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Towards the European Higher Education Area: Curricula and Methods in Chemical Engineering

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Abstract

Winds of changes have been blowing in the European Higher Education Area (EHEA) over the past years, with visible effects. In these notes and in the lecture I shall identify and examine both some of the 'high pressures sources' that are responsible for such 'winds' and the changes that are occurring. I shall also comment and give my views on some of the main tasks ahead for the building of the European Higher Education Area and on some specific implications in methods and curricula in the chemical engineering area.

Keywords: Bologna Process, qualifications framework, quality assurance; paradigms of chemical engineering.

1. European model of development

The building of the EHEA is a key issue in the reforms related with the Bologna Process.

When examining this and other related issues it is important to give note that such has to be done in the wider context of a European model for development, decided at political level during the final years of the last century. And furthermore, it is relevant to start by identifying three main groups of interrelated developments responsible for the changes that are taking place, viz. –

(i) Progress observed in Science and Technology, particularly felt as of major relevance for Society in the last two decades of the last Century; We speak specifically of progress in digital systems and communications technology and in the crucial disciplines of health and life sciences, the latter with all the related implications in the increase of Life Expectancy and on related changes in social systems.

(ii) Political changes that took place in Europe, also on the last decades of the 20th Century; these, together with the availability of powerful communications tools, have paved the way for a full market economy in a global world of opportunities and jobs.
(iii) Expectations and demands of Society, Education for All, in the more developed European countries; the Education for All movement, launched and promoted by UNESCO back in the nineties, as a global commitment to provide quality, has been rightly perceived in the European countries as a right for higher education for all, putting pressure in Governments to offer adequate education programmes to young and 'not-so-young' citizens

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Let us examine in more detail some of the effects:

People will live longer and as such expectedly will work longer years, even if only because otherwise pension schemes are not sustainable.

The new concepts of flexible professional carriers that the open market economy brought to our life, together with the indisputable decrease of 'knowledge half life time', makes Lifelong Learning the only way for keeping competitiveness of individual professional carriers. LLL is an obvious major issue and represents a major shift in learning paradigms.

With the new demands of Society, with the new motivations of the young generation, with the increasing number of potential learners and of course with the availability of new tools and means for education, Higher Education Institutions are under pressure to re-organize and deliver new courses and new degrees, with new methods, to a wider public, with different interests and backgrounds.

Among several problems, one should be raised – are we expecting that all these increasing numbers of learners go all the way to second cycle studies? Or should we do better in offering shorter flexible paths for initial education, leaving always the option for some schools and students to go all the way to second cycles?

It is only fair to say that globally the University community understood well in advance this need for change. The Magna Charta of Universities, signed by Rectors of all over Europe, in Bologna on 18 September 1988, is a statement of the required changes.. that arrived 10 years later..

<u>The Bologna Process</u>

The Bologna Process should be understood within this historical background. European leaders of the eighties understood the requirements for Europe in this future of an open global market and have signed a commitment of guidelines or a model for development, the Lisbon Declaration of March 2000 - a competitive economy based on a knowledge society, a model for growth and jobs.

The Bologna Process should be seen on a dual environment of related, but different, academic and political issues.
The more political objective is to build a wide and attractive area for higher education together with a wide area for research, in order to promote mobility and trans-national co-operation, through which gains are obtained in social cohesion and in competitiveness.

This can only be based on TRUST, which is only achieved with readable national qualification frameworks and degree systems and with transparent quality assurance systems.

2. Issues of the reform

The degree system in engineering

The agreements signed by Ministers in Bergen 2005 have consolidated the concept of a three cycle structure, supported by possible intermediate qualifications, of which, it is my opinion, those within or linked to the first cycle are of utmost relevance for many countries.

In another forum, that of the European engineering associations[1], 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.

In direct relation with the agreements of the Bologna Process and with the views expressed by the professional organisations, The European Commission and the European Parliament have approved in September 2005 the new Directive for Professional Recognition[2] that precisely proposes these two levels of professional qualifications (Art. 11 d) and art. 11 e)).

As far as professional engineering is of concern, we should thus discuss qualifications frameworks, contents and criteria for quality assurance, having in mind both the Bologna agreements and the Directive for Professional Recognition. This means to consider essentially two levels of professional qualifications, generally speaking directly related to first cycle and second cycle qualifications. Here a question is raised by a significant number of schools, concerning the professional qualifications of first cycles in more theoretical oriented profiles, an issue that will be commented in the lecture. The facts are that two profiles and two main qualification levels exist and that in those degrees of a more theoretical nature (also known as integrated studies), it so may happen that first cycles may not be accredited for professional competences.

[1] www.feani.org, active in July 2007
[2] http://register.consilium.eu.int/pdf/en/05/st03/st03627.en05.pdf, active in July 2007

Qualifications framework

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 CHEMEPASS – Chemical Engineering Mobility Tools[3], currently in progress, 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.

Within the Bologna Process, the issue has deserved guidelines for the future in the London Communiqué of Ministers in London (May, 2007), having the Council of Europe been asked to support the sharing of experiences in the elaboration of national qualifications frameworks.

