

## Forum on Chemical Engineering Education Notes for discussion

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### Some reference work

- ☞ Recommendations of the WPE-EFCE
- ☞ Engineering Changes at MIT and in the USA in general
- ☞ Curricula for Chemical Engineering Degree Courses at Universities and Fachhochschulen, produced by VDI-GVC, Germany
- ☞ The TUNING project
- ☞ The CDIO Initiative (Conceiving - Designing - Implementing - Operating real-world systems ), Chalmers, MIT and others
- ☞ The E4 Guidelines for Engineering Core Profiles 2010 (Florence University and others)

## Some references

- ✓ Cussler, E., Chemical Product Development, Keynote lecture, 7th World Congress on Chemical Engineering, Glasgow, 10-14 July 2005
- ✓ Gillett, J.E. (2001), *Chemical Engineering Education in the Next Century*, Chem. Eng. Tech. 24(6) 561-570.
- ✓ Molzhan, M., Chemical Engineering Education in Europe - Trends and Challenges, Keynote Lecture, ECCE-4, Granada, 21-25 September, 2003
- ✓ Feyo de Azevedo, S., Which Education of Chemical Engineers in 2020?, Plebary Lecture, CHEMPOR 2002, Aveiro, 12-14 September 2001
  
- ✓ MANY MORE REFERENCES IN THE FUTURE WITH THE NEW PORTUGUESE JOURNAL -

👉 **ENGENHARIA QUÍMICA - Indústria, Ciência e Tecnologia**

## A Touch of History - Paradigms

- ① 1st paradigm -Key Words - Unit Operations
- ② 2nd paradigm Key Words - Chemical Engineering Science
- ② 3rd paradigm - we are trying to model and conceptualise this new paradigm

## A Tribute to the Second Paradigm New Identity(ies) – Chemical Engineering in *Lactus Sensus*

- ☞ Somewhere in the seventies
  - ☞ Concepts and methods of Chemical Engineering applied to a space of disciplines and knowledge wider than those of the old chemical engineering as understood in a *Strictus Sensus*.

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## A Paradigm shift?

- ☞ Changes in Mindset are caused by -
  - Evolution of human knowledge
  - Human effort to increase knowledge
  - Dominant driving forces in Societies in each historical moment or age
    - The pressure to fulfill societal needs and demands
- ☞ Yes, Indeed,
  - the birth and growth of the third paradigm...

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### 3rd Paradigm ?

- ☞ **3rd paradigm - still fuzzy, but we can see it**
  - Whole integrated approaches
  - Skills and competencies
  - Cultural interchanges
- ☞ **Pro-active attitude for life-long learning as the key for individual career management**
- ☞ **European co-operation through Core Quality Criteria within diversity**

### 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

## 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...
- Management has acquired a new relevance
- Free Societies' new demands - *Education for All vs. distributed balance of skills*

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## Some Sensitive Questions / Issues - I

- Which skills and competencies should be promoted?
- What role of cultural interchanges and how to use international co-operation for promoting such interchanges?
- 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?

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## Some Sensitive Questions / Issues - II

- Should we bring in disciplines from life sciences?
- Should CEE include new disciplines or topics 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?

## So What for Chemical Engineering Education?

- ☞ This enlargement of the potential role of CE, together with new demands from the Society, brings the need for

### New Directions for Chemical Engineering Education

- ☞ Key Words are:  
**Whole integrated development; transnational co-operation**
- ☞ Structural decisions have to be taken on
  - ✓ What role and distinction at different levels of education
  - ✓ What structure and core contents of chemical engineering curricula for a first degree?

## Some Directions for CEE

### 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, from 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.'

## Some Directions for CEE

### About contents

- ☞ Have to decide 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

## Some Directions for CEE

- ☞ University first degrees in Engineering, though strong in fundamentals and depositing the seeds for research, will have to be directed to the more basic and practical requirements of industry and of the society
- ☞ Should leave for a second stage the effort for growing and developing new concepts, with formal courses, with compulsory and elective subjects, for a longer research oriented horizon

## Skills, Personal Career and Lifelong Learning - I

- ☞ Companies value nowadays competencies and skills that are not limited to the technical areas. Indeed, Companies more easily provide opportunities for developing those other skills and competencies that are of the short-term benefit of their organisations.



## Some typical skills and competencies valued by Industry (adapted from Gillett, 2000)

- ☞ **Job related skills**
  - ✓ Teamwork, Communication, Leadership
- ☞ **Competencies (How tasks are done)**
  - ✓ Holistic thinking, influencing, Self-management, achievement of objectives..
- ☞ **Technical knowledge (depends on industry)**
  - ✓ Continuous processing, batch processing,, systems engineering, process control, organics, biotech...

## Skills, Personal Career and Lifelong Learning - II

- ☞ Lifelong learning is the key for ensuring progress,
  - ✓ 1<sup>st</sup> degrees for sure do not cover all relevant technical topics,
  - ✓ It is the only way to avoid obsolescence.
- ☞ Formal courses, 'hands-on' and 'on-the-job' training, distance and interactive courses...obviously the Internet...
- ☞ Paradox - 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

## Chemical Engineering Degrees Major subjects to bring in? Yes...

- ☞ In the core curriculum
  - ✓ Life sciences contents
  - ✓ Computer-aided process engineering concepts
    - Students should be made aware of significant developments in process operations
  - ✓ Management
- ☞ In electives or embedded in the teaching (e.g. in project work...)
  - ✓ Product and formulation engineering
  - ✓ New paradigms in Unit Operations and processes...

