In schools and universities, for industry and public awareness

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Fieldwork interactive training in geosciences: Cognitive acquisition

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One of the main problems that we are facing now is the appalling lack of interest and information about the Geosciences shown by the first year students at our university. This is due to the impoverishment of the Geology curricula within the Portuguese high school. The Geosciences Section of the Mining Engineering Department uses systematic fieldwork within the themes of Geology during the first three years of the 5-year degree course. These activities have been very successful. They lead to a quicker and more efficient learning and to a higher level of motivation to Geosciences. This is due to group informal interaction linkages between student teachers and between the students themselves during fieldwork practice. For this purpose they use a model of teaching – learning strategy based on informal learning processes.

1 MINING ENGINEERING AND HIGHER EDUCATION IN THE EEC

The shrinking of the domestic industrial base in mining in the EEC has lead to a sharp drop in the number of students in specific channels of this industry (geological exploration, raw materials processing). Since many changes occurred in recent years in the European Mining Sector, with the closure of coal, iron and tin mines, traditional mining engineering curricula have been rethought at several universities. Some mining departments were even closed or are expected to be closed soon. This process is occurring all over Europe.

Throughout the EEC there are twenty-eight academic institutions providing mining education leading to the degree of mining engineer after a required curriculum of at least four years at the university level (since these curricula are, in most European countries, organised over a minimum of five years, it is not possible to combine them with three-year curricula). Their geographic distribution among the Member States is far from being uniform, as also is the number of degrees awarded yearly, a total of which was estimated to be close to 900 for the year 1990. According to the regional opportunities and to the evolving situation of the mining sector in each country, different policies have been elaborated in the higher education institutions...
regarding mining engineering curricula contents. Three different cases can be envisaged:

- A strongly specialised curriculum, with more than 30% contribution of mining engineering subjects to the whole programme. This policy can be observed in the British Mining Engineering Curricula and in the mining engineering offered at the German Institutions;

- A more diversified programme, which however maintains the coverage of mining engineering courses above 10%. The majority of the mining curricula offered by the EEC institutions correspond to this policy, but with varying degrees. The diversity may result either from a better equilibrated distribution of subjects, or from the organisation of options oriented towards geotechnical and geoscience courses, making more room for basic engineering and Earth-science subjects.

- An extremely diversified programme, in which the contribution of mining engineering courses is reduced to only a few percent or even nothing, while the title of mining engineer is maintained. This is realised by introducing options (processing, geophysics and engineering geology) or other options that are far from the mining field (as, for instance, in the French and Spanish institutions).

The number of subjects directly related to mining techniques may vary (representing in some curricula up to 45% of the total teaching hours, while in others it amounts to less than 10%). The mining engineer's degree may cover very different educational contents. This would most probably not be true of other engineering degrees. The reason can be found in the prestige that surrounds the title of mining engineer in Europe since the creation of the first mining schools at the end of the XVIII century, when the mining sector was the largest part of European industrial development.

In comparison with the many other engineering degrees that have been created, later, the mining engineering curriculum became more and more diversified and polyvalent as the one that ensures the most polyvalent engineering education. This is particularly appreciated in the mining industry, but also in many other sectors and industries. Compared with the other engineering studies, mining engineering education is characterised by the inclusion of Earth-sciences in addition to the basic component parts (basic science, engineering and non-technical courses) of every engineering education. These courses certainly contribute to give the required polyvalence: they represent the mining engineering curricula at least 10% of the total programme.

Thus, Mining Engineering curricula in EEC offer a very wide selection of courses, from very specialised to more polyvalent ones. Although some programmes are very rigid, there is a clear tendency towards higher flexibility through the introduction of options, semi-optional courses and even free elective courses, so that different programmes may be followed within a given institution, leading to different Mining Engineering Degrees.

