

Engineering Education in Portugal

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Abstract - Engineering Education in Portugal is right now, in the academic year of 2006/2007 and for the years to come, undergoing a process of deep changes, both in the structure of offer of degree programmes, in contents and in paradigms of teaching/learning. In this talk we shall present the main changes taking place and a personal perspective of the desired changes to come.

Index Terms – Degree system, Competences, Qualifications Framework

THE NEW DEGREE SYSTEM AND ITS APPLICATION IN ENGINEERING PROGRAMMES

It is important to start by clarifying the changes that are taking place and the meaning of the wording employed to identify the degree structure.

The reference is Law 74/2006, concerning the new degree structure and promulgated on March 24.

Before the changes, the framework for engineering education was characterized as a binary system composed of universities and polytechnic institutes. This concept of binary system was indeed strengthened by Law 74/2006.

In the old system

In universities, engineering education corresponded to five years of integrated education that lead to the degree of *Licenciado* (Licence to...). The profiles of university degrees were generally considered as leading to the competences identified for 'theoretical oriented engineering programmes'.

In Polytechnic Institutes, students were offered two cycles: (i) a first cycle of three years, leading to the *Bacharel* (Bachelor) degree, and (ii) a second cycle of two years, leading to the degree of *Licenciado*, a degree officially equivalent to the *Licenciado* degree awarded by Universities. The profiles of polytechnic degrees were generally considered as leading to the competences generally identified for 'applications oriented engineering programmes'.

Graduates with the *Bacharel* degree from Polytechnics could pursue their studies either in the polytechnic subsystem or in the university subsystem, in this case usually through some bridging programmes. If successful, they would be awarded the *Licenciado* degree of the University. This means that they had the alternative routes of finalising the studies for the *Licenciado* degree either in a Polytechnic Institute or in a University.

In the new system

The legislation promulgated on March 24, 2006 formalizes the framework of education agreed upon in Bergen. A three cycle system is enforced with the first cycle corresponding to the degree of *Licenciado* (*Bachelor*), the second cycle to the degree of *Mestre* (Master) and the third cycle to the degree of *doutor* (*Doctor or Ph.D.*).

The following general notes should be added concerning the new system:

- The rule is to have independent cycles.
- First cycle studies conducting to *Licenciado* are organized both in universities and polytechnic schools.
- Second cycle master studies can also be organized in universities and polytechnics, subject for both subsystems, to a positive evaluation of appropriate research and development conditions, both in terms of teaching staff and research staff and laboratories.
- To enhance student mobility, within the spirit of the Bologna Process, studies are organized in semesters and the binomial competences-workload is characterized by using the ECTS-European Credit Transfer Systems.
- Graduates with the *licenciado* degree have access to second cycle studies.
- Integrated studies conducting directly to the second cycle degree will be authorized for a limited number of scientific areas, leading to more theoretical oriented profiles of competences. In such cases, however, a first degree after 180 ECTS equivalent of studies has to be offered. Typically in the engineering area first degrees in 'engineering science', and not in 'engineering', are offered.
- Graduates of the second cycle have access to third cycle programmes that are restricted to universities.
- Finally, post-secondary short cycles (strongly vocational) and complementary professional courses, are legally possible and encouraged, in all cases with the possibility of the recognition of studies for pursuing formal education.

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The new system - directive for professional recognition

It is worth noting the obvious link that exists between the agreements (degree structure) of the Bologna Process and the new Directive for Professional Recognition² approved by the European Commission and the European Parliament in September 2005, and indeed that will become national legislation in the EU countries by 2007.

In direct relation with the views expressed by a majority of professional organisations, the directive recognises in its article 11 three main levels of professional qualifications, related to formal post-secondary studies:

- Art. 11, c) - Up to one year and a half of vocational studies (not necessarily in higher education schools), which indeed can be related to our CET degrees.
- Art. 11 d) – between three and four years of studies in higher education institutions (plus adequate professional training) that corresponds to our first cycles; and
- Art. 11, e) – four or more years of studies in higher education institutions (plus adequate professional training) that corresponds to our second cycles

This overall framework has obviously to find its counterpart on a professional recognition of two main levels of professional qualifications in the engineering activity, which indeed is the structure recognised by Institution of Engineers, Portugal (Ordem dos Engenheiros), in line with the European understanding of the engineering profession.

