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Training in Geological Engineering. The experience of University of Évora (Portugal)

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ABSTRACT: This paper intends to share the experience gathered by the University of Évora during the past 25 years spent in the Education and Training in Geo-Engineering Sciences. The training on Geological Engineering has its basis on a two cycle's degree, as a result of the adaptation to the Bologna process of the previous degree course that lasted for five years. The introduction of course units (namely Engineering Geology, Soil Mechanics, Rock Mechanics and Geological Resources Exploration) along the first cycle degree provides the students the acquisition of specific abilities thus allowing them to enter the professional life. On the other hand, the curricula program provides the graduates with the generic competences and the necessary basis to progress his studies entering a second cycle degree in Geological Engineering or a similar course in the European Union.

1 INTRODUCTION

The first references concerning to education and research in Geosciences in Évora are made in a document drafted in 1975 by researchers of the so called University Institute of Évora. In this document is suggested the possibility of developing the graduate teaching and research in Georesources (hydric and geological). The opinion of eminent personalities from the areas of engineering and geology have been request and they were unanimously favourable to the existence of a teaching and research pole in Geosciences in Évora.

During the past 25 years the University of Évora invested on human resources, laboratory spaces and equipment for the Education and Training in Geo-Engineering Sciences. Nowadays, there are in this institution, the first cycle - Graduation Degree (3 years) and the second cycle - Master's degree (2 years) in Geological Engineering.

2 AIMS OF THE FIRST CYCLE DEGREE IN GEOLOGICAL ENGINEERING

The aims that guide the adaptation of the Graduation Degree in Geological Engineering, that had exist initially in the University of Évora, with the duration of 5 years (recognised by the Professional Association of Engineers since the year 2000 until now), for the first cycle (3 years) in Geological Engineering, are based essentially in the available legislation for the

adaptation of courses in the extent of the spirit of Bologna, in the strategic Document for the formative offer of the University of Évora, and in the consultation of formative offers of existing similar graduations in other national and international institutions, and in the consultation to teachers, students, graduates and employer entities.

In this way, it can be stand out as the main objectives: 1 - possibility of employment at the end of the first cycle; 2 - flexibility of the Plan of Studies, allowing the students' mobility; 3 - organization of the Course in a only trunk with 180 ECTS , of which 147 ECTS are obligatory and 33 ECTS are optional, mainly in the areas of Geological Resources and Geotechnics; 4 - the functioning of specific course units in the 3rd year (5th and 6th semester), allows the transversal mobility of students among Institutions with similar courses, and the access of the students to Specialization Courses or Advanced Courses of second cycle.

The relation between the Geological Engineering Course of the University of Évora and the surrounding region is a reality achieved through the insertion of the graduates in the labour market, the services supplied to the enterprises and to the community, beyond the organization of workshops, seminars and conferences.

In the period between 2000 and 2008, were established several protocols of collaboration with more than 30 enterprises and institutions of the Country, involving the participation of several teachers and students in research and applied projects.

3 THE DEGREE AND THE PROFESSION OF GEOLOGICAL ENGINEER

Located in the Évora historical centre we have a University which has several branches over Alentejo – South of Portugal. The Alentejo region provides a huge natural laboratory due to its richness in Georesources (e.g. marbles, granites, shists, soils for geotechnical projects, metallic minerals like Au, Cu, Sn, Zn, Pb, etc.). Beneficiating from these natural resources, the Course of University of Évora in Geological Engineering provides to their students an exceptional background in the investigation, characterisation, quantification and application of techniques and methods for the supported exploration of the Georesources. The first degree course has also a major component in Geotechnics, Environmental Geology and Hydric Resources endowing its students with a basic knowledge to enable them the entrance in the professional world.

The teaching on Geological Engineering as a Graduation Degree Course provided by University of Évora successfully have placed on the labour market tens of professionals, and about 90 % of which develops their professional activity in the Geological Engineering area (Georesources and Geotechnics).

4 GENERIC COMPETENCES AND SPECIFIC COMPETENCES

The course organization is based in a two cycle formation and results from the consultation of several documents produced by international organizations (e.g. Tuning, Eurocode 7), by the Professional Association of Engineers, the Portuguese Institute of Quality and by the consultation of the formative offers existing in similar graduations in several national and international universities.

There is the necessity of assuring transparency in the relation “designation-content-competence”, therefore: 1) in the first cycle formation the Professional in Engineering must acquire the competences that give him the capacity of intervening at the level of Execution, Innovation and Development; 2) with the second cycle formation the Professional in Engineering should be able to work at all levels of Engineering, namely in the Conception, Execution, Innovation, Development and Research in projects in its subject specific competence.

The abridging competences that the students acquire in the first cycle will allow the mobility of the graduated between the universities, giving him the possibility and capacity necessary to proceed to the second cycle studies (Master's degree) in the Geological Engineering courses and similar.