## Chemical Engineering Degrees Forms and Methods

- ☞ Improving procedures for learning/teaching
- ☞ Structuring courses, motivating self-learning (for Portugal)
  - Cut down on direct weekly contact time
  - Cut down on examination time
  - Define and implement new evaluation procedures

## Sustainability and Holistic Thinking

- ☞ There is now a true and deep global concern, both in the scientific and the industrial society, for the environment and for the problems of overpopulation and industrialisation.
- ☞ This need for developing sustainable technology and for sustainability as an attitude has now become an active premise of work for chemical engineers.
- ☞ Sustainability can also be taught and learned indirectly through increasing knowledge on environmental problems, on biochemistry, on life cycle analysis and as well on economics, just to mention a few subjects.

## Practical Training, Teaching Aids - I

- ☞ It all comes to the same, to bring students nearer to the practice of chemical engineering, to promote integrated approaches, to exchange cultures.
- ☞ The availability of teaching aids, namely interactive and distance learning computer-based aids is now impressive.
- ☞ The Internet lead to this extraordinary number of aids available, several free of charge, for basically all topics and disciplines.
- ☞ Also, at laboratory level, small pilot-rigs with high level of educational features, are Today available tha make it possible to increase engineering practice.

## Practical Training, Teaching Aids - II

- ☞ **Appropriate choice of case studies and of practical pilot plant work for integration of knowledge**
  - ✓ The operation of process units (in steady-state) can be optimised through methods of process systems engineering (strategy of process operation)
  - ✓ Strength horizontal subjects
    - batch or fed-batch process operation, allow discussing again inter-relations, now together with process control and safety procedures.
  - ✓ Pilot cases related to the practice -
    - Co-operation programmes with industry would allow the construction and operation of suitable pilot units related to real industrial problems

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## WPE-EFCE

### Serving Education in Chemical Engineering

- ☞ **Promote discussion on Education Issues**
- ☞ **Propose recommendations on Core**
- ☞ **European Site**
  - ✓ <http://www.efce.info/wpe.html>
- ☞ **Portuguese Site**
  - ✓ <http://www.fe.up.pt/eqedu>
  - ✓ <http://www.deb.uminho.pt/eqedu>

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## The Belgian case-study

☞ An excellent example of evolution without breaking with the past

**University of Liege:**

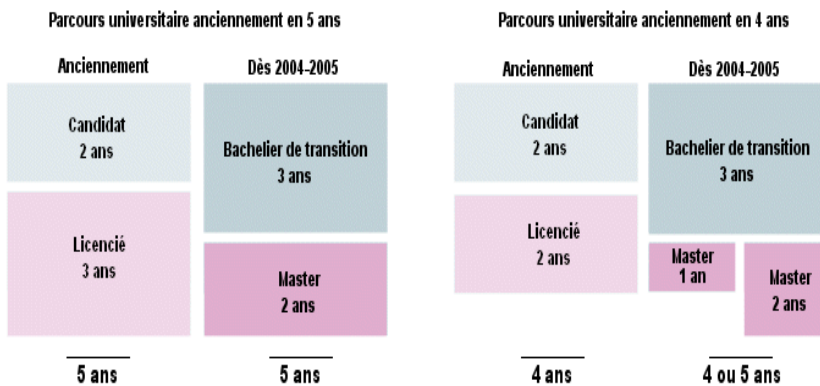
<http://www.ulg.ac.be/bologne/>

<http://www.ulg.ac.be/bologne/structure.html>

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## An European Example - Belgium, U. Liège (I)

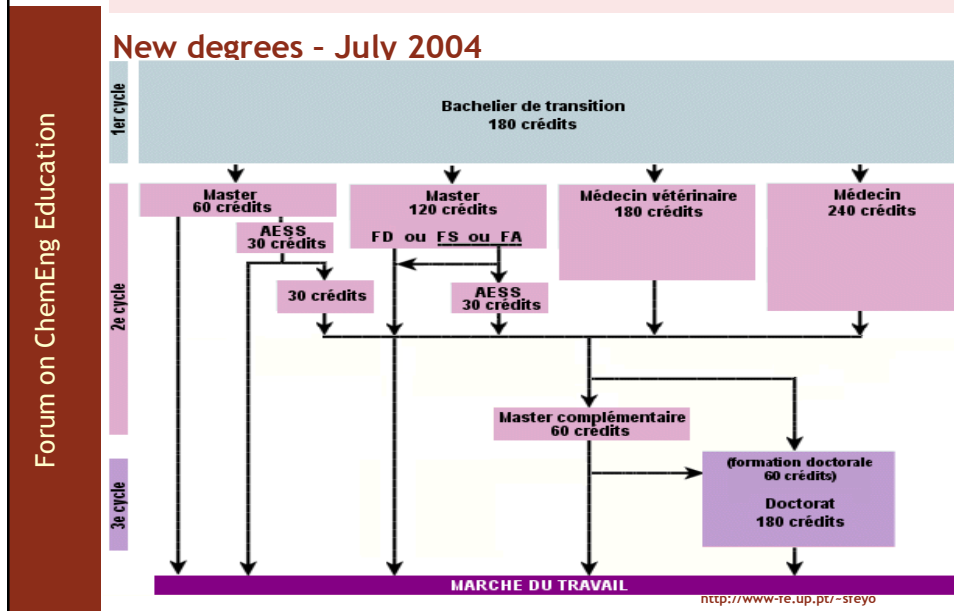


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## An European Example - Belgium, U. Liège (II)

### New degrees - July 2004



## A model for Portugal

