



Educating Chemical Engineers for coming Challenges

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To say what I am going to say...

- ① **Why Changes or Reforms are so urgently required?**
 - ① Life Today
 - ① European Strategy for Development
 - ① The Bologna Process
- ② **Some Key Issues of the Bologna Process**
 - ② European Qualifications Frameworks and the Directive for Professional Recognition
 - ② Structure vs Substance - Academic Degree Structures vs. Learning Methods
- ③ **Chemical Engineering Education in and for the future**
 - ③ Main directions for Chemical Engineering Education
 - ③ Chemical Engineering at FEUP - a good Case Study
- ④ **Concluding Notes**

European Strategy for Development I - Driving forces for changes

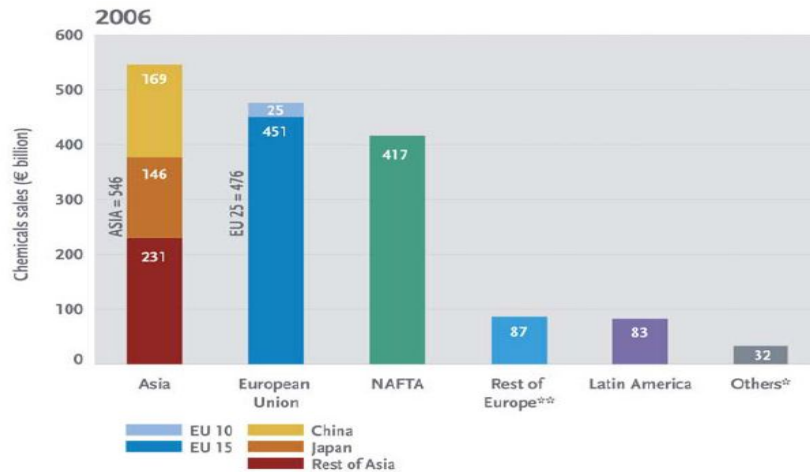
- ☞ **Last quarter of the 20th Century - Intense search of new routes for Europe and for the role of Europe in the World, driven by**
 - ✓ **Progress observed in Science and Technology, namely**
 - **in digital systems and communications**
 - **in health and life sciences**
 - ✓ **Political changes that took place in Europe**
 - ✓ **Expectations and demands of Society**
 - **Education for All**
 - **Quality requirements**

European Strategy for Development II - Life Today

- **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**
- **The increase of Expectation of Life - Social sustainability**
- **Sharp increase in standards and competition - Worldwide and within the European Space**
- **Significant change in the concepts of individual career management**
- **Job market and opportunities - wider than ever**

European Strategy for Development III - Just an Example of World Competition

(A) Geographic breakdown of world chemicals sales, CEFIC F&F2006



World chemicals sales in 2006 are estimated at € 1641 billion
The EU accounts for 29% of the total

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European Strategy for Development IV - A New Model...

☞ 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 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” .

☞ Is being pursued with the Lisbon Treaty, 2007.....

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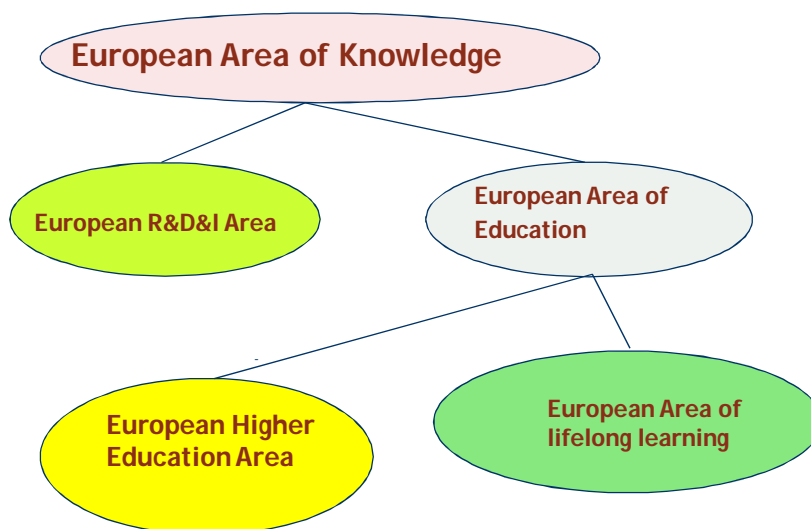
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European Strategy for Development V - The three dimensions of the Strategy

- ☞ **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

The Bologna Process Revisited I - Building the European Area of Knowledge... till 2010 !!!



