iTeach Workshop

PROPOSED PEDAGOGICAL APPROACHES TESTED DURING PILOT STAGE

- PRACTICAL INSTRUCTION VIA LABS
- WORK-BASED LEARNING
- TRADITIONAL LECTURES
- SELF-INSTRUCTION DELIVERY
- PROBLEM BASED LEARNING
- RECORDED LECTURES

Lifelong Learning Programme
Programme

8:30  Project outline (Prof Glassey, Newcastle Uni)

8:40  Chemical engineering education today – Are we teaching the right things? (Prof Glassey, Newcastle Uni)

9:15  Open forum discussion

9:45  Can we measure effectiveness of teaching? (Prof Schaer, Uni Lorraine)

10:15 Open forum discussion

10:30 Coffee

11:00 Application of framework to reaction engineering courses (Prof Madeira, FEUP)

11:30 Open forum discussion
iTeach Project outline

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Consortium partners

+ 16 Higher Education Institutions, Professional Institutions and Employers

Jarka Glassey (project coordinator)

Eric Schaer

Luis Miguel Madeira

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<table>
<thead>
<tr>
<th>#</th>
<th>Name of organisation</th>
<th>Type of institution</th>
<th>Country</th>
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<tr>
<td>1</td>
<td>Czech Society of Chemical Engineering</td>
<td>Professional membership association</td>
<td>Czech Republic</td>
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<td>2</td>
<td>Institution of Chemical Engineers (IChemE)</td>
<td>Global Professional membership organisation</td>
<td>United Kingdom</td>
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<td>3</td>
<td>Portuguese Engineers's Association</td>
<td>Professional membership association</td>
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<td>4</td>
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<td>5</td>
<td>Société Française de Génie des Procédés</td>
<td>Professional membership association</td>
<td>France</td>
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<td>6</td>
<td>DECHEMA; ProcessNet</td>
<td>Professional membership association</td>
<td>Deutschland</td>
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<td>7</td>
<td>Industrial Advisory Board, CEAM/Chemistry</td>
<td>Independent Industrial advisory board</td>
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<td>8</td>
<td>ThyssenKrupp Uhde, GmbH</td>
<td>Private – chemical engineering company</td>
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<td>9</td>
<td>Portuguese Society for Engineering Education</td>
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<td>University of Belgrade</td>
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<td>15</td>
<td>University of Chemical Technology and Metallurgy</td>
<td>Higher Education Institution</td>
<td>Bulgaria</td>
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<td>16</td>
<td>University of Istanbul, Faculty of Engineering</td>
<td>Higher Education Institution</td>
<td>Turkey</td>
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Project motivation

• How do we ensure continuing relevance of CE degrees with changing industrial landscape and societal challenges?

• How do we ensure ‘quality experience’ for the increasing student numbers?

• Lab provision, tutorials, placement provision

• Not just doing the ‘same old’ numerous times

• We must start doing ‘smarter’ things

• Students are changing (expectations, education experience, technology ‘savviness’)

•
Project Aim

Develop a framework to **assess the teaching effectiveness** in delivering core chemical engineering knowledge and employability competencies.

www.iteach-chemeng.eu


- **WP1** - Management
- **WP2** – Data Gathering & Analysis
- **WP3** – Assessment Framework
- **WP4** – Pilot Implementation
- **WP5** – Quality Assurance
- **WP6** – Dissemination
- **WP7** - Exploitation
Objectives

1. Review the learning outcomes of a chemical engineering education formation in consultation with industrial and academic partners (WP2);

2. Promote closer involvement of employer organizations in chemical engineering curriculum formation - focus groups, questionnaires to identify the skill gaps and requirements (WP2);

3. Establish state-of-the art in assessing the effectiveness of teaching (core) Chem. Eng. knowledge and on the development of professional skills and competencies required to increase the employability of the graduates (WP2);
Objectives

4. Define various indicators of the effectiveness of teaching in chemical engineering higher education (WP3);

5. Investigate in more depth methods of effectively acquiring employability competencies, using psychometric approaches amongst others (WP3);

6. Use decision making technology and multi-objective optimisation to identify the most appropriate evaluation methods and develop a robust framework (WP3);

7. Test the framework at partner institutions focusing on various pedagogic methodologies in each geographical area to enable the investigation of dependencies between educational systems and the effectiveness of pedagogic methodologies (WP4);
Chemical engineering education today — Are we teaching the right things?

Work Package 2
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WP2 Process overview – Establishing baseline in effectiveness

• Review of various (inter)national CE accreditation requirements
• List of learning outcomes (LO) collated
• Survey sent to academics, industrialists and graduates on the importance of knowledge, skill and competency areas (> 260 valid responses)
• Statistical analysis of the quantitative data responses to identify any trends and their significance
• Analysis of qualitative responses through Nvivo theme identification and correlation to the trends in the quantitative data
• National focus groups with all stakeholders to explore emerging themes
Review of accreditation requirements

STAGE 1 COMPETENCY STANDARD FOR PROFESSIONAL ENGINEER

ROLE DESCRIPTION - THE MATURE, PROFESSIONAL ENGINEER

The following characterises the senior practice role that the mature Professional Engineer may be expected to fulfill and has been extracted from the role portrayed in the Engineers Australia - Chartered Status Handbook. This is the expectation of the development of the engineer who on graduation satisfied the Stage 1 Competency Standard for Professional Engineer.

