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

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To say what I am going to say...

1. European Strategy for Development
   1. The Bologna Process
   2. The Directive for Recognition of Professional Qualifications

2. European Qualifications Frameworks

3. Academic Degree Structures

4. Quality Assurance
   4. Quality Assurance and Qualifications Frameworks - what is equal, what is different

5. Chemical Engineering Degrees in and for the future
European Strategy for Development
Recall what is at stake... (I)

- Last quarter of the 20th Century - Intense search of new routes for Europe and for the World, driven by
  - Progress observed in Science and Technology
    - Namely in digital systems and communications and in health and life sciences
  - Political changes that took place in Europe
    - Paved the way for the market economy
  - Social and economical changes with related expectations and demands of Society
    - Changing concepts of individual careers
    - Education for All

European Strategy for Development
Recall what is at stake... (II)

- Culminated with the European Council of Heads of State and Governments, March 2000, Lisbon
  - The Lisbon Strategy for Growth and Jobs
  - Competitive positioning relatively to the other blocks of the Planet
  - Stating of a strategic objective:

  “By 2010, making Europe the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion”.

A simple example of World Competition
Geographic breakdown of world chemicals sales

World chemicals sales in 2004 is estimated at € 1736 billion.
The EU accounts for 33% of the total.

Source: Cefic
Definition: Rest of Europe™ Switzerland, Norway, and other Central & Eastern Europe (excluding the new EU 10 countries)
Other™ including Canada, Mexico, Africa & Oceania

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European Strategy for Development
Scientific development and the Market

Scientific Computing, March 2007
Drastic reductions in development time
European Strategy for Development

The three dimensions of the Strategy

- A strategy based on Knowledge and Transnational Cooperation, where we can recognize -
  - The Economy Dimension -
    - Including the movement that converged in the creation of the EURO
  - The Social Dimension -
    - In line with the European culture of humanism, reasoning, freedom and democracy
  - The Knowledge Society Dimension -
    - Identified with the Bologna Process and the creation of the European Higher Education Area

European Strategy for Development

What matters for Today’s talk

- The Bologna Process and the creation of the European Higher Education Area (EHEA)
  - The Bergen Communiqué, signed by 45 Ministers of Education on May 19, 2005
- The Directive for Recognition of Professional Qualifications, approved by the European Parliament and by the Council on September 7, 2005
The Bologna Process Revisited
Building the European Area of Knowledge

European Area of Knowledge

- European R&D&I Area
- European Area of Education
- European Higher Education Area
- European Area of life long learning

The Bologna Process Revisited
The Bergen Communiqué (I)

- The Bergen Communiqué signed by Ministers of Education of 45 Countries, on May 20, 2005

- Framework for qualifications comprising three main cycles and a short cycle
- Standards and guidelines for quality assurance in the EHEA
  - A model for peer review of quality assurance agencies on a national basis,
  - European register of quality assurance agencies based on national review.
- Recognition of degree and study periods
  - Recognition of foreign qualifications and prior learning,
The Bologna Process Revisited
From Bologna … to London... and beyond...
Main reform areas and issues in Higher Education

Curricular reform -
✓ Degree System and Teaching / Learning Paradigms
✓ Qualifications Frameworks
✓ Quality Assurance
✓ Recognition of degrees and study periods
✓ Lifelong Learning

Social issues - Employability, social dimension...

Global dimension - Attractiveness

Institutional reforms - Funding and Governance Reform

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The Bologna Process Revisited
Political issues

Where to draw the line for promoting the enlarging of higher education? For mass education?

Promoting TRUST for mobility and cooperation
✓ Keywords - Mobility, Cooperation, TRUST, Accreditation
✓ Key Action - Quality Assurance procedures - which consequences?

Framework for development - put in practice...
✓ A new offer of degrees
✓ LLL policies

New governance and funding systems

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The Directive for Recognition of Professional Qualifications (I)

- Reaffirms previous Directive, accepting 7 professional areas with recognized specifications
  - Medical training
  - Training of veterinary surgeons
  - Basic dental training
  - Training as pharmacists
  - Training of nurses
  - Training of midwives
  - Training of architects
- Engineering (as Law) is out of this group

The Directive for Recognition of Professional Qualifications (II)

- Article 11 - Five levels of qualification particularly relevant for professions that are out of the Annex
  - 2 levels requiring secondary education, general or vocational
  - 1 level, requiring short post-secondary education, not necessarily at higher education level, plus professional training
  - 2 levels of post-secondary education at higher education level, plus adequate professional training
The Directive for Recognition of Professional Qualifications (III)

Art. 11, e)
...completed a post-secondary course of at least four years’ duration...at a university or establishment of higher education...and where appropriate completed professional training...