The Bologna Process revisited

II - What needs to be understood

- ☞ Understand the Bologna Process as one of the dimensions of the prevailing strategy for European development
- ☞ Understand the Bologna Process as having two main groups of objectives, naturally interlinked
 - ✓ Objectives of political, social, and economical nature
 - ✓ Objectives of a dominant academic nature
- ☞ Understand that indeed these objectives mean, in many countries, a major reform (... a small revolution...) in Higher Education and in Society

The Bologna Process Revisited

III - Objectives... From another point of view

(A) Social, economical and political objectives

- ☞ From a social and economical point of view - to guarantee development and competitiveness through -
 - ✓ The increment of transnational cooperation and mobility, both in higher education and in R&D
- ☞ From a more political point of view - to contribute for European cohesion
 - ✓ Again, through mobility and cooperation, at all levels, of both students and professionals
- ☞ Still at political level
 - ✓ To guarantee the Social Dimension
 - ✓ To promote the External Dimension of the European model

The Bologna Process Revisited

III - Objectives... From another point of view

(B) Objectives of a more academic nature

☞ Political / academic

- ✓ **Restructuring the offer of higher education**
 - **more attractive and nearer to the needs and interests of Society**
 - **Serving better the increased demand for higher education**

☞ Academic

- ✓ **An evolution of teaching/learning paradigms - adapted to the concepts and perspectives of the modern society and to the available technical tools, projecting education to more adult phases of life**

From Bologna, 1999 ... to London, 2007... and beyond...

Key issues expressed in the London Communiqué

☞ Mobility - a central issue, far from a success...

☞ Curricular reform -

- ✓ **Degree System and Teaching / Learning Paradigms**
 - **Stabilising the closely related concepts of Learning Outcomes and Credit System**
- ✓ **Qualifications Frameworks - National Qualifications Frameworks**
- ✓ **Quality Assurance - implementing the Register**
- ✓ **Recognition of degrees and study periods**
- ✓ **Lifelong Learning**

☞ Social issues - Employability, social dimension...

☞ Global dimension - Attractiveness

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Relevant Mobility Concepts and Instruments

I - ECTS - European Credit (Accumulation) and Transfer System (I)

- ☞ **ECTS** is a learner-centred system for credit accumulation and transfer based on the transparency of learning outcomes and learning processes.
 - ✓ It aims to facilitate planning, delivery, evaluation, recognition and validation of qualifications and units of learning as well as student mobility.
- ☞ **ECTS credits** are based on the workload students need in order to achieve expected learning outcomes.
- ☞ **Learning outcomes** describe what a learner is expected to know, understand and be able to do after successful completion of a process of learning. They relate to level descriptors in national and European qualifications frameworks.

Relevant Mobility Concepts and Instruments

I - ECTS - European Credit (Accumulation) and Transfer System (II)

- ☞ **Workload** indicates the time students typically need to complete all learning activities (such as lectures, seminars, projects, practical work, self-study and examinations) required to achieve the expected learning outcomes.
- ☞ **60 ECTS credits** are attached to the workload of a full-time year of formal learning (academic year) and the associated learning outcomes.
- ☞ In most cases:
 - ✓ student workload ranges from 1,500 to 1,800 hours for an academic year,
 - ✓ whereby one credit corresponds to 25 to 30 hours of work.

Qualifications Frameworks

The different layers - from general to specific...

- ☞ **High Level Descriptors**
 - ✓ Characterize high level groups of qualifications
- ☞ **Sectoral Descriptors**
 - ✓ Ideally resulting from wide transnational agreements
 - ✓ The TUNING methodology
 - ✓ In Engineering - TU-3 descriptors, CDIO, EUR-ACE, ABET...
- ☞ **Specific Descriptors for sub-sectors (see the case of engineering)**
 - ✓ For each discipline, thus depending on the sector
 - ✓ Including, if applicable, the identification of professional activities for which the candidates are to be prepared
- ☞ **Contents - core curricula - Working Parties on Education...**
 - ✓ Learning Outcomes have to earn the trust of society through the specialists opinion, link to Contents and Workload
 - ✓ Significant work of European Working Parties...