The quality of a degree also depends on the quality of the enrolling students, and therefore of the utmost importance to be able to attract the best students. The unattractive and eventually negative impact on the public image of the mining industry is mainly in relation to environmental impact and working conditions, is the main reason for low student enrolments. The mining industry does not have a good public image as a professional opening: the '3-D syndrome': dirty, dangerous, dark.
ous, dying is frequently associated with the image of this profession, partly because it is linked in people’s minds with the coal sector with its well-known recent decay in the Community. To these external factors that lead to a negative perception by the public, internal reasons may also be added; inside the engineering faculty the mining curriculum is sometimes considered to be old-fashioned in comparison with the new ‘high-tech’ engineering courses. That is why the average quality of students currently entering traditional mining engineering courses is somewhat inferior to that of most engineering students.

In Portugal the situation is not very different from that of other European countries. Nevertheless, the quarry and ornamental stone industry and also activities parallel to mining are absorbing a very large number of fresh graduates.

Concerning recruitment a ‘numerus clausus’ national policy was implemented by the Ministry of Education during the last half of the 1980’s as the number of students wishing to enter University started to become excessive in comparison with available places. The first effect of this measure led to the enrolment in Mining Engineering students having as their only aim to become graduates (sometimes they want to become engineers). Thus, for some years now, we are facing a population of first year students possessing all the wrong motivations to enrol in the Course and also marks low enough to be rejected by the more appealing technical courses.

Being sensible to these handicaps, that concern at the same time job opportunities and student’s recruitment. In 1990 (6 years after the last large revision of the course), the Mining Engineering Department started a lengthy reflection about its previous pedagogic and didactic experience. In this collective task, some results of consultations with the industry, carried out by University – Enterprise Partnerships, in the framework of the EEC-COMETT Programme, as well as some conclusions of general meetings with persons in industry, were taken into consideration. The work finally led to a new degree curriculum that we think is innovative in many ways.

2 MINING ENGINEERING CURRICULUM AT PORTO UNIVERSITY

The two first years of the curriculum are mainly used for Basic Engineering Science teaching, but an emphasis is given to the Earth-sciences. In the two intermediate years mining specific technologies and their scientific foundations are studied, divided into three main groups:

- Exploration Technologies (including Geophysics);
- Exploitation Technologies (including Geotechnics, Tunnelling, and Greater Exploitation);

In each group there is a systematic approach, starting with an analytical approach and fishing with a holistic viewpoint. The final year, besides seminars concerned with Engineering Strategy and Design, is devoted to advanced Sciences such as Statistics, Mathematical Foundations for Geophysical Data Management, and Control and Automation, which give the students the advanced theoretical tools needed.
Table 1. Earth-sciences and exploration technology courses.

<table>
<thead>
<tr>
<th>Year</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>Geology</td>
</tr>
<tr>
<td>2nd year</td>
<td>Mineralogy; Petrology</td>
</tr>
<tr>
<td>3rd year</td>
<td>Geological and hydrogeological exploration; Geophysical exploration; and diagraphics</td>
</tr>
<tr>
<td>4th year</td>
<td>Global metalogenesis; Geology and metalogenesis of Portugal; Geotechnition</td>
</tr>
<tr>
<td>5th year</td>
<td>Theory of Geophysics; Geological models and optimisation; Geostatistics</td>
</tr>
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3 EARTH-SCIENCES AND EXPLORATION TECHNOLOGY CURRICULUM

These subjects are taught throughout the five years of the degree course. All these subjects comprise a total of 49 credit units of a total of 225, this results in a large teaching load in Earth-science. One credit unit is equivalent to 15 hours of theoretical teaching time or 40 hours of practical teaching time.

4 THE MINING SPIRIT

Holders of diplomas in Mining Engineering are said to present a particular profile, the ‘mining spirit’ that is greatly appreciated by operator is no doubt the result of the nature of the training received. Unlike the strict specialist who works out a very precise solution for a specific task; the ‘mining-spirit’ involves in a multi-disciplinary approach, pursuing a reorganization between all the elements:

- Natural elements (mineral deposits, rocks, soil properties);
- Economic imperatives (cost price, financing);
- Available time for execution;
- Existing infrastructures and equipment;
- Respect for the environment.