Art. 11, d)
...training at post-secondary level of at least three and not more than four years’ duration...at a university or establishment of higher education...as well as the professional training that may be required...

Art. 11, c)
...training at post-secondary level other than that referred in d) and e) of a duration of at least one year...as well as the professional training which may be required in addition to that post-secondary course...

The new Qualifications Framework and the Directive
A striking coincidence or concerted action?

The Bergen Declaration and the Directive point out in the same direction

- Recognition of different qualification levels and profiles
- Recognition that qualifications can be attained through routes in two different subsystems

They fit remarkably well in the world of engineering and the offer of engineering education in Europe

They should obviously be translated into our accreditation systems
To say what I am going to say...

1. European Strategy for Development
   ① The Bologna Process
   ② The Directive for Recognition of Professional Qualifications

2. European Qualifications Frameworks
   ① Academic Degree Structures
   ② Quality Assurance
   ③ Quality Assurance and Qualifications Frameworks - what is equal, what is different
   ④ Chemical Engineering Degrees for the future

European Qualifications Frameworks
Two Frameworks ... requiring convergence...

- EQF-EHEA - European Qualifications Framework
  ✓ Adopted in Bergen 2005, within the Bologna Process, with descriptors for the three cycles in higher education

- EQF-LLL - European Qualifications Framework for Lifelong Learning
  ✓ Adopted by the EC, adopting 8 reference levels
  ✓ Levels 6 to 8 correspond to the three Bologna cycles, with some linguistic differences in defining knowledge, skills and competences
European Qualifications Frameworks
General Descriptors - the Dublin Descriptors (2003)

- Dublin Descriptors for the Bologna degree structure
  - Characterizing levels to be attained in
    - knowledge and understanding
    - applying knowledge and understanding
    - making judgements
    - communication
    - Learning skills

- These are high level broad descriptors that will have to lead to more specific descriptors in each area or specialty within a given area

European Qualifications Frameworks
The TUNING Methodology (2000-2004-)

- University project to answer the Bologna Challenges, that aims mainly at
  - Finding ways to implement the two main cycles of Bologna
  - Developing professional profiles and comparable and compatible learning outcomes
  - Facilitating employability by promoting transparency in educational structures (easily readable and comparable degrees)
  - Developing a common language which is understood by all stakeholders (Higher education sector, employers, professional bodies)

- TUNING has lead to specific descriptors for each area of knowledge.
European Qualifications Frameworks

The TU-3 translation of the Dublin Descriptors for technical degrees

- Distinguishes 7 areas of competences that characterise an University Graduate
  - Competence in one or more scientific disciplines
  - Competence in doing research
  - Competence in designing
  - Competence in developing a scientific approach
  - Competence in basic intellectual skills
  - Competence in co-operating and communicating
  - Competence in taking account of the temporal and the social contexts

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European Qualifications Frameworks

The E4 descriptors - application of TUNING to Engineering

- E4 - Thematic Network co-ordinated by U. Florence
  - Proposes first cycle and second cycle descriptors for the various disciplines in Engineering
  - Core profile guidelines for university planning, lifelong learning and accreditation
  - Specifications output oriented
  - Requirements
    - Personal and Academic requirements for Bachelor and Master levels
    - Institutional requirements
European Qualifications Frameworks
The CDIO Syllabus (Chalmers, Linköping, KTH, MIT) (I)

CDIO - Conceive - Design - Implement - Operate

Building Blocks

1 TECHNICAL KNOWLEDGE AND REASONING
   1.1 KNOWLEDGE OF UNDERLYING SCIENCE [a]
   1.2 CORE ENGINEERING FUNDAMENTAL KNOWLEDGE [a]
   1.3 ADVANCED ENGINEERING FUNDAMENTAL KNOWLEDGE [k]

2 PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES
   2.1 ENGINEERING REASONING AND PROBLEM SOLVING [e]
   2.2 EXPERIMENTATION AND KNOWLEDGE DISCOVERY [b]
   2.3 SYSTEM THINKING
   2.4 PERSONAL SKILLS AND ATTITUDES
   2.5 PROFESSIONAL SKILLS AND ATTITUDE

European Qualifications Frameworks
The CDIO Syllabus (II)

Building Blocks (Cont.)