Qualifications Frameworks and the Directive for Recognition of Professional Qualifications

☞ Three major documents at High Level

- ✓ **The EQF-EHEA - European Qualifications Framework for the European Higher Education Area**
 - **Adopted in Bergen 2005, within the Bologna Process**
- ✓ **The EQF-LLL - European Qualifications Framework for Lifelong Learning**
 - **Adopted by the EC - approved on April 23, 2008 by the Parliament and the Council of the European Union**
- ✓ **The Directive for Recognition of Professional Qualifications, approved by the European Parliament and by the Council on September 7, 2005**
 - **National laws should have been passed in all EC Countries till the end of 2007**

Three major documents

I - EQF-EHEA - European Qualifications Framework for the European Higher Education Area

- ☞ **A degree structure with three main cycles and a short cycle within or linked to the First Cycle**
- ☞ **Adopts the Dublin Descriptors (developed by the Joint Quality Initiative informal Group) as the cycle descriptors, 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 for each specialty within a given area**



Three major documents

II - EQF-LLL - The European Qualifications Framework for Lifelong Learning

- ☞ Approved by the Parliament and the Council of the European Union on April 23, 2008
- ☞ Adopts 8 levels of qualifications characterized in terms of
 - Knowledge
 - Skills
 - Competences
- ☞ Adopts common principles for Quality Assurance in Higher Education and Vocational Education and Training in the context of the European Qualifications Frameworks
- ☞ Establishes a link of compatibility with the Framework for Qualifications of the European Higher Education Area

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Three major documents

III - The Directive for Recognition of Professional Qualifications (I)

- ☞ Reaffirms previous Directive, accepting 7 professional areas with recognized specifications

✓ Medical training	Minimum education - 6 anos IT
✓ Training of veterinary surgeons	Minimum education - 5 anos IT
✓ Basic dental training	Minimum education - 5 anos IT
✓ Training as pharmacists	Minimum education - 5 anos IT
✓ Training of nurses	Minimum education - 3 anos IT
✓ Training of midwives	Minimum education - 3 anos IT
✓ Training of architects	Minimum education - 4 anos IT
- ☞ Engineering (as Law) is out of this group
 - ✓ For these - three main levels are recognized as associated to professional qualifications (the All Important Article 11)

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Three major documents

III - The Directive for Recognition of Professional Qualifications (II)

- ☞ **Art. 11, e) - higher level**
 ...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) - intermediate level**
 ...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) - lower level**
 ...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...

Qualifications Frameworks and the Directive

A striking coincidence or concerted action?

Bologna EQF-EHEA CYCLES	European Union EQF-LLL LEVELS	EU-Directive of Professional Recognition Art. 11 - LEVELS
Third Cycles	Level 8	
Second Cycles	Level 7	Art 11° e)
First Cycles	Level 6	Art. 11° d)
Short Cycles Linked to or Within First Cycles	Level 5	Art. 11° c)

Qualifications Frameworks and the Directive A striking coincidence or concerted action?

- ☞ **The EQF-EHEA, the EQF-LLL and the Directive point out in the same direction**
 - ✓ **Recognition of different qualification levels linked to formal education**
- ☞ **They fit remarkably well in the world of engineering and the offer of engineering education in Europe**
- ☞ **They should obviously be translated into our Quality Assurance Systems**

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Academic Degree Structures in Engineering

I - 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 \geq 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): \geq 4U + Professional Training \geq X, with X=?**
 - **Second Cycle Degrees are the basis for achieving the qualification of Engineers, or equivalent European designation**

