Engineering Education within the Building of the European Higher Education Area

Sebastião Feyo de Azevedo, sfeyo@reit.up.pt
Professor of Chemical Engineering,
Rector, University of Porto

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OUTLINE

Concepts and models of Today, concerning Engineering Education

1. Life Today – Changes in Society – The Young Generation, the ‘Millenials’

2. TRUST, cooperation and mobility in the EHEA - European Higher Education Area
   3. The concept of a three-layer Qualifications Frameworks for engineering education

3. Directions for Engineering Education
   4. ‘Education/Learning without boundaries and without walls’ - tools in the information age, in the era of communications
LIFE TODAY - GLOBALISATION
A MIX OF CHALLENGES, THREATS AND OPPORTUNITIES (I)

- Major political changes in the World, the Fall of the Berlin Wall, on 9 November 1989
- Disruptive Advances in Science and Technology, by the end of the XX Century
  - The Computer and Communications era - dramatic changes of the concepts of time and space
  - Advances in Life Sciences - The increase of Expectation of Life
- Expectation of Life vs. Social sustainability – work longer years
- The decrease of knowledge half-time – Study longer years
- For all these reasons – Lifelong Learning, a requirement for development

SFA, WEEF, Florence, 24 September 2015

LIFE TODAY - GLOBALISATION
A MIX OF CHALLENGES, THREATS AND OPPORTUNITIES (II)

- The global market economy - driving today’s Societies
  - Sharp increase in standards and competition Worldwide
  - Volatility of jobs
  - Job market and opportunities, wider than ever
- Very significant changes in the concept of individual career management, mainly for Young People
- Very significant changes in the concepts of education
- An evolution that we have to understand and support, mainly by adapting the STRUCTURE AND THE SUBSTANCE OF THE OFFER OF EDUCATION

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**Life Today - Production Moves East**

**Geographic Breakdown of World Chemicals Sales - 2004**

<table>
<thead>
<tr>
<th>Region</th>
<th>2004 Sales (€ billion)</th>
<th>European Union (25)</th>
<th>Asia</th>
<th>United States</th>
<th>Other**</th>
<th>Rest of Europe*</th>
<th>Latin America</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 10</td>
<td>21</td>
<td>21</td>
<td>143</td>
<td>417</td>
<td>68</td>
<td>63</td>
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<tr>
<td>EU 15</td>
<td></td>
<td>EU 15</td>
<td>181</td>
<td>209</td>
<td>83</td>
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</tr>
</tbody>
</table>

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

**Life Today - Production Moves East**

**Geographic Breakdown of World Chemicals Sales - 2007**

<table>
<thead>
<tr>
<th>Region</th>
<th>2007 Sales (€ Billion)</th>
<th>Asia</th>
<th>EU27</th>
<th>NAFTA</th>
<th>Latin America</th>
<th>Rest of Europe**</th>
<th>Other***</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU12</td>
<td></td>
<td>116</td>
<td>506</td>
<td>405</td>
<td>90</td>
<td>63</td>
<td>15</td>
</tr>
<tr>
<td>EU15</td>
<td></td>
<td>279</td>
<td>506</td>
<td>405</td>
<td>90</td>
<td>63</td>
<td>15</td>
</tr>
</tbody>
</table>

World chemicals sales in 2007 are valued at €1820 billion. The EU accounts for 29.5% of the total.

Source: Cefic Chemdata International
Other*** = Oceania and Africa
Rest of Europe** = Switzerland, Norway and other Central & Eastern Europe (excluding the new EU 12 countries)
LIFE TODAY - PRODUCTION MOVES EAST
GEOGRAPHIC BREAKDOWN OF WORLD CHEMICALS SALES - 2011

Source - Mary Meeker (KPCB), Internet Trends 2015
(Code conference: http://goo.gl/gjWrTG)
Today, as in the past, the issue is to train and widen the scope of thinking of young people.

BUT, just some major differences from the past and a major difference for the future are that ‘millenials’:

- will live longer
- will work longer
- will have to study longer
- more and more will have to work away from the original home
- indeed will have to think global, just to the dimension of Earth (... or even beyond...)

A global World living in and with a new paradigm of coexistence

- COOPETITION = COOPERATION + COMPETITION

THE NEED to understand other cultures and backgrounds

THE NEED to think global, namely in large global companies, – 24/7 – when Asia goes to sleep we start our work, when we go to sleep America start their work

THE NEED to promote mobility and cooperation, by promoting TRUST

- Develop comparable qualifications frameworks
- Apply quality assurance procedures that are recognised and accepted by all stakeholders
LIFE TODAY
ESSENTIAL INSTRUMENTS AND POLICIES FOR THE FUTURE

SO, WE NEED
- New management and transnational cooperation policies
- A new cultural paradigm of Education - Lifelong Learning
- To promote Mobility of students and professionals

Which in turn requires
- Policies and Instruments for recognition of academic and professional qualifications
- POLITICAL VISION AND WILL

AND, HOW DID EUROPE REACT TO THIS CHALLENGE?
THE EUROPEAN AREA OF... KNOWLEDGE...
LAUNCHED ON 11-12 MARCH 2010, IN BUDAPEST-VIENNA –
STILL UNDER CONSTRUCTION... TILL 2020...