3 INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION
   3.1 MULTI-DISCIPLINARY TEAMWORK [d]
   3.2 COMMUNICATIONS [g]
   3.3 COMMUNICATIONS IN FOREIGN LANGUAGES

4 CONCEIVING, DESIGNING, IMPLEMENTING, AND OPERATING SYSTEMS
   IN THE ENTERPRISE AND SOCIETAL CONTEXT [h]
   4.1 EXTERNAL AND SOCIETAL CONTEXT
   4.2 ENTERPRISE AND BUSINESS CONTEXT
   4.3 CONCEIVING AND ENGINEERING SYSTEMS [c]
   4.4 DESIGNING [c]
   4.5 IMPLEMENTING [c]
   4.6 OPERATING [c]
### European Qualifications Frameworks

#### Application of CDIO to the design of the new Master Degree in Chemical Engineering - University of Porto

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<td>Matriz of CDIO Competences</td>
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#### The difficult bits

- **Still fuzzy the relation Workload -Outcomes**
  - New guidelines for ECTS are about to be proposed

- There are still difficulties in interpreting EQF and in developing and applying related accreditation criteria, especially in the comparative distinction between FCD (Bachelor) and SCD (Master) programmes.
  - The EQF and the Professional Directive 2005/36 are by no means clear in this respect.

- Overcoming these difficulties will be a fundamental test for the validity and applicability of the EQF
European Qualifications Frameworks
Understanding differences between
levels of qualifications

- Programme Outcomes must be evaluated in relation with the level of intervention in the Engineering Activity
  - Social responsibility (namely, signing projects)
  - Capacity to tackle large, complex problems
  - Capacity to adapt to new jobs of high complexity and responsibility
  - Capacity for effective activity in the production line
  - ....
- For the different subsets of Programme Outcomes, and for the First and Second Cycle Degrees, the differences in requirements are mostly related with
  - scope, depth and breath
- For the Master degree, developing the right ATTITUDE to use knowledge or skills in a given situation is a major outcome

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National Qualifications Frameworks
Bringing Bologna into Practice

- National Qualifications Frameworks will have to articulate with European Qualifications Framework

- For some countries, the most difficult bit of the Bologna Reform
  - Defining NQF compatible with EQF
  - Characterizing the programmes through ECTS - Workload plus Outcomes
  - Re-doing of all modules within this new framework
  - Giving evidence that approved Learning Outcomes are achieved

- Or simply, bringing Bologna into practice...

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3. **Academic Degree Structures**
   - Quality Assurance
   - Quality Assurance and Qualifications Frameworks - what is equal, what is different
4. Chemical Engineering Degrees for the future

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**Academic Degree Structures**

Concerning levels of qualification - (II) - Art. 11, d) and e)

- **Two levels of qualifications associated to those levels approved in the Directive**

- **LEVEL 1 - Art. 11, d): (3-4)U + Professional Training >= Y, with**
  - Y=?
  - First Cycle Degrees are the basis for achieving the qualification of Technical (or Associate) Engineers, whatever the European designation

- **LEVEL 2 - Art. 11, e): >= 4U + Professional Training >= X, with**
  - X=?
  - Second Cycle Degrees are the basis for achieving the qualification of Engineers, or equivalent European designation
Academic Degree Structures Concerning Profiles

- Two main engineering profiles

  - More Theoretically oriented
    - Programmes with a stronger emphasis on basic and engineering sciences in the first years
    - Generally linked to Second Cycle degrees

  - More Applications oriented
    - Designed to qualify after First Cycle, independently of pursuit of studies through Second Cycles, be it directly or through bridging programmes

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Academic Degree Structures Offer of Programmes

