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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 inte[r] and information about the Geosciences shown by the first year students at ou[r] versity. This is due to the impoverishment of the Geology curricula within the [P] guese high school. The Geosciences Section of the Mining Engineering Depar[t] uses systematic fieldwork within the themes of Geology during the first three of the 5-year degree course. These activities have been very successful. They l[e] a quicker and more efficient learning and to a higher level of motivation to Geosciences. This is due to group informal interaction linkages between studen[t] teachers and between the students themselves during fieldwork practice. Fo[r] 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 (ge[o] exploration raw materials processing). Since many changes occurred in recent in the European Mining Sector, with the closure of coal, iron and tin mines, th[e] ditional mining engineering curricula have been rethought at several univer[sities]. Some mining departments were even closed or are expected to be closed sh[ortly]. This process is occurring all over Europe.

Throughout the EEC there are twenty-eight academic institutions providing [h] 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 Eur[opean] institutions, organised over a minimum of five years, it is not possible to co[mpare] them with three year curricula). Their geographic distribution among the M[ember] States is far from being uniform, as also is the number of degrees awarded yearl[y, the] total of which was estimated to be close to 900 for the year 1990. According [to] regional opportunities and to the evolving situation of the mining sector in [each] country, different policies have been elaborated in the higher education instit[utions] regarding mining engineering curricula contents. Three different cases c nised:

– A strongly specialised curriculum. with more than 30% contribu mining engineering subjects to the whole programme. This policy can be the British Mining Engineering Curricula and in the mining engineering fered at the German Institutions;

– A more diversified programme, which however maintains the con the mining engineering courses above 10%. The majority of the mining curricula offered by the EEC institutions correspond to this policy, bu ways. The diversity may result either from a better equilibrated distrib different groups of subjects, or from the organisation of options oriente and geotechnology, making more room for basic engineering and Earth-sc

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

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

In comparison with the many other engineering degrees that have duced, later, the mining engineering curriculum became more and more to ered as the one that ensures the most polyvalent engineering education. T lent character is particularly appreciated in the mining industry, but i highly prized by many employers outside the mining sector. Compared engineering studies, mining engineering education is characterised by th of Earth-sciences in addition to the basic component parts (basic science gineering and non-technical courses) of every engineering education. Th subjects certainly contribute to give the required polyvalence: they repres mining engineering curricula at least 10% of the total programme.

Thus, Mining Engineering curricula in EEC offer a very wide select grammes, from very specialised to more polyvalent ones. Although some very rigid, there is a clear tendency towards higher flexibility through th tion of options, semi-optional courses and even free elective courses, so ferent programmes may be followed within a given institution, leading t Mining Engineering Degree.

The quality of a degree also depends on the quality of the enrolling stu therefore of the utmost importance to be able to attract the best students the unattractive and eventually negative impact public image of the minin mainly in relation to environmental impact and working conditions, is main reason for low student enrolments. The mining industry does not vourable public image as a professional opening: the '3-D syndrome': *dir* *ous, dying* is frequently associated with the image of this profession, partly becau is linked in people's minds with the coal sector with its well-known recent dev ment in the Community. To these external factors that lead to a negative perce by the public, internal reasons may also be added; inside the engineering facu the mining curriculum is sometimes considered to be old-fashioned in compa with the new 'high-tech' engineering courses. That is why the average quality c students currently entering traditional mining engineering courses is somewhat rior to that of most engineering students.

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

Concerning recruitment a 'numerus clausus' national policy was implement the Ministry of Education during the last half of the 1980's as the number of stu wishing to enter University started to become excessive in comparison with avai places. The first effect of this measure led to the enrolment in Mining Engineeri students having as their only aim to become graduates (sometimes they want engineers). Thus, for some years now, we are facing a population of first yea dents 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 opportu and student's recruitment. in 1990 (6 years after the last large revision of the cu lum), the Mining Engineering Department started a lengthy reflection about it vious pedagogic and didactic experience. In this collective task. some results quiries to the industry, carried out by University – Enterprise Partnerships, i framework of the EEC-COMETT Programme, as were as some conclusions o eral meetings with persons in industry, were taken into consideration. The wc nally 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 Sci teaching, but an emphasis is given to the Earth-sciences. In the two interm years mining specific technologies and their scientific foundations are studie vided into three main groups:

– Exploration Technologies (including Geophysics);

– Exploitation Technologies (including Geotechnics, Tunnelling, and Grou ter Exploitation);

– Process Engineering Technologies (mainly Mineral Processing, Raw Ma Processing and Recycling).