Unlike the other Engineering Degrees that deal with man-made systems, Mining Engineering Degree applies a technical/econometric quantitative analysis of the world of nature – with all its variability and uncertainty. Thus the peculiarity of the course deeply depends on the subject of study – the Earth. That is, sciences play such an important role in the curriculum, not only to condense the knowledge but also to create in the students a particular way of dealing with scientific problems.

5 WHAT IS GEOLOGY FOR?

Instead of the classical scheme, commencing with Mineralogy, in our course, Geology is studied at once during the first year. Thus it has a leading role in the formation of the students' interest towards the course, but it also aims at other targets:

- To produce the need to observe and understand Nature and namely the Earth;
- To supply the main geological concepts that will act as cognitive resources for subsequent subjects;
To present the Earth, with its internal and external characteristics, as a dyrm and coherent entity.

We would like the students to be able to visualise mountains growing, by the of the first academic year, and to feel and understand that the observable phenom in Geology are restricted to a very thin veneer (equivalent to an apple's skin). consequence, the inner dynamics and structure of the Earth are not observabl indirect methods must be used). All the rocks now at the surface are evidence of observable past events, but at the first instance, they seem mute. We need to how to put them to speaking: 'there are sermons in stones'.

6 FIELDWORK

Since 1989 the Mining Engineering Department – Geosciences Section has incl systematic fieldwork within each Geology subject taught during the first three of the degree course. The work involves all the students attending Geology first Mineralogy and Petrology second year, and Metagenesis third year. The month of the academic year is used by the instructors to plan the joint activities eering inside the three subjects. One area near Porto with immediate geological est and easy access by public transportation (i.e. easy reach of students) is chosen. This area will be studied simultaneously by the students of all three years. For purpose it is divided into small plots of land to be ascribed to each working part the same time the geological, mineralogical-petrological and metalogenic prob to be presented to the students are prepared. A map of the working area with scription of some of its general features is produced.

One to one and a half month after the beginning of academic year, all the stu attending the first three Geology subjects, visit for the first time the working. They receive no previous information whatsoever about it and they are not instr about what they will be seeing. On arriving at the spot, they are merely told to and to try to 'grasp reality'. No geological explanations (simple or elaborated provided by the instructors – only questions raised by the instructors while wa around and demonstrating the area. Some of them are very general, such as:

- 'Do you think the area is likely to have some mineralisation?'
- 'What clues of mineralisation would you look for?'

Other more precise questions, are chosen in order to be impossible to answ by the students at this stage of knowledge. This type of attitude usually deeply tates the students, particularly those attending the last years of the course, be they are forced to face ignorance and cannot stand it. They like to be provided certainty and instead are getting doubts from their teachers. The first year stu (those who have no previous high-school geology training) are not only irritated also confused. They do not know what to do or to say because they are only to look and to observe without any more orientation. They just wander in the downheartedly, not knowing what to do or to say.

After this period which last for one/two hours some more precise question asked, carefully chosen in order to be related to the type of work they are goi undertake:

- What is this? What type of rock is that?
Do you think that this set of lodes is more recent or older than that one?

Again, these are such as they will not be able to answer them yet. Furthermore, they adhere to them as a shipwrecked sailor clings to a pilar, thus being motivated towards the problems they are facing. At this stage or interpretation whatsoever is given to them. On the contrary, in the case of these conflicts are caused in each individual. The aim is to provoke and to diversify, to focus attention on some particular questions and to help generate propitious to interrogation and selective collection of field information must be given to selectivity of data gathering since one of the main difficulties students face is to decide what kind of information is relevant to them.

During the first class, in-doors, after the field visit they are briefly introduced to the working area and are provided with a very simple field guide that contains:
- A map describing the area;
- A description of the work to be performed detailing the several steps;
- The ‘rules of the game’;
- The targets to attain;
- Bibliographic references to be used.