4.1 *Generic competences*

In the first cycle that is structured in a six semester basis, the syllabus of the course is designed to achieve the following generic competences (Project Tuning, unpubl.):

- Capacity to individual and group work;
- Ability to express in a good oral and written form;
- General skills in informatics and computer sciences;
- Knowledge of a second language;
- Good general cultural level;
- Competences in the basic sciences (Mathematics, Physics, Chemistry, Programming, Management, among others), where the geosciences competences are naturally important (Geology, Mineralogy, Petrology, Structural Geology, Field Geology, Hydrogeology, Sedimentology, Mineral resources);
- Acquire some competences in the engineering sciences with special relevance to Geological Engineering (Topography, Technical Drawing, Hydraulics, Engineering Geology, Resistance of Materials, Construction Materials, Applied Geochemistry and Geophysics, Rock Mechanics, Soil Mechanics, Mineral exploration, etc.).

4.2 *Specific competences*

Among the different competences developed is expected that the first cycle graduates are able to develop the following tasks:

1. Capacity to execute and develop field works for several purposes demonstrating accuracy, ability of observation and interpretation of the results: a) develop geological mapping at different scales for support to: exploration and exploitation of mineral resources; implantation of engineering works; regional and urban planning; b) perform, and supervise works of geological and geotechnical exploration, sampling and well logging, geological, geotechnical and geophysical *in-situ* testing.
2. Capacity to perform laboratory testing in the geosciences scope demonstrating the ability for an accurate interpretation in a scientific basis: a) performance, accompaniment and supervision of laboratory testing for the physical, chemical, mineralogical and geomechanical characterization of geomaterials (rock, soils and water); b) identification, characterization, selection and beneficiation of geological materials with industrial application.
3. Develop the capacity to utilize the results of geological engineering works: a) capacity to analyse and interpret the results from laboratory and *in-situ* testing; b) control and supervision the productive processes in the extractive

and transforming industry of Natural Stone; c) accompaniment of plans of environmental recovery and territory planning; d) accompaniment and supervision of engineer works in the scope of Geotechnics.

5 ORGANIZATION OF THE CYCLE OF STUDIES

A summary presentation of the organization of the first cycle in Geological Engineering of the University of Évora is made in Table 1. The degree has a total number of 180 ECTS and the cycle of studies has duration of 6 semesters. This structure provides, in the first semesters, the matters of the base sciences and of some engineering sciences.

The course units, that include applied speciality sciences and engineering sciences with relevance for the Geological Engineering (namely Engineering Geology, Soil Mechanics, Rock Mechanics and Geological Resources Exploitation), are supplied in the last semesters, with the aim to provide to the graduate of the first cycle some necessary competences for the exercise of the profession in the job market.

It must be highlighted the strong component of practical nature of the field and laboratory classes foreseen in many of the course units described in the Course Plan, constituting one more way to provide the "know-how" to the graduate, so requested by the employers entities.

In Engineering Geology, Soil Mechanics and Rock Mechanics course units, about 50% of the hours of contact correspond to laboratory practice where the students learn how to do the main geotechnical tests, to interpret the obtained results, to classify soils and rocks or to carry out borehole logging, etc.; all of them are fundamental tasks for the geotechnical study of an engineering project. The strong practical component of the Course, the acquired competences in the speciality course units and the presentation of works performed in a real context allow that the students can analyse "case-studies" and solve real problems.

Besides this teaching methodology for the acquisition of competences, the acquired experience demonstrated us that other informal mechanisms exist, such as, workshops, seminars, free courses, apprenticeships, study visits and field classes, that instigate a closer relationship teacher - student, allowing a faster and effective consolidation of knowledge and consequently its practical application, implementing a professional approach. On the other hand, the students' integration in research works developed by the teachers allows them from very early to contact closely with real problems stimulating their capability for the research.

Table 1. Geological Engineering - first degree programme.

Course Units/ Semester	ECTS**
1 st Semester	30
1. Linear Algebra and Geometry I	6
2. Mathematical Analysis I	6
3. General Chemistry	6
4. General Geology	6
5. Numerical Programming	6
2 nd Semester	30
1. Mathematical Analysis II	6
2. Introduction to Probability and Statistics	6
3. Physics 1.1	6
4. Technical Drawing Assisted by Computer	5
5. Mineralogy	7
3 rd Semester	30
1. Physics 1.2	5
2. Topography	4
3. Hydraulics	5
4. Petrology	7
5. Structural Geology	6
6. Optional free Course Unit *	3
4 th Semester	30
1. Hydrogeology	6
2. Field techniques on geosciences	5
3. Engineering Geology	6
4. Management	5
5. Remote sensing and GIS	5
6. Sedimentology	3
5 th Semester	30
1. Mineral Resources	6
2. Soil Mechanics and Foundation Engineering I	6
3. Resistance of Materials I *	5
4. Construction Materials I *	5
5. Applied Geophysics *	6
6. Subsurface Exploration *	4
7. Geostatistics*	5
8. Geomorphology *	5
9. Hydrology *	6
10. Groundwater Prospecting *	6
11. Quality and Use of Water *	6
12. Optional free Course Unit *	2,3 or 4
6 th Semester	30
1. Rock Mechanics	6
2. Geological Resources Exploitation	9
3. Industrial and Ornamental Rocks *	5
4. Slope Stability *	5
5. Applied geochemistry *	5
6. Hygienic and Security at Work *	5
7. Geological Mapping *	5
8. Environmental Geology&Land Management*	5
9. Monitoring Water Resources *	5
10. Management of water *	6
11. Supervision of Hydraulic Structures *	4