Comparing titles and competences, in short

In Portugal, the following academic titles were awarded in engineering before the reform:

- *Bacharel* (a 3 years’ course, only in polytechnics)
- *Licenciado* (after 5 years of accumulated studies in higher education, awarded both by universities and polytechnics))
- *Mestre* (typically corresponding to 7 to 8 years of accumulated studies in higher education, awarded only in universities)
- *Doutor* (typically after 8 to 11 years of accumulated studies, awarded only by universities)

The current system, after the reform leads to:

- *Licenciado*, after 6 to 8 semesters of work (full-time equivalent), either in universities or in polytechnics
- *Mestre*, after further 3 to 4 semesters or semesters through the equivalent work within an integrated programme.
- *Doutor*, after a minimum of 3 years of course and research work.

We can see immediately that the title *Licenciado* is employed in both systems.

Having in mind the comments made above, concerning the directive of professional qualifications, it is clear that in terms of competences, and that is what counts, the term has clearly different meanings:

- The new *Licenciado* is a first cycle degree, having associated potential professional competences of first cycles. It should correspond to a positive upgrading of the old first cycles (bacharel degree), namely due to the

investment in new concepts and methods, but the new 3-year degree will not substitute the old 5-year degree.

- The old *Licenciado*, if an equivalence is to be given, has to be seen as very close to the new second cycle degree.
- The new *Master* degree is a second cycle degree. It should correspond to a positive upgrading of the old second cycle (*Licenciado*) degree, namely due to the investment in new concepts and methods, but equally it is not to be compared to the old *Master* that required seven or more years of accumulated studies. This old *Master* was a specialization that will find in the near future its equivalent in complementary advanced studies that universities are already starting to offer.

Numbers of the reform

Before the reform there were about 310 courses offered by higher education institutions, corresponding to the degree *Licenciado*, i.e. second cycle level.

With the new system a number of different degrees proliferated.

Table 1 show figures obtained from the analysis of the public information provided by the General Directorate for Higher Education.

The offer is not yet stabilised. It is estimated that from 2007/2008 about 90% of the old courses have undergone some transformation. Also, it is known that a number of proposals is still waiting for approval in the General Directorate of Higher Education. This is particularly true for independent second cycle degrees, where it is expected a significant increase in the offer. But, the numbers indicate a trend and give a picture of the future to come.

Institutions	First Cycle Degrees: 'Licenciatura' In Engineering Science	First Cycle Degrees: 'Licenciatura' In Engineering	Second Cycle Degrees: Master	Integrated Second Cycle Degrees: Master
Public Universities **	24	44	60 + ?	47
Private Universities	5	18	?	14
Public Polytechnic Institutes **	0	116	11 + ?	0
Private Polytechnic Institutes	0	10	?	0
Total	29	188	?	61

* resulting from the adapting of previous degree programmes or from the creation of new programmes; Source: public information, from Directorate-General for Higher Education, www.acessoensinosuperior.pt/indarea.asp
 ** Includes degrees offered by the Catholic University

² <http://register.consilium.eu.int/pdf/en/05/st03/st03627.en05.pdf>, active in July 2007

ABOUT THE LEARNING PARADIGM – WHAT IS IT AND WILL REALLY CHANGE?

The Bologna Process has quite obvious political and academic issues. The first concern of the Academia is with the latter. A few closing comments concerning this matter are appropriate.

In Portugal, as in a significant number of other European countries we face the challenge of adapting structures, contents and methods in a harmonised (readable) way.

It is only fair to recognise that a tremendous effort is being made, across Europe, for finding adequate solutions to these complex problems, particularly on the identification of a reference framework for qualifications, on the setting up of an acceptable scheme for quality assurance and recognition and also at a lower level for the identification of core curricula.

In the forum of the European engineering associations³, and as commented above, it became for now a stabilised concept that two types of education profiles should be offered, viz.- (i) the so-called more theoretically oriented profiles, usually associated to a minimum of four years of formal studies in Higher Education Institutions; and (ii) the more applications oriented profiles, including between 3 and 4 years of formal studies.

Qualifications frameworks are recognised as important instruments for achieving comparability and transparency within the EHEA, thinking of encouraging greater mobility of students and teachers and improve employability. They are not yet stabilised at national levels and for sure not yet well perceived between countries. The sharing of experiences should be stimulated for improvement on defining learning outcomes and on the recognition of (formal and informal) qualifications.

The European project CHEMEMPASS – Chemical Engineering Mobility Tools⁴, currently in progress in the chemical engineering area, is a good example of European (plus South African) effort towards this goal of mutual improved understanding of qualifications. It involves 12 partners and aims mainly at (i) evaluation and recognition of competences in connection with reference frameworks, and (ii) identification and testing of knowledge at different levels.

The E4 Group⁵ - Enhancing European Engineering Education - equally proposes sets of competences related to contents in all engineering areas.