Professional Engineers are required to take responsibility for engineering projects and programs in the most far-reaching sense. This includes the reliable functioning of all materials, components, sub-systems and technologies used; their integration to form a complete, sustainable and self-consistent system; and all interactions between the technical system and the context within which it functions. The latter includes understanding the requirements of clients, wide ranging stakeholders and of society as a whole; working to optimise social, environmental and economic outcomes over the full lifetime of the engineering product or program; interacting effectively with other disciplines, professions and people; and ensuring that the engineering contribution is properly integrated into the totality of the undertaking. Professional Engineers are responsible for interpreting technological possibilities to society, business and government; and for ensuring as far as possible that policy decisions are properly informed by such possibilities and consequences, and that costs, risks and limitations are properly understood as the desirable outcomes.

Professional Engineers are responsible for bringing knowledge to bear from multiple sources to develop solutions to complex problems and issues, for ensuring that technical and non-technical considerations are properly integrated, and for managing risk as well as sustainability issues. While the outcomes of engineering have physical forms, the work of Professional Engineers is predominantly intellectual in nature. In a technical sense, Professional Engineers are primarily concerned with the advancement of technologies and with the development of new technologies and their applications through innovation, creativity and change. Professional Engineers may conduct research concerned with advancing the science of engineering and with developing new principles and technologies within a broad engineering discipline. Alternatively, they may contribute to continual improvement in the practice of engineering, and in devising and updating the codes and standards that govern it.

Professional Engineers have a particular responsibility for ensuring that all aspects of a project are soundly based in theory and fundamental principle, and for understanding clearly how new developments relate to established practice and experience and to other disciplines with which they may interact. One hallmark of a professional is the capacity to break new ground in an informed, responsible and sustainable fashion.

Professional Engineers may lead or manage teams appropriate to these activities, and may establish their own companies or move into senior management roles in engineering and related enterprises.
Example learning outcomes

2 Core Chemical Engineering

2.1 Fundamentals

- Understand the principles of mass and energy balances.
- Understand the thermodynamic and transport properties of fluids, solids and multiphase systems.
- Understand the principles of momentum, heat and mass transfer, and be able to apply them to problems involving flowing fluids and multiple phases.
- Be able to apply thermodynamic analysis to processes with heat and work transfer.
- Understand the principles of equilibrium and chemical thermodynamics, and be able to apply them to phase behaviour, and to systems with chemical reaction.
- Understand the principles of chemical reaction engineering

2.2 Mathematical Modelling and Quantitative Methods

2.3 Process and Product Technology
Questionnaires

• Survey sent electronically to academics, industrialists and graduates on the importance of knowledge, skill and competency areas

• > 260 valid responses in total, sufficient in each stakeholder category

• Group comparison was carried out after classifying the responses geographically using United Nations Geoscheme for Europe, created by the UN Statistics Division

  [link](http://millenniumindicators.un.org/unsd/methods/m49/m49region.htm)

• One way ANOVA and Fisher pairwise comparisons carried out and trends analysed
Some highlights – academics, importance of LO

![Pie Chart of CountryGroup](chart.png)

- **West**: 24, 28.2%
- **South**: 18, 21.2%
- **East**: 14, 16.5%
- **ROW**: 6, 7.1%

*Legend:*
- Red: 2.0
- Blue: 3.0
- Yellow: 4.0
- Green: 5.0
Underpinning sciences
Underpinning sciences

Chart of Country Group, Biology

- **Country Group**: N, W, E, S, ROW
- **Biology**:
  - Orange: 5.0
  - Green: 4.0
  - Yellow: 3.0
  - Red: 2.0
  - Blue: 1.0

Percentages are distributed across the groups as follows:
- N: Orange (5.0), Green (4.0), Yellow (3.0), Red (2.0), Blue (1.0)
- W: Orange (5.0), Green (4.0), Yellow (3.0), Red (2.0), Blue (1.0)
- E: Orange (5.0), Green (4.0), Yellow (3.0), Red (2.0), Blue (1.0)
- S: Orange (5.0), Green (4.0), Yellow (3.0), Red (2.0), Blue (1.0)
- ROW: Orange (5.0), Green (4.0), Yellow (3.0), Red (2.0), Blue (1.0)
Underpinning sciences

**Interval Plot of Biology vs CountryGroup**

95% CI for the Mean

![Graph showing the relationship between Biology and CountryGroup](chart.png)
Core CE - fundamentals