The fieldwork guide of the first year students has, in addition, a geomorphological problem to be solved that concerns the entire area. The working area is not too large, small enough to be surveyed easily in one or two field trips) are usually divided into working parties, usually of three students. The second and third year students are accompanied by their instructor only after explicit request from one or two groups, but, in the case of the first year students, the next visits to the working party is led by the Geology instructor. Usually each working party asks the instructor to provide in-field explanations about at least twice.

The in-door classes of Geology will go on in a normal way, with the usual three hours per week and the field trips are done using spare time. However, whenever it is possible links to the field problems are made.

A very precise schedule of the work is established, comprising the preparation of one or two interim reports; and the presentation of written conclusions. The delivery of the final report each team does its presentation to the class of all the students. The aim of this activity is to train the capacity of working in a team. Due to the individualistic character of the present class this is a definite problem to overcome. All the audio-visual aids are made by each student and each individual presentation is marked. The student's marking is not always coincident with that of the monograph.

7 THEORETICAL BACKGROUND: SIGNIFICATIVE LEARNING THEORY

According to Ausubel (1976), significant learning is attained when new is connected to the subsumed concepts. All newly acquired knowledge
cally used to modify the content of the subsumed key concepts. Thus, it is of the most importance to evaluate the knowledge background of 1st year students in E. sciences. To ascertain what the student knows is to identify the relevant key prev
concepts that he has or, in Ausubel’s words, to ‘identify his subsumed concepts’
we know that they almost always have not received specific information in E.
science in High School, their conceptual framework is composed by the com
knowledge concepts that the person ‘in the street’ possesses – those divulged by
media; and common-sense concepts – illusive, quite often – related to landfo
rivers, mountains, shore processes and so on.

To take advantage of this, we use Geomorphology as a conceptual organi
framework. It deals with phenomena that belong to the day-to-day experience o
students and consists of empirical concepts – even if some of them are misleadin
that way it is rather easy to give them a set of parallel subsumed concepts to w
cognitive links can easily be made. As all the geomorphological reasoning is fou
on the Law of Continuity of Space and Time, it is rather easy to link landform te
netic processes. So, in parallel and over the Geomorphology framework used li
mould, the student is able to erect the conceptual building of a Dynamic Earth.

8 STEPS IN LEARNING

The authors have recognised various steps in learning in their field work methc
ogy, following Gil (1990) – the syncretic phase, analytical phase, synthetic phase
application phase. This final section of their text has been editorially abridged.
those interested should contact the authors. Their method of teaching involves
giving students a set of certitude’s but rather a ‘sea of doubts’ – they are inculc:
a questioning attitude to Earth-science not teaching by rote a set of ‘certain facts’

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Berger, Anthony R. & William J. Lam (eds.)
Geodicators – Assessing rapid environmental systems
1996, 25 cm, 480 pp., Hfl.165 / $95.00 / £67
This book introduces geological indicators of rapid change, a concept developed as a contribution to environment reporting and to the assessments of sustainability. Geodicators constitute a new kind of indicator, one that reinforces the view of nature as dynamic, in ways that are not always predictable: humans are a cause of environmental stress. The book contains indicators for some major geological environments: permafrost terrains, groundwater systems, coastal wetlands, soils, oceans, corals and reefs. Other papers discuss mathematical and policy frameworks for geodicators and the first edition of an international checklist of indicators produced under the aegis of the International Union of Geological Sciences. These are described to a common format for monitoring geological change in any territorial area. The book is of interest to a wide range of geoscientists concerned with assessing sustainability through indicators and monitoring.

Mulder, E.F. de & B.P. Hageman (eds.)
Applied Quaternary research – Proceedings of a conference held at the XIIth INQUA Congress, Ottawa, 31 August to 5 September 1989, 25 cm, 196 pp., Hfl.150 / $85.00 / £55

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