The CDIO initiative⁶ – Conceiving, Designing, Implementing and Operating real-world systems and products – that currently includes more than twenty institutions all over the world, proposes a framework of competences organised in four sections (i) Technical Knowledge and Reasoning; (ii) Personal and Professional Skills and Attributes; (iii) Interpersonal Skills; (iv) Conceiving, Designing, Implementing and Operating systems in the enterprise and societal context. It is a most

useful framework of competences for organizing curricula contents and methods.

The effort is clear in trying to bring contents and competences nearer to the interest of Society and of the market, particularly at first cycle level. This is a concept that is not peacefully absorbed by academics in many countries.

Slowly, but steadily, the European Register for Quality Assurance Agencies, is being put in place as a major tool for mutual recognition of accreditation and quality assurance decisions.

Major activity is being developed by European engineering associations concerning this issue. Fourteen associations, supported by an European project, worked for three years in defining criteria and standards for first and second cycles, including a methodology for quality assurance. This has been registered as the EUR-ACE criteria for engineering accreditation. An Agency was born in 2006, the ENAEE-European Network for Accreditation of Engineering Education⁷, currently with sixteen full members, that aims at managing and maintaining such label. It is expected that this agency provides an example of good practice in transnational co-operation within the area of quality assurance.

Quality assurance will equally represent a major issue for the successful construction of EHEA.

Concerning contents, and using again the example coming from Chemical Engineering, the Working Party on Education of the European Federation of Chemical Engineering⁸ proposed in 2005 a set of recommendations for a core curriculum, both for first and second cycles.

New feasible curricula – contents and methods

So, how feasible, which objectives, which structure of education and of offer of studies in Portugal?

In practical terms, the objective of the exercise is to finally choose (decide) the (appropriate) answers to two main questions:

- What role and distinction of education at the tertiary stage (University education)?
- What should be the structure and the core content of engineering curricula for a first degree? What, what depth, when, how, which teaching aids?

No easy answers available, depending as they are on deciding about so many other sensitive questions, but the future will have to accommodate the solution for some of the following, viz. –

- Which skills and competencies should be promoted, thinking of both the needs of industry and the individual right of managing a career?
- What is the role of cultural interchanges and how to use international co-operation for promoting such interchanges?
- Assuming as a fact its relevance, how to induce holistic thinking and concepts of integrated development?
- To what extent should engineering education (EE) approach (or combine with) industrial practice?
- Should EE rather be research oriented?
- Should EE be oriented towards societal needs such as environmental protection, and sustainability?

³ www.feani.org, active in July 2007

⁴ <http://www.cpe.fr/chemepass/CEPLYon-CHEMEMPASS.htm>, active on July 2007

⁵ www.unifi.it/tne4/, active in July 2007

⁶ www.cdio.org, active on July 2007-07-22

⁷ www.enace.eu, active on July 2007

⁸ www.efce.info/wpe.html, active on July 2007

- Should EE include new disciplines such as industrial informatics, information technology, process intensification and miniaturisation technology?
- Which new methods and tools for teaching and how to induce self-learning?

It is clear that there is not 'a single' structure for a curriculum. Independently of questions of European accreditation, which will very shortly be raised in the rapidly expanding European Space, the fact is that it seems clear that no core curriculum should be imposed (by what authority?) on existing programmes, but guidelines coming out of a consensus should serve for countries seeking to develop their training programmes, having in mind that they have to meet the reference qualification framework accepted. The following general guidelines seem to deserve consensus:

- The basic sciences, now enlarged with life sciences, and the engineering core have to be there, to be complemented by electives and external training.
- Sustainability must be induced through the everyday work in all disciplines;
- Students should be brought nearer to the practice of engineering. It is important that sufficient practical experience, both in the laboratory, pilot plant and industry should be included in the core curriculum;
- Topics for promoting holistic thinking through integrated approaches and strengthening of horizontal issues should be part of the studies.
- A reasonable degree of diversity in engineering education is desirable. To take advantage of this diversity, student and educational staff exchanges between countries and cultures should be encouraged.
- It is important to keep a database, at European level, that provide (to Industry) coherent and regularly updated information on the extremely wide range of curricula available.

IS THIS A PARADIGM SHIFT?

This is a question that has been raised and is being discussed in several fora.

If the current evolution is not a paradigm shift, it is at least a movement that will help in re-thinking the role of engineering education institutions in Society, on a time of Education for All.

I believe that in this way, with the diversity of offer that will emerge, the result will be an education that will be pushed to somewhere nearer to the interests of Society both in the short and in the long term - in the former case an education that will help in solving the problems of Today; in the latter, an education that will lead to pushing the frontiers of engineering beyond its present limits.