- Three main offers of Programmes in Engineering Education

  - The offer of First-cycle programmes, aiming at fulfilling the level of requirements for accreditation and professional recognition of LEVEL 1

  - The offer of Second-cycle programmes, aiming at fulfilling the level of requirements for accreditation and professional recognition of LEVEL 2

  - The offer of two-cycle programmes, within a philosophy of integrated studies, aiming mainly at fulfilling the requirements of accreditation and professional recognition at LEVEL 2
Academic Degree Structures
Routes for the different qualification levels (I)

Qualification Level

Level 2
Art. 11 e)

2nd cycle degree in Engineering + Training

Professional Designation

Engineer

1st cycle degree in Engineering + Training

Route T
Route A

? Associate Engineer ?

Academic Degree Structures
Routes for the different qualification levels (II)

Qualification Level

Level 2
Art. 11 e)

2nd cycle degree in Engineering + Training

Professional Designation

Engineer

1st cycle degree in engineering science (not leading to professional recognition)

1st cycle in Engineering + Training

Route T
Route A

? Associate Engineer ?
Academic Degree Structures
Prevaling concepts in the design of the Degree System (I)

- The Bologna Process has brought unprecedented pressure on the Higher Education Institutions for more dialogue with the Society to incorporate its more immediate interests
- More flexible paths - MORE differentiation (competences) offered
  - Either more research oriented, or more innovation oriented, or with a higher entrepreneurial spirit, etc....
  - Bringing in the concept of “Communication Pipes” between different profiles of education - Bridging programs
- More attractive offer in order to bring into the system students with different backgrounds and interests
- Promotion of a true offer for lifelong learning through
  - Complementary modules of (advanced) specialization courses
  - Implementing the concept of ‘accumulated credits’ for recognition of studies

60 ECTS, including Scientific or Professional Thesis - 30 ECTS
60 ECTS
1 Semester Theoretically Oriented
60 ECTS, Including Short Thesis - 12 ECTS
60 ECTS
60 ECTS
Accredited 2nd Cycle in Engineering
Non Accredited 1st Cycle in Engineering Science
Theoretically Oriented Profile
60 ECTS, Including Short Thesis - 12 ECTS
60 ECTS
1 Semester Applications Oriented, Including Design Work
60 ECTS
60 ECTS
Accredited 1st Cycle in Engineering
Applications Oriented Profile

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**Quality Assurance - Recognition of Professional Qualifications**

**Programme Outcomes for Accreditation (I)**

- Quality assurance procedures rely on accepted qualifications frameworks
- Programme outcomes for accreditation should always be related to potential professional recognition of engineering qualifications

As such:

- There should be only one set of programme outcomes for accreditation of Second Cycle Degrees
  - (Whatever the profile and programme)

- There should be only one set of programme outcomes for accreditation of First Cycle Degrees
Quality Assurance
The EUR-ACE Project (I)

- European Project that aimed at establishing an European System for Accreditation of Engineering Education programmes
- to ensure suitability of programme as entry route to the [engineering] profession
- 14 European Institutions, among them the Portuguese Institution of Engineers
  - FEANI, SEFI, CESRER, EUROCADRES, ENQHEE, ASIN, CTI, IEI, CoPI, UNIFI, OE, UAI, RAEE, EC-UK
- EUR-ACE has been supported by the European Commission (DG EaC) within SOCRATES and TEMPUS programmes
- Concluded in 2005

Quality Assurance
The EUR-ACE Project (II)

- Programme Outcomes that must be satisfied
  - 6 categories of learning outcomes are defined
    - Knowledge and Understanding
    - Engineering Analysis
    - Engineering Design
    - Investigations
    - Engineering Practice
    - Transferable (personal) Skills
  - For each category, the EUR-ACE Framework Standards list the expected Programme Outcomes of First Cycle and Second Cycle Studies
Quality Assurance
The EUR-ACE Project and ENAEE (I)

- The EUR-ACE project has lead to the creation in 8 February 2006 of an European Association
- The ENAEE - European Network for Accreditation of Engineering Education
- The ENAEE is responsible for maintaining and awarding the EUR-ACE label
- 6 European Agencies are currently accredited for awarding the EUR-ACE Label
- Institution of Engineers, Portugal is one such Agency and is now preparing its accreditations