Academic Degree Structures in Engineering

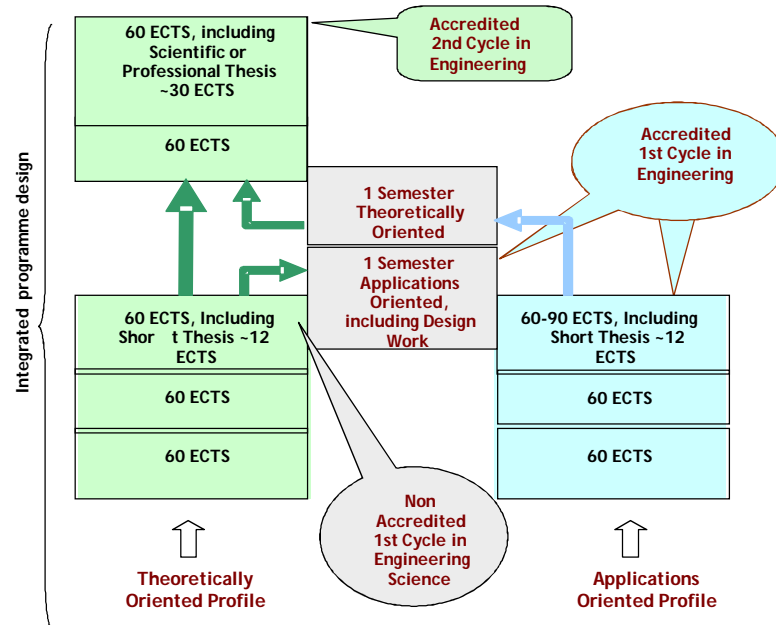
II - Concerning Profiles

- ☞ **Two main profiles in Engineering**
 - **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

New Directions for Engineering Education

I - Prevailing concepts in the design of the Degree System

- ☞ 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



Academic Degrees in Engineering Understanding fundamental 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 in Engineering, the differences in outcomes 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

New Directions for Engineering Education II - Questions... at academic level

- ☞ Which new methods and tools for teaching and how to induce self-learning?
- ☞ Change from
 - ✓ Teacher-Centred to Student-Centred methodologies
 - ✓ Teaching based on Teacher Inputs to Learning Centred in well defined objectives - Learning Outcomes
 - ✓ Teaching Times to Student Workloads required to achieve desired Learning Outcomes
- ☞ Which contents adapted to Today's life?
- ☞ How to induce holistic thinking and concepts of integrated development?

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A little bit of History Paradigm shifts in Chemical Engineering Education

- ☞ **1st Paradigm(s)**
 - In general terms - First quarter of the XX Century - Education close to industrial operations - **Unit Operations**
- ☞ **2nd Paradigm(s)**
 - In general terms - Third quarter of the XX Century - Education shift to **Engineering Science**
- ☞ **3rd Paradigm ?**
 - ✓ We are at present on the process of developing a model and of conceptualizing the evolution for a new paradigm... which is not yet quite identified...

New Directions for Chemical Engineering Education I - Recent 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)
 - ☞ US National Research Council Report (2003)
 - ☞ The proposals of TUNING-E4 Thematic Network (2003)
 - ☞ The recommendations of EFCE-WPE (2005)
 - ☞ The CHEMEPASS Project (2007)
 - ☞ Individual views from the Industry

Contributions to Chemical Engineering Education The WPE-EFCE Recommendations (I)

- ☞ See WPE site on <http://www.efce.info/wpe.html>
- ☞ 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 a first and a second level degree study

Contributions to Chemical Engineering Education The CHEMPASS Project (2006-2009) (I)

- ☞ **Financed by the European Commission within the Erasmus Mundus Programme - Action 4: "Enhancing Attractiveness". Started: November 2006. E.U. grant for 3 years.**
- ☞ **Composed of 13 Higher Education Institutions of 9 European countries and 1 of South Africa:**
CPE Lyon (France) (Coordinator), Institut Quimic de Sarrià (Spain), Universidade do Porto (Portugal), Politecnico di Torino (Italy), INPL-ENSIC Nancy (France), INPT-ENSIACET Toulouse (France), Technische Universiteit Delft (The Netherlands), University College Dublin (Ireland), Technische Universität München (Germany), UCTM Sofia (Bulgaria), Jagiellonian University (Poland), Lappeenranta University of Technology (Finland), Durban University of Technology (South Africa).

Contributions to Chemical Engineering Education The CHEMPASS Project (II)

- ☞ **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 II - Address problems, answer demands

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


New Directions for Chemical Engineering Education III - Incorporate new knowledge, competences and skills


☞ Of course directed to scientific and technical knowledge (depending on the discipline)

BUT

☞ Should include developing of skills and competences valued by Industry and Society in general

- Skills and competences for innovation and entrepreneurship
- Job related skills
 - ✓ Teamwork; Communication, Leadership
- Competencies (How tasks are done)
 - ✓ Holistic thinking, influencing, Self-management, achievement of objectives..


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Educating Chemical Engineers ...