Chart of Country Group, Fundamentals

Percent

Fundamentals
- 5.0
- 4.0
- 3.0
- 2.0

Country Group
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

N    W    E    S    ROW
Core CE - fundamentals

Interval Plot of Fundamentals vs CountryGroup
95% CI for the Mean

CountryGroup
N   W   E   S   ROW

Fundamentals
Core CE - safety

Chart of Country Group, Safety

Percent

Country Group

N  W  E  S  ROW
Core CE - safety

Interval Plot of Safety vs CountryGroup
95% CI for the Mean

N     W     E     S     ROW
Importance of skills – problem solving

Chart of CountryGroup, ProblemSolvingSkills

- ProblemSolvingSkills
  - 5.0
  - 4.0

CountryGroup | N | W | E | S | ROW
---|---|---|---|---|---
1.0 |  |  |  |  | 0.0
2.0 |  |  |  | 20 | 0.0
3.0 |  |  |  | 40 | 20
4.0 |  |  |  | 60 | 40
5.0 |  |  |  | 80 | 60

Percent | 0 | 20 | 40 | 60 | 80
---|---|---|---|---|---
Importance of skills – communication

Chart of CountryGroup, CommunicationSkills

Percent

CountryGroup

N W E S ROW

CommunicationSkills

5.0

4.0
Importance of skills – data analysis
Questionnaires – CE knowledge and skills summary

• Further analysis to be carried out to compare differences between stakeholder groups

• MVDA methods was used on the quantitative responses, but no predominant themes were observed in the initial analysis

• The differences (even if identified as statistically significant) are typically just outside the CI, hence very close

• This is reassuring as it indicates overall agreement Europe-(world)wide about the importance of core CE knowledge and skills outcomes

• The influence of personal views of respondents is acknowledged

• Detailed report will be available on the project website (preliminary analysis already available)
Predominant methods of delivery
Questions for you

1. Which method of delivery do you believe was identified as predominantly used by institutions for the delivery of core knowledge?

2. Do you think any areas of core knowledge differed from this (fundamentals, modelling, process & product tech, systems, safety, environment) and if so how?

3. How about the other areas of CE curriculum (underpinning science, eng. practice, design, advanced (master) knowledge)?

Discuss in groups of 2-3 no more than 5 mins
Current position – core knowledge
Engagement in lectures

• Expectation raising - ‘Why’ questions at the start
• Use of electronic voting
If activities of two enzymes are:

\[ E_1 = 0.05 \text{ kat} \] and \[ E_2 = 500 \text{ U} \]

is the activity:

1. \( E_1 > E_2 \)
2. \( E_1 < E_2 \)
3. \( E_1 = E_2 \)
Given that $10^{-6}$ is the required sterility level and $10^{11}$ initial conc. of contaminants, D at $120\,^0C = 1.5\,\text{min}, F =$

1. 15 min
2. 25.5 min
3. 16.5 min
The clickers concentrated my attention

1. Yes, I wanted to get the answers right
2. Yes, they broke up the lecture, but I’m not bothered whether I get the answers right
3. No, just a gimmick, I pay attention anyway

n = 63, Stage 3
Seeing the question responses of the rest of the group helps me to gauge my performance

1. Strongly Agree
2. Agree
3. Disagree
4. Strongly Disagree

n = 136, Stage 1
Assessing the efficiency – how do we know we do it well?

• Academics

• Industry
State of the art and latest developments

• Very little ‘hard’ evidence in pedagogical literature

• Typically a single pedagogical approach compared to another, either based on student scores in tests and exams, independent test (Chemepass) or performance in specific tasks and student satisfaction

• Confounding effects rarely accounted for (overall improvement of student cohort from one year to next, staff change, other context changes, etc)

• Long-term impact rarely tested

• UK government linking the fee level to teaching quality

• Structure of TEF now clear, implementation not so
Acknowledgements

• Dr Alina Schartner, Dr Ulrike Thomas, Dr Chris O’Malley – Newcastle University
• All consortium full and associate partners
• All respondents to the questionnaires and focus groups
• EU Erasmus for funding the project
  Grant **539959-LLP-1-2013-1-UK-ERASMUS-EQR**
Response rates and demographics

- 97 academic, 97 employer and 70 graduate responses
Response rates and demographics

**Region**
- Northern Europe: 60.8%
- Western Europe: 21.5%
- Eastern Europe: 8.9%
- Southern Europe: 7.6%
- Rest of World: 1.3%

**Number of Employees**
- >1000: 37.1%
- 1-50: 23.7%
- 50-100: 19.6%
- 100-500: 10.3%
- 500-1000: 9.3%
Response rates and demographics

Region:
- Northern Europe: 30.0%
- Western Europe: 25.0%
- Eastern Europe: 2.5%
- Southern Europe: 2.5%
- Rest of World: 2.5%

Position:
- Technical: 57.1%
- Non-technical: 42.9%