European Area of Knowledge
European Area of R&D&I
European Area of Education
European Higher Education Area
European Area of Lifelong Learning

2014, ... ?
Horizon 2020
In 2010
In 2020...?
FROM BOLOGNA (1999) TO YEREVAN (2015)... AND BEYOND
CHARACTERIZING THE PROCESS TODAY

❖ Policy areas
➢ Including great concern with the challenge of ‘Education without Boundaries’.. . Which is already massively with us!!!

❖ The Structure - organization issues

❖ The Substance – academic issues

FROM BOLOGNA TO YEREVAN ... AND BEYOND
THE STRUCTURE - ACTION LINES AND INSTRUMENTS FOR ACTION

✓ Degree Structure –
  • Based on recognised QUALIFICATIONS FRAMEWORKS

✓ A System to measure work and OUTCOMES
  • The ECTS credit and accumulation system, reviewed in 2015

✓ A way of documenting qualifications
  • The DIPLOMA SUPPLEMENT

✓ A System to guarantee transparency, reviewed in 2015
  • Building accepted QUALITY ASSURANCE procedures

✓ A System for recognition of qualifications
  • OVERCOMING DIFFICULTIES posed by the diversity of ‘recognition cultures’
FROM BOLOGNA TO YEREVAN... AND BEYOND
THE SUBSTANCE - THE LATECOMER IN THE BOLOGNA PROCESS...

- Changes in slow progress...
  - New contents... closer to more immediate Societal concerns
  - New programme structures, linked to a concept of lifelong Learning
  - New Methods – change from
    - Teacher-Centred to Student-Centred methodologies
    - Teaching based on Teacher Inputs to Learning Centred in well defined objectives – Learning Outcomes
    - Digital repository support systems to Digital Collaborative and Cooperative Systems

- New tools for distance and cooperative learning
- The third wave – Pedagogical qualification of ‘Faculty’

QUALIFICATIONS FRAMEWORKS - A THREE LAYER VISION
I – META FRAMEWORKS: QF-EHEA AND EQF-LL

- High level descriptors – Meta Frameworks
  - Characterized at institutional level of governments and stakeholders
  - They represent the ‘legal crust’ and the basis for National Qualifications Frameworks

1. The QF-EHEA – Framework for Qualifications of the European Higher Education Area
   - Launched in 2005, within the Bologna Process, with 3 main cycles

2. The EQF-LL – European Qualifications Framework for Lifelong Learning
   - A vertical framework, with 8 levels, from basic secondary to higher education, approved at EU level on April 23, 2008
   - Establishes a link of compatibility with the Framework for Qualifications of the European Higher Education Area
Relevance of Sectoral and/or Curriculum Frameworks - taken from the Leuven/Louvain-la-Neuve Communique of Ministers, on 29 April 2009

“...
Curricular reform will thus be an ongoing process leading to high quality, flexible and more individually tailored education paths.

Academics, in close cooperation with student and employer representatives, will continue to develop learning outcomes and international reference points for a growing number of subject areas ...
”

- Sectoral Frameworks develop sectoral descriptors
  - By area and specialty
  - In close cooperation with higher education institutions and professional associations
  - In transnational cooperation
  - They represent Bologna in practice

1. A few Sectoral Frameworks proposals for Engineering Education

2. The EUR-ACE Framework and Accreditation System
  - The European System for Qualification of Engineering Education programs
EUR-ACE DEVELOPMENT AND IMPLEMENTATION

EUR-ACE, a consortium of 14 European partners, Academic and Professional Associations and Academic Institutions, started with the support of 2 EU SOCRATES and TEMPUS projects.

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 – [www.enaee.eu](http://www.enaee.eu)
  - Today with 17 full members and 5 associate members

The ENAEE is responsible for maintaining and awarding the EUR-ACE label.

QUALIFICATIONS FRAMEWORKS - A THREE LAYER VISION

III – DESCRIPTORS AT BRANCH LEVEL

- Sectoral Frameworks should be complemented by descriptors at branch level
  - Typically developed in Education Working parties and Academic Consortia, at European Level, or within regulatory bodies at national level
  - They are the basis for credibility of the whole system

- This concept is largely employed informally, but has not yet received formal recognition
  - CORE branch level descriptors are most relevant, BUT:
    - We still have to overcome concerns about the possibility of falling into a too prescriptive path that might damage ‘autonomy, diversity and innovation’....