New Directions for Chemical Engineering Education IV - Today and for the future, we have to... (I)

- ☞ **Speak of**
 - ✓ Life sciences and of biology as one of the four basic sciences,
 - ✓ Environmental issues and sustainability
 - ✓ (Nano) structures and material science issues
- ☞ **Speak of ENERGY and OPTIMAL Operation**
 - ✓ An economy based on alternative energy resources
 - ✓ Systems engineering and knowledge based methods for optimised, safe, simple to operate systems
- ☞ **Give an answer to the demand of Society for specificity and quality**
 - ✓ New products - competencies in product design

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Educating Chemical Engineers ...

New Directions for Chemical Engineering Education IV - Today and for the future, we have to... (II)

- ☞ **Prepare our programmes for cooperation - Joint Degrees**
- ☞ **Develop within our institutions an International Dimension (not only European) and Culture of Quality through mobility and academic cooperation and interchange**

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

☞ **Using as reference** accumulated knowledge, competences and skills after a Second Cycle in Chemical Engineering



☞ **See the balanced proposals of the Working Party on Education of the EFCE**

- ✓ **Basic sciences, enlarged with life sciences, have to be there,**
- ✓ **With engineering core**
- ✓ **With engineering design,**
- ✓ **With a dissertation for training R&D&I,**
- ✓ **and complemented by electives and external training.**

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

☞ **A decision has to be 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**

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

- Teach and induce sustainability through everyday work
- Bring students nearer to the practice of chemical engineering
- Give sufficient practical experience, both in the laboratory, pilot plant and industry in the core curriculum
- Promote holistic thinking through integrated case-studies and strengthening of horizontal issues

New Directions for Chemical Engineering Education VI - Two Notes about Innovation (I)

- ☞ Innovation is work and attitude aiming at
 - Bringing in NEW PRODUCTS, NEW TECHNOLOGY, NEW MODELS....
 - ✓ Whatever NEW means....
 - Bringing Research into Practice
- ☞ Innovation and Research - normally distinguish from each other in
 - ✓ The time scale
 - ✓ The objective
 - ✓ The type of partnerships

New Directions for Chemical Engineering Education VI - Two Notes about Innovation (II)

- ☞ In Engineering, to develop knowledge, competences and skills in Innovation we must work in innovative projects and objectives
- ☞ For Innovation as for Applied Research we need
 - ✓ Human Capital
 - ✓ Knowledge and experience
 - ✓ Resources
 - ✓ Strategy
 - ✓ Industrial partnership and clear perception of societal requirements and demands

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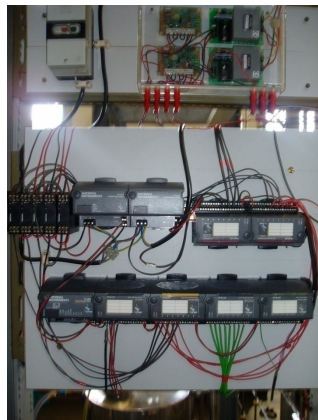
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The Master Degree in Chemical Engineering at the Faculty of Engineering of the University of Porto

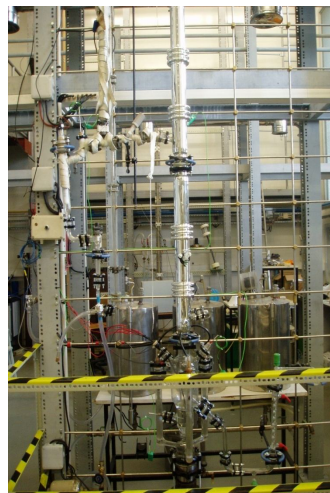
- ☞ We offer a **First Cycle in Chemical Engineering Science and a Second Cycle in Chemical Engineering, with 300 accumulated credits ECTS, in a philosophy of integrated programmes design**
- ☞ With reference to these 300 credits:
 - ✓ **Laboratory work (including Informatics) - ~40 ECTS**
 - ✓ **Engineering Design - 22,5 ECTS**
 - ✓ **Dissertation - 30 ECTS**
- ☞ Out of the 94 dissertations of last year and a half
 - ✓ **58 in industrial environment**
 - ✓ **12 abroad in mobility programmes**
 - ✓ **24 in our research labs**

The Master Degree in Chemical Engineering at the Faculty of Engineering of the University of Porto Pilot Units available for student training (I)

- ☞ **Distillation Unit offered by GALP s.a.**



'Field point' Control Unit





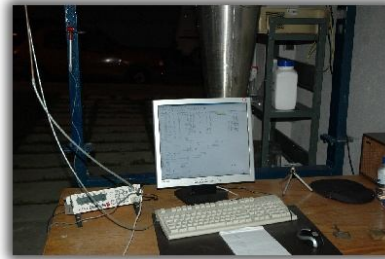
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The Master Degree in Chemical Engineering at the Faculty of Engineering of the University of Porto Pilot Units available for student training (II)

- ☞ Cyclone Unit for industrial dedusting, designed, built and operated by Prof. R. Salcedo and students



Instalações Piloto de Ciclones



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Educating Chemical Engineers ...