* Optional Course Unit

** ECTS – European Credit Transfer System

6 OBJECTIVES AND ORGANIZATION OF THE SECOND CYCLE (MASTER'S DEGREE)

6.1 Objectives

In the new framing of the proposed system for the higher education (Bologna Process), the University of Évora chosed, for most of their courses, the model 3 + 2 (first cycle = 3 years; second cycle = 2 years).

The second cycle corresponds to Master's degree and it is obtained with the accomplishment of 120 ECTS.

The Plan of Studies proposed has as main objective to supply the futures masters a solid and integrated formation in the area of the Geological Engineering, mainly, Georesources and Geotechnics, which allows them capacities of performance in several domains. So, the Master in Geological Engineering will be enabled to exercise his activity in the organisms of the central and regional administration, town's local government, project offices and consultancy, public and private laboratories, specialized building companies, extractive and transformation companies of industrial and dimension stones and centres of professional formation. The attainment of these objectives presupposes the acquisition of a series of technical and scientific competences that are supplied in the several course units.

6.2 Teaching methodologies

As for the teaching methodologies a diversification of methods were adopted, avoiding restricting the evaluation just to the accomplishment of written proofs. In that sense it refers to the systematic implementation of performance of individual and group works, aiming to introduce competences of effective knowledge, being in a team work atmosphere, being by the stimulating the individual capacity to develop concepts and projects. Frequently, the presentation of the works made by the students is demanded, with the intention of promoting the capacity to transmit technical and scientific contents vocally for enlarged publics.

In way to stimulate the individual study and to increase the accessibility of the bibliographical supports to the students, it is fallen back on the platform of e-learning.

6.3 Organization of the second cycle

The second cycle in Geological Engineering of the University of Évora is organized in four semesters framed in the European Credit Transfer System (ECTS). To conclude the cycle, the student should obtain 120 credits, evenly distributed by the semesters, 42 of which correspond to the dissertation / project / apprenticeship (Table 2).

The dissertation / project / apprenticeship, will work in the 4th and last semester, where it is intended the specialization of the student in an area of his/her interest. In this case, the student should make a work of improvement of his professional competences, with an component of innovation, development and investigation whenever possible, integrated in industrial / business atmosphere. The student should elaborate a report / dissertation, which jointly with its discussion will constitute the elements of evaluation of this course unit.

Table 2. Geological Engineering - second degree programme.

Course Units/ Semester	ECTS**
1 st Semester	30
1. Mathematical Analysis III	6
2. Geological and Mining Exploration	6
3. Quarry Technology	6
4. Environmental Impact Assessment	4
5. Geotechnics in Transportation Facilities*	5
6. Geostatistics*	5
7. Applied Geophysics*	6
8. Construction Materials I*	5
9. Subsurface Exploration*	4
10. Optional free Course Unit I*	2,3 or 4
2 nd Semester	30
1. Thematic Mapping	9
2. Soil Mechanics and Foundation Engineering II	6
3. Slope Stabilization	5
4. Natural Resources Economy*	6
5. Clays Technology*	4
6. Industrial and Ornamental Rocks*	5
7. Applied Geochemistry*	5
8. Security and Hygienic at Work*	5
9. Optional free Course Unit II*	4 or 5
3 rd Semester	30
1. Energetic Resources	6
2. Mining Technology	6
3. Project/Apprenticeship/ Dissertation	12
4. Environmental Rehabilitation*	6
5. Planning Mine Assessment*	4
6. Hydrology*	6
7. Optional free Course Unit III*	2
4 th Semester	30
1. Project/Apprenticeship/ Dissertation	

* Optional Course Unit

** ECTS – European Credit Transfer System

7 CONCLUSIONS

One of the most considered aspects of the successive evaluations of the Geological Engineering Degree was the high rate of insertion in the labour market of the graduates and the connection with the enterprises of this region. The high rate of employment opportunities is connected to the “know-how”, highly considered by the enterprises in the office, as in the laboratory or in the fieldwork.

The relationship between the students and the University of Évora does not finish with the diploma. It goes on and strengthens through the cooperation requested from some former students in helping them with the services they supply or even solving real problems.

The first and second cycle degree programmes are not inflexible. They can always be modified in way to give response to the students' interests and to the enterprises' requirements.

8 REFERENCES

Bologna Process, Main documents 2007. Available in URL: <http://www.ond.vlaanderen.be/hogeronderwijs/bologna/documents/>