Quality Assurance
The EUR-ACE Project and ENAEE (II)

- The EUR-ACE system is now being implemented by six Agencies, that will form its initial “core”:
  - ASIN (DE)
  - EC (UK)
  - IEI-EngineersIreland
  - CTI (FR)
  - OE (PT)
  - RAEE (RU)

- The representatives of these Agencies sit in the EUR-ACE Label Committee
Quality Assurance
The EUR-ACE Project and ENAEE (III)

EUROPEAN ACCREDITED ENGINEERING BACHELOR
-FIRST-CYCLE DEGREE PROGRAMME-

EUROPEAN ACCREDITED ENGINEERING MASTER
-SECOND-CYCLE DEGREE PROGRAMME-

Quality Assurance
The ABET System -
ABET 07-08 Criterion 3 - Outcomes and Assessment

a. An ability to apply knowledge of mathematics, science, and engineering.
b. An ability to design and conduct experiments, as well as to analyse and interpret data.
c. An ability to design a system, component, or process to meet desired needs.
d. An ability to function on multi-disciplinary teams.
e. An ability to identify, formulate, and solve engineering problems.
f. An understanding of professional and ethical responsibility.
g. An ability to communicate effectively.
h. The broad education necessary to understand the impact of engineering solutions in a global and societal context.
i. A recognition of the need for, and an ability to engage in life-long learning.
j. A knowledge of contemporary issues.
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
Quality Assurance and Qualifications Frameworks
What is equal, what is different: CDIO-Dublin-EUR-ACE-ABET

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<th>Dublin - Master</th>
<th>EUR-ACE</th>
<th>ABET</th>
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<td>5. Design and development</td>
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<td>6. Engineering and construction</td>
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<tr>
<td>7. Entrepreneurship</td>
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Quality Assurance
EUR-ACE vs. The Washington Accord

- Fundamental differentiation/barrier between
  - “Professional Engineers” and
  - “Engineering Technologist”

- Define all recognized (accredited) “Engineers” degrees as “Bachelor”.

- These features are not in the spirit of the EQF nor of EU Directive 2005/36

- Indeed some discussion is currently on the air, concerning recognition of standards
To say what I am going to say...

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Why New Directions for Chemical Engineering?
The Second Paradigm...Chemical Engineering Sciences

The 2nd Paradigm transported chemical engineering away from the limited number of unit operations that dominated the conceptual approaches of the fifties

✓ It has been possible to enlarge the frontiers of chemical engineering.

Today, Chemical Engineering, *latus sensus*, addresses a wide set of disciplines and industrial applications

- The classical process engineering industries...
- Environment engineering
- Biotechnology
- Product engineering
  ...........

What about Tomorrow?

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Why New Directions for Chemical Engineering?  
Life Today - What matters for the discussion - I

- Economy and market forces - driving force of Today’s Societies
- The computer and communications era - dramatic changes of the concepts of time and space - globalisation
- Job market and opportunities - wider than ever
- Significant change in the concepts of individual career management
- Sharp increase in standards and competition - Worldwide and within the European Space
- Management and transnational cooperation have acquired a new relevance

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Why New Directions for Chemical Engineering?  
Life Today - What matters for the discussion - II

- Process and product development times came down sharply (3 to 5 fold) - risk management...
- New concerns on environment problems and generally on sustainability
- New paradigms on Unit Operations open for discussion - micro-systems, process intensification...
- Sharp demand for ‘performance products’ - specialties, food, personal care products...
- ......

SFA, ECCE’4, 17 September, 2007
Why New Directions for Chemical Engineering?
The Second Paradigm... and beyond...

- Today and for the future, we speak of
  - Life sciences and of biology as one of the four basic sciences,
  - Environmental issues and sustainability
  - (Nano) structures and material science issues

- We have to speak of
  - An economy based on hydrogen and on other alternative energy resources
  - Systems engineering and knowledge based methods for optimised, safe, simple to operate systems

- All this perceived necessarily in a multidisciplinary context.

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New Directions for Chemical Engineering Education
Questions... with no easy answers... (I)

- 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

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New Directions for Chemical Engineering Education Questions... with no easy answers... (II)

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?

How to induce holistic thinking and concepts of integrated development?

To what extent should CEE approach (or combine with) industrial practice?