Examples of successful innovative work at the CE Department, Faculty of Engineering, U. Porto (I)

- ☞ New paint formulations - Prof. A. Mendes and final year students
- ☞ Cooperation with a major paint producer



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Examples of successful innovative work at the CE Department, Faculty of Engineering, U. Porto (II)

- ☛ New patented method for producing alcohol-free beer - Prof. A. Mendes
- ☛ Cooperation with a major beer producer



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Examples of successful innovative work at the CE Department, Faculty of Engineering, U. Porto (III)

- ☛ New Patented Cyclone Systems for industrial dedusting - Prof. R. Salcedo
- ☛ Cooperation with a major equipment producer



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The Master Degree in Chemical Engineering at the Faculty of Engineering of the University of Porto Examples of dissertations developed together with Industry

- ☞ Radiation Control Coatings - paints for optimised management of energy consumption in buildings - with CIN SA.
- ☞ Production of vesiculated particles and its incorporation in paints - with CIN SA
- ☞ Development of the laboratory instrument ROBpaint for studies of rheology - with FLUIDINOVA-Barbot.
- ☞ Nanoparticle development using the NETmix technology - with FLUIDINOVA SA.
- ☞ Methods and Processes for CO₂ separation by adsorption - with SYSADVANCE



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The need for New Directions for (Chemical) Engineering Education

- ✓ Major progress observed in Science and Technology
- ✓ Major political, economical and social changes in the World, particularly in Europe
- ✓ Increased expectations and demands of European Society
- ✓ 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.
- ✓ Competition is global, Standards must be high, inflexibly high, attitude holistic, mind flexible.

Keywords of the Bologna Process and the creation of the European Higher Education Area

- ☞ **MOBILITY, COOPERATION, TRUST, ACCREDITATION**
- ✓ **MOBILITY AND COOPERATION** require professional recognition
- ✓ Professional recognition requires **TRUST**
- ✓ **TRUST** requires transparency and readability of structures and professional qualifications
- ☞ **All is achieved through:**
- ✓ **COMPARABLE QUALIFICATIONS FRAMEWORKS**
- And**
- ✓ **ACCEPTED QUALITY ASSURANCE PROCEDURES**

Bologna and Routes for Professional Qualification and Transnational Cooperation

- ☞ The Engineering Profession requires different qualification levels and education profiles **that should be guaranteed and identified through transparent Quality Assurance Procedures**
- ☞ The framework being developed and put in practice within the Bologna agreements seem to serve adequately the needs of industry and society in general
 - ✓ Short vocational studies, first cycle studies and second cycle studies (stand-alone or integrated) constitute the basis of such framework
- ☞ The concept of **Credit Accumulation, together with Lifelong Learning**, is of utmost relevance in this new paradigm of building professional qualifications

New Directions for Chemical Engineering Education Prospectively...

- ☞ A core group of topics, concerning basics and engineering, and of skills and competencies, should be part of the programmes
- ☞ A complementary group of elective modules should lead the student to work on frontier topics of chemical engineering and/or should enlarge their cultural background
- ☞ External training, more practical 'hands-on' training is required, mainly for first-degree level
- ☞ Academia and Industry should 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
- ☞ **Lifelong learning is the key concept to have the edge**

Inspiring words from 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'.

☞ Words of Ralph Landau, Stanford University, 1997*:

'I believe chemical engineering's third paradigm, if there is one, is to return the discipline closer to the practices in industry'

* Landau, R. (1997), "Education: Moving from Chemistry to Chemical Engineering and Beyond," Chemical Engineering Progress, AIChE, pp. 52-65

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 - based on transnational cooperation
- Pro-active attitude for lifelong learning as the key for individual career management

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New Directions for Chemical Engineering Education Third Paradigm ? Prospectively...

☞ **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.**