ENQUIRY-BASED LEARNING IN ENGINEERING CURRICULUM:

Are we preparing graduates ready to face future challenges?

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Outline

- Drivers
- Approach
- Does it work?
- Concluding remarks
Drivers

- Societal challenges
- Changing character of the industry worldwide
- Rapidly changing technology impacting learning preferences/future work mode of graduates
- UK specific – funding changes

IChemE Technical Roadmap, 2012
Approach

- To review the teaching of chemical engineering Ug degrees to ensure that the curriculum is:
  - Compliant with external requirements (assessments, ILO), IChemE, InstMC & EI accreditation
  - Relevant to chemical engineers of the future
  - Integrated across years/subjects
  - Effective for larger cohorts of students

- Review started in 2007 taking into account input from all stakeholders
Process

✓ Core curriculum design group convened (DPDs, industrial representative, staff with external experience) and facilitated by QuiLT rep

✓ Overview of UK competitor degrees, consultation where appropriate

✓ Consultations as detailed in next slide

✓ Feedback from Faculty

✓ Establishing a focus group of practising industrialists

✓ Away day

✓ Subject groups lead by future module leaders

✓ Preparation of the required documentation
Consultations

- Accreditation discussions with IChemE
- Consultation with the External examiner
- HEA workshops on Enquiry based learning, assessment and feedback, curriculum review and ILO
- Observation of PBL in the Medical faculty, detailed discussions on the process, advantages, problems
- Meeting with student representatives on SSC and BoS
- Questionnaire sent to recent past graduates in a range of industries (consultancy, specialty and bulk chemicals, procurement, petrochemicals, etc.)
- Meeting with practising chemical engineers from a range of industries
- Discussions with the Ug Dean and Faculty administrator
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<thead>
<tr>
<th></th>
<th>Master Level</th>
<th>Bachelor Level</th>
<th>Further Learning to Master Level</th>
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<tbody>
<tr>
<td>Underpinning Mathematics and Science</td>
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<tr>
<td>Core Chemical Engineering</td>
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<tr>
<td>Engineering Practice</td>
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<td>Design Practice</td>
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<td>Embedded Learning (SHE, Sustainability)</td>
<td>Sufficient, clear demonstration#</td>
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<tr>
<td>Embedded Learning (Transferable Skills)</td>
<td>Sufficient, clear demonstration#</td>
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<td>Advanced Chemical Engineering - Depth</td>
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<td>Advanced Chemical Engineering - Breadth</td>
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<td>Advanced Chemical Engineering Practice</td>
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<tr>
<td>Advanced Chemical Engineering Design Practice</td>
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<tr>
<td>Total IChemE Specified Content</td>
<td>185</td>
<td>125</td>
<td>60</td>
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Broad areas of chem. eng. employment

- Design Engineering
- Operations & Management
- Process/Product Development

Case studies in different stages, integrating different subjects, culminating in the design project
Case studies - benefits

- Critical to the aims of the curriculum restructuring
- Linking knowledge from a number of modules as well as developing professional skills in ‘real life’ scenarios
- Small group learning promoting problem solving, team working, initiative & leadership/negotiation skills, computing skills, data synthesis and critical analysis
- Assessment via more appropriate forms – reports (including reflective individual reports) and presentations promoting the development of presentation and report writing skills
- Promoting independence of learning and peer assisted learning
Case studies – requirements

- Realistic case study scenarios – input of industrial contacts
- Development of case studies in student-friendly format
- Small group learning space
- Relevant computing packages and support
- Staff buy-in – restructuring lecture material in relevant modules so that it links closely with case studies (on demand) is seen as critical to the success of this scheme
- Transition to a different mode of delivery will require a period of adjustment and more support to both staff and students
Case study example – Stage 1
Case study example – Stage 2

Stage 1 Kinetics (regression)

Stage 2 Reaction eng (multiple reactions)
  - Series reaction simulation study
  - Parallel reaction simulation study

Stage 2 DOE / Stats
  - Full scheme simulation optimisation study

Stage 2 Reaction eng Heat balance
  - Exotherm, Scale Up simulation study – thermal runaway

Stage 3 Safety (Vent sizing)

Stage 3 Safety (Thermal runaway) how to design for energetic reactions

Stage 2 Reaction eng PFR and CSTR
Does it work?

- Student focus groups on the effectiveness of different methods – diamond ranking
- Questionnaires on case study on reaction engineering in Stage 2 (66 students, 53 responding)
- Analysis of the self-reflection reports from case study in Stage 1 (103 reports analysed)
Most applications of Unit Operations are currently Petrochemical. Maybe try to pull on different industries?

We should be taught how to use the programme on computer, not straight into doing projects on them.

Plant visit with more hands on large chem plant.

Modeling:
- Predictive skills
- Feedforwarding

Use of genuine industrial skills proper P+IDs in Project appreciation of commissioning

Difference between this and a P&I diagram.
- Use of just draw a quick Flow

How to use the software Particularly Aspen Plus (Extended Project)

Do control of units as you go through modules.

useful but often consulted with industrial professionals for advice.

more specific than subjects above

more assign or different than course

Orange juice? again centred around distillation, maybe use different examples e.g. conc.

Streamline + amalgamate Control 1 and 2.

Reactor and Separation Processes:
- How to select separation units? (Project?)
- Amalgamate filtering/distillation lig/lign + parted

Useful for understanding course but very infrequently used unless in specialist design office.

Newcastle University
Stage 2 case study

- Yes, helped with understanding the module: 50%
- Yes, helped with general understanding: 40%
- Not really: 10%

I found hands-on delivery better than traditional lecturing for this material.
Evaluation of self-reflective reports

Stage 1

- Relatively small contribution to Stage mark (~10 credits)
- Shorter report required (2 pages max), but introducing the idea of self-reflection
- Less comprehensive assessment produced overall, but aspects of team working evaluation and self-criticism clearly visible
- Overseas students much more positive in their assessment and less willing to be critical of team mates

...Unfortunately I did not feel like our group worked well towards the start of the project. However...

...I honestly enjoyed working with such a group in which I have never thought that working on a case study or a report with a group would be easy and fun and would have no conflict such as this group

...we just met for the year enrolment and the fact that everyone comes from a different backgrounds. The thought of having hard time mixing around would always bug me up, but fortunately we all able to understand the situation...

... I was a pretty terrible group member if I’m honest, I wasn’t very good at attending meetings, and...
Concluding remarks

- All stages of BEng course now revised with Stage 4 currently being finalised for MEng courses
- First BEng graduates from the revised course graduated this summer
- EBL taking both lecturers and students out of their comfort zone, but reinforcing in-depth learning of principles and professional skills
- Long-term process requiring full commitment and continuous re-evaluation
Thanks to all CEAM colleagues (academic and admin alike) involved in the curriculum re-structuring

Thank you for your attention