In each group there is a systematic approach, starting with an analytical app and fishing with a holistic viewpoint. The final year, besides seminars conc Engineering Strategy and Design, is devoted to advanced Sciences such as G tistics, Mathematical Foundations for Geophysical Data Management, and C and Automation, which give the students the advanced theoretical tools needed.

Table 1. Earth-sciences and exploration technology courses.

1st year	Geology
2nd year	Mineralogy; Petrology
3rd year	Geological and hydrogeological exploration; Geophysical exploration; (and diagraphics
4th year	Global metalogenesis; Geology and metalogenesis of Portugal; Geotech gation
5th year	Theory of Geophysics; Geological models and optimisation; Geostatisti

3 EARTH-SCIENCES AND EXPLORATION TECHNOLOGY CURR

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 e 15 hours of theoretical teaching time or 40 hours of practical teaching tim

4 THE MINING SPIRIT

Holders of diplomas in Mining Engineering are said to present a partic logical 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 p 'mining-spirit' involves in a multi-disciplinary approach, pursuing a re promise 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 m Mining Engineering Degree applies a technical/econometric quantitative the world of nature – with all its variability and uncertainty. Thus the pec 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 con edge but also to create in the students a particular way of dealing with sci

5 WHAT IS GEOLOGY FOR?

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

– To produce the need to observe and understand Nature and namely th

– To supply the main geological concepts that will act as cognitive r subsequent subjects;

– To present the Earth, with its internal and external characteristics, as a dyr and coherent entity.

We would like the students to be able to visualise mountains growing, by th of the first academic year, and to feel and understand that the observable pheno 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 Metalogenesis third year. The month of the academic year is used by the instructors to plan the joint activities ering inside the three subjects. One area near Porto with immediate geological i est and easy access by public transportation (i.e. easy reach of students) is ch This area will be studied simultaneously by the students of all three years. Fo 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 be 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, bec 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 c

Again, these are such as they will not be able to answer them yet. bewilderment, they adhere to them as a shipwrecked sailor clings to a p and start to be motivated towards the problems they are facing. At this swer or interpretation whatsoever is given to them. On the contrary, in conflicts are caused in each individual. The aim is to provoke and to versy, to focus attention on some particular questions and to help gener mind propitious to interrogation and selective collection of field inforn must be given to selectivity of data gathering since one of the main dif students face is to decide what kind of information is relevant to them not.

During the first class, in-doors, after the field visit they are brief working area and are provided with a very simple field guide that contai

– A map describing the area;
– A description of the work to be performed detailing the several step
– The 'rules of the game';
– The targets to attain;
– Bibliographic references to be used.

The fieldwork guide of the 1st year students has, in addition, a geom problem to be solved that concerns the entire area. The working area p area small enough to be surveyed easily in one or two field trips) are working parties, usually of three students. The second and third year stu accompanied by their instructor only after explicit request from one or m groups, but, in the case of the first year students, the next visits to the are led by the Geology instructor, Usually each working party asks the to provide in-field explanations about at least twice.

The in-door classes of Geology will go on in a normal way, with the ule (five hours per week) and the field trips are done using spare time door instruction, whenever it is possible links to the field problems are the students are systematically asked how things are going ('students harassment' – as it is called internally).

A very precise schedule of the work is established, comprising the pr one or two interim reports; and the presentation of final written conclu the delivery of the final report each team does its presentation to the Lastly, a team constituted by one student from each group presents a sy the conclusions to the entire Department. One aim of this activity is to capacity of working in a team. Due to the individualistic character of the students this is a definite problem to overcome. All the audio-visual ai make a 'professional' presentation are supplied. Each one of the mc marked and each individual student is marked. The student's marking is torily coincident with that of the monograph.

7 THEORETICAL BACKGROUND: SIGNIFICATIVE LEARNING T

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 th 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 orga 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 to 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 metho 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 inculca a questioning attitude to Earth-science not teaching by rote a set of 'certain facts'

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