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New Directions for Chemical Engineering Education Questions... with no easy answers... (III)

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?
**New Directions for Chemical Engineering Education**

**Contributions**

- Very many contributions addressing scientific, academic and political issues of the required reform or adapting of the degree structures and contents
  - AIChE Workshops on New Frontiers... Education (2003)
  - The proposals of E4 Thematic Network (2003)
  - The recommendations of EFCE-WPE (2005)
  - The CHEMEPASS Project (2007)
  - Individual views from the industry

**New Directions for Chemical Engineering Education**

**The WPE-EFCE Recommendations**

These recommendations cover

- Learning outcomes
  - General chemical engineering skills and knowledge
  - Transferable skills
- Achieving the learning outcomes
  - Core curriculum
  - Teaching and learning
  - Industrial experience
  - Review of the educational process
  - Student assessment

- The core curriculum proposed covers only approx. two thirds of first and of second level degree studies

- It fully fits in the frameworks that are being adopted at European level
New Directions for Chemical Engineering Education
The CHEMEPASS Project for enhancing Attractiveness of Chemical Engineering

✓ Co-ordinated by Sebastien Gagneur, CPE Lyon

Milestones
✓ Identification of relevant general and specific Learning Outcomes for Chemical Engineering Programmes
✓ Identification of knowledge to be tested among Chemical Engineering core subjects
✓ Development of a database with test questions

New Directions for Chemical Engineering Education
Third Paradigm? Is it so?

If there is, it is of a different nature of the second paradigm

Still fuzzy, can we see it?
- Whole integrated approaches
- Student centred learning methods
- Skills and competencies
- Cultural interchanges
- Pro-active attitude for lifelong learning as the key for individual career management

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New Directions for Chemical Engineering Education Guidelines... not a single degree structure... (I)

* Basic sciences, enlarged with life sciences, have to be there, with engineering core and complemented by electives and external training.

* A decision has to me made on appropriate dosage of depth and scale of phenomena analysis
  - Molecular modelling and microscopic scale?
    - Polymer properties, microporous materials, vapour-liquid equilibria...
  - Macroscopic scale
    - Process modelling and process synthesis, full plant models for optimisation, computer-aided process operations
    - Modelling through knowledge integration

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New Directions for Chemical Engineering Education Guidelines... not a single degree structure... (II)

* Sustainability taught and induced through everyday work
* Students brought nearer to the practice of chemical engineering
* Sufficient practical experience, both in the laboratory, pilot plant and industry in the core curriculum
* NEW laboratory concepts in student training
* Topics for promoting holistic thinking through integrated approaches and strengthening of horizontal issues

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New Directions for Chemical Engineering Education Guidelines... not a single degree structure... (III)

- Should include skills and competences valued by Industry
- Job related skills
  - Teamwork, communication, leadership
- Competencies (How tasks are done)
  - Holistic thinking, influencing, self-management, achievement of objectives...
- Technical knowledge (depends on the type of industry)
  - Continuous processing, batch processing, systems engineering, process control, organics, biotech...

New Directions for Chemical Engineering Education Guidelines... not a single degree structure... (VI)

- Lifelong learning is the key for ensuring progress
  - It is the only way to avoid obsolescence
  - Early formal education for sure do not cover all relevant technical topics
  - Complementary offer - formal courses, ‘hands-on’ and ‘on-the-job’ training, distance and interactive courses... obviously the Internet...
- Paradox - some employers, promoting short-term jobs and forced mobility, are reluctant to educate staff - SOMETHING TO FIGHT AGAINST
- In a number of countries there is pro-active legislation with incentives for innovation
SO, New Directions for Chemical Engineering Education?
We should not forget the Sine Wave of Life

The words of A.B. Newman, President AIChE, 1938:
‘Theoretical descriptions should be limited to illustrate the engineering fundamentals, because a manager does not hire a young engineer just because he is able to describe how a product is produced’

The words of Ralph Landau*, Stanford University, 1997:
Landau, R. (1997), “Education: Moving from Chemistry to Chemical Engineering and Beyond,” Chemical Engineering Progress, AIChE, pp. 52-65:
‘I believe chemical engineering’s third paradigm, if there is one, is to return the discipline closer to the practices in industry’