy transfer of data between them.

Graphics are a very important issue. VULCAN's graphics engine is based on OpenGL. A quality graphics adapter with OpenGL acceleration can have a great effect on the workstation's performance when visualising large complex surface models with shading and textures or large block models. Large monitors are also important. A 17" monitor should be the minimum for a VULCAN workstation.

### 4.2 Peripheral Systems

These include an AO plotter and a backup device to store the large databases produced by the software.

The plotter should support the HP/GL2 language. A Postscript A4 laser printer could be useful for printing reports and other course-related material.

## 5 APPLICATIONS OF COMPUTERS TO GEOTECHNICAL AND MINING WORKS

### 5.1 Overview

The aim of the course is to expose students to a number of real-life applications of computers in the field of mining and geotechnical works. Students must be able to see, through a set of tutorials and theory, how certain things happen in a real working environment using computers and sophisticated computer software. Clearly, it is not possible to cover every single application in great depth. There are time constraints as well as knowledge limits that determine the type of applications and the extent to which they are covered during the course.

The content of the course can be adapted according to the special characteristics of each student group. Some students are more computer literate than others and some students can understand 3D visual information better than others. This affects the speed of the course as well as the type of applications covered. These applications should, however, cover subjects such as exploration and reserve estimation, surface and underground mine design and optimisation, and production scheduling.

### 5.2 The Tutorials

The main part of the course is a set of tutorials that take place in the specially arranged computer laboratory. The tutorials are two hours long and cover application areas such as:

- *Mining software basics*: data sources, data structures, databases.
- *Computer Aided Design*: object design and advanced editing options specific to mine designs.
- *Surface and solid modelling*: triangulation modelling using the Delaunay algorithm and solid triangulations, advanced triangulation manipulation options, draping of photographic images and block model intersections.
- *Drillhole and sample databases*: samples from drillholes and other sources, compositing, basic requirements for database generation, database manipulation and 3D visualisation.
- *Geological modelling*: display, analysis and manipulation of lithological, analytical, structural and mineralogical information, profiling, and stratigraphic modelling.
- *Resource and reserve estimation*: advanced statistics, geostatistics, grid modelling, block modelling, contouring, reserve calculations and reporting.

- *Underground mine design and optimisation:* layout design including roadways, cross-cuts, panels, pillars, longwalls or shortwalls, and stopes, using specialised mine design options, and solid model generation using centerlines and cross-sections (primitives) or roof and floor polygons.
- *Surface mine design and optimisation:* top-down and bottom-up approach, ramp design, switchbacks, open pit optimisation using the Lerchs-Grossman algorithm, design intersection with topography and other features.
- *Road design:* combining horizontal and cross-sectional designs, multiple road sections design, design of super elevated turns and cross-falls for surface drainage, fly-over and drive-along viewing of the simulated road.
- *Production scheduling:* mine design breakdown to mining phases and blocks, analysis and determination of key scheduling parameters, long-term and short-term planning and scheduling.
- *Environmental management:* groundwater modelling, visual impact assessment, site monitoring, rehabilitation and contaminant control.

Each tutorial is fully documented in the course notes and the various steps are described together with the necessary VULCAN commands and functions. These commands are given hierarchically, i.e., the entire route to the command is provided, helping students to cope with VULCAN's massive menu structure and be more productive.

## 6 CONCLUSIONS

### 6.1 Current situation

In this paper, the use of an integrated mining software package for the training of mining technologists has been analysed. The choice of the software package has been explained. The way the software is used through a course titled "Applications of Computers to Geotechnical and Mining Works" has been described and various benefits and problems have been identified.

As it was shown, training students using such so-

phisticated software can enhance their understanding of how mining works in real life and how their knowledge of mining can be applied to produce complex mine designs and production scenarios. Students gain hands-on experience in applying estimation and modelling algorithms that they would otherwise only know in theory.

Visualisation of mine designs as well as geological information in a 3D graphical environment gives students a very good approximation of a real mining situation that is impossible to provide through other means such as drawings, diagrams or even plots and printouts. The ability to view the same design from multiple positions or in animation improves students' understanding of three-dimensional entities, from drillholes to complete mine designs.

### 6.2 Future work

So far, the software has been used only for the purposes of one particular module. Its integration with other modules as well as its use for research work and postgraduate studies is being considered. The software is also to be used for final year projects. All of these require proper time and organisation of resources. Improvements are also expected on the software package itself: a better graphical user interface and integration with the computer's operating system is on the way.

Generally, the concept of using such software is in its early stages, and it is expected to mature with time to give even more benefits to the department as well as solutions to current problems.

## REFERENCES

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