The VDI-GVC Recommendation for Chemical and Processing Engineering (2008)

The CHEMEEPASS Project (2006-2009) – that aimed at identifying relevant general and specific Learning Outcomes for Chemical Engineering Programmes

These recommendations cover

- Learning outcomes
  - Adopting the EUR-ACE Framework Standards for Accreditation of Engineering Education
- Achieving the learning outcomes
  - Core curriculum, leaving large room for diversity
  - Teaching and learning
  - Industrial experience
  - Review of the educational process
  - Student assessment
NEW DIRECTIONS FOR ENGINEERING EDUCATION
GENERAL GUIDELINES ON HOW TO PROCEED (I)

❖ Revisit and modernize the programme
  ➢ Bring in new topics – raise the awareness of new topics
  ➢ Incorporate new Knowledge, Skills and Competences

❖ Bring in new methods for learning – adapted to the available tools and to the cultural evolution of society

❖ Develop within the institution an International Dimension (not only European) and Culture of Quality through mobility and academic cooperation and interchange
  ➢ Prepare programmes for cooperation – Joint Degrees

❖ Prepare programmes to attract new publics – Lifelong Learning

NEW DIRECTIONS FOR ENGINEERING EDUCATION
GENERAL GUIDELINES ON HOW TO PROCEED (II)

❖ Make recognition of qualifications easy
  ➢ Re-design curricula with reference to agreed recommendations or descriptors of learning outcomes at high level, sectoral level and branch level
  ➢ Perform internal quality assurance exercises, following agreed guidelines
  ➢ Submit the programme to recognized external quality assurance agencies
NEW DIRECTIONS FOR ENGINEERING EDUCATION
INCORPORATE NEW KNOWLEDGE, COMPETENCES AND SKILLS

Programmes are of course directed to raise scientific and technical knowledge – fundamentals should represent the core

BUT

Must bring in the development of attitude, skills and competences valued by Industry and Society in general

- Skills and competencies for innovation and entrepreneurship
- Job related skills
  - Teamwork, Communication, Leadership
- Competencies (How tasks are done)
  - Holistic thinking, self-management, achievement of objectives..

TOOLS IN THE INFORMATION AGE, IN THE ERA OF COMMUNICATIONS

The ‘good old days of Moodle’?

- Moodle is indeed and essentially a digital repository system with some capacity for interchange

Google Apps (or equivalent tools...) for education?

- Google Apps are indeed tools for collaborative study and learning
- A growing number of universities are going ‘Google Apps’

MOOCs – Massive Open Online Courses – Coursera, EdX...

- Tools and means for learning through cooperative learning
- They challenge the educational model... the concept /paradigm of ‘constant time - variable learning’
- Indeed platforms for education without boundaries – a political issue
9. Consider a sequence protocol of authentication, where $R_1$ and $R_2$ are identifiers "once-in-a-lifetime" (nonce). Which of the following affirmations is incorrect?

a. The protocol is vulnerable to attacks by replay.

b. The protocol is vulnerable to attacks by repetition of message signatures.

c. The protocol is based on one-way hash functions.

10. In the properties of ACID, which of the following definitions is not valid (AT12 · 01)?

a. Atomic: if a transaction does not complete execution, all the operations, some of which are executed without any condition.

b. Consistent: transactions should not affect the integrity of the database.

c. Isolated: if the two or more transactions occur at the same time, the result is final if the same values are executed sequentially.

d. Durable: the effects of a transaction are permanent (even if committed) and are permanent.
Millennials’ Most Valued Work Benefits =
1) Training & Development 2) Flexible Hours 3) Cash Bonuses

Which Three Benefits Would You Most Value From an Employer?
% Ranking Each 1st Place, Global

- Training and Development: 22%
- Flexible Working Hours: 19%
- Cash Bonuses: 14%
- Free Private Healthcare: 8%
- Pension Scheme or Other Retirement Funding: 6%
- Greater Vacation Allowance: 6%
- Financial Assistance with Housing: 5%
- Company Car: 4%
- Assistance in Clearing Debts Incurred While Studying: 3%
- Maternity / Paternity Benefits: 3%
- Subsidized Travel Costs: 2%
- Free Child Care: 2%
- Access to Low Interest Loans / Borrowing Options: 2%
- Time Off to Do Community / Charity Work: 1%
- I’d Prefer No Benefits and Higher Wages: 4%

BACK TO MILLENNIALS!!!

Source: Mary Meeker, Internet Trends 2015
(Code conference: http://goo.gl/gjWrTG)

Training & Development
People>> Companies>> Technologies

CORPORATE
MOOCS

Mobile, on-demand
Scalable and collaborative
Flexible, easy to use
Cost effective
Rich, multimedia experience
Skill-based, practical and engaging

Promote employee engagement
Enable anyone, anywhere to create content
Allow training to be tailored to organizations
Enhance relevance of tailored learning content

Source:
Dennis Yang & Dan Chou, Revolutionizing Corporate Workplace Training with MOOCs, 2014
(http://goo.gl/1mql9a)
**TAKE HOME...**

WHERE DO WE HEAD TO IN ENGINEERING EDUCATION?

- **1st Paradigm(s)** - First quarter of the XX Century - Education close to industrial operations

- **2nd Paradigm(s)** - Third quarter of the XX Century – Education shift to Engineering Science - a priori design

- **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...
  - The challenge is to understand and anticipate the evolution of the World and the motivations of the young generations

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**YET, it seems that Engineering Education is moving in the direction of returning closer to the practices of Industry .... proving that Life to a large extent evolves as a sine wave.....**