Qualifications frameworks represent a major issue for the successful construction of EHEA.

Quality Assurance

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 Education[4], 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 trans-national co-operation within the area of quality assurance.

[3] http://www.cpe.fr/chemepass/CPELyon-CHEMEPASS.htm, active on July 2007
[4] www.enaee.eu, active on July 2007

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

3. The structure and contents of Chemical Engineering degrees

The more interesting academic issues have to do with changes in the degree structure, in contents and in methods.

The structure and contents of chemical engineering studies have been the subject of publications by several distinguished scientists and professional engineers (Villadsen, 1997; Gillett, 2001; Molzhan and Wittstock, 2002; Molzhan, 2003; Cussler, 2005), just to mention some.

In 2003 a (well known) publication was produced, 'Beyond the Molecular Frontier: Challenges fro Chemistry and Chemical Engineering' authored by a Committee on Challenges for the Chemical Sciences in the 21st Century, sponsored by the US national Research Council. This has put in perspective the opportunities and challenges for scientists and professionals of these disciplines and largely influenced the reviewing of programmes.

In a significant number of European countries we face the challenge of adapting both structures and contents (leave the methods aside for the moment). Several organizations have been investing efforts for finding adequate solutions to these complex problems, particularly on the identification of a reference framework for qualifications and on the identification of core curricula.

The Working Party on Education of the European Federation of Chemical Engineering[5] proposed in 2005 a set of recommendations for a core curriculum, both for first and second cycles.

The E4 Group[6] - Enhancing European Engineering Education - equally proposes sets of competences related to contents in all engineering areas, including Chemical Engineering

The CDIO initiative[7] – 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.

An extension of the second paradigm?

[5] www.efce.info/wpe.html, active on July 2007
[6] www.unifi.it/tne4/, active in July 2007
[7] www.cdio.org, active on July 2007-07-22

Somewhere back in the sixties the second paradigm of chemical engineering emerged and swiftly gained recognition.

With transport phenomena and studies based on elementary mechanisms it has been possible to transport chemical engineering away from the limited number of unit operations that dominated the conceptual approaches and in that way it has been possible to enlarge the frontiers of chemical engineering. Today, we speak of life sciences and of biology as one of the four basic sciences, together with mathematics, physics and chemistry. We speak of environmental issues and of sustainability, of (nano) structures and of material science issues. We have to speak of an economy based on hydrogen and on other alternative energy resources, and we have to speak of optimised, safe, simple to operate systems, for that developing the required systems engineering knowledge.

All this is part of chemical engineering, perceived necessarily on a multidisciplinary context.

Feasible curricula

How feasible, which objectives, which structure of education and of offer of studies?

Much through the reasons commented above the domains of chemical engineering are again being enlarged. Indeed chemical engineering, now in a *latus sensus*, encompasses a wide set of disciplines from the classical process engineering to biotechnology, environment engineering, industrial chemistry, process systems engineering, material sciences and product engineering.

This enlargement of the potential role of chemical engineers, together with new demands and requirements from the society, with the changing time- and space-scale of technical developments, the change in working practices and together with the dominant economic factors affecting company organisation, raises major questions concerning the need for new directions of chemical engineering education (CEE).

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 chemical 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, 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 CEE approach (or combine with) industrial practice?
- Should CEE rather be research oriented?
- Should CEE be oriented towards societal needs such as environmental protection, and sustainability?
- Should CEE include new disciplines such as industrial informatics, information technology, process intensification and miniaturisation technology?
- Should we shift from process design to product development?
- 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
- Students should be brought nearer to the practice of chemical 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 chemical 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.

4. Conclusion

Third paradigm?

Yes, most probably. There are not yet enough documents to make this shift of mindset completely clear or as clear as what we have discussed about Unit Operations and Chemical Engineering Science. Prospectively, for sure that in 2020 such shift will be crystal clear.

Fuzzy as the shape may still be we recognize a number of major lines of reference:

- Our individual and local universe is larger and larger.
- Time and space concepts and dimensions have changed dramatically.

- The reference of whatever (quality, competition, etc.) is now Europe and the World, not our City or our Country.
- Standards must be high, inflexibly high, attitude holistic, mind flexible.
- The Chemical Engineering discipline on its own merits, much due to life during the 2nd paradigm, has enlarged significantly its universe of influence.
- The need is clear for a reference qualifications framework and for international recognition of quality assurance standards and procedures,
- A core group of disciplines, concerning basics and engineering, and of skills and competencies, should be recognized by consensus and implemented.
- A complementary group of elective advanced curricular modules should lead the student to work on frontier topics of chemical engineering.
- External training, more practical 'hands-on' training is required for first-degree level. If possible in another Country.
- There must be an understanding that it is essential that Academia and Industry, in the European Space, co-operate offering each other aided-value, by accepting students for training (the Industry), by jointly designing pilot case studies, by providing theoretical background through courses (the Academia).
- Lifelong learning is the key concept to have the edge.

If this is not a paradigm shift, it is at least an extension of the concepts of the second paradigm that, as fifty years ago, will help in pushing the frontiers of chemical engineering beyond its present limits.

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