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Process Engineering:

Reflections on an evolving journey towards an award-winning programme for sustainability

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1. Introduction
2. The Journey
3. A Process of Directed Chance
4. International recognition; A Staging post
5. Conclusion and Learnings
1. Introduction

2. The Journey

3. A Process of Directed Chance

4. International recognition; A Staging post

5. Conclusion and Learnings
"Dedicated modules and elective streams alone are not in themselves sufficient to demonstrate how sustainability should be the context through which 21st Century chemical engineering must be practiced. To do this programmes must inherently and consistently demonstrate the need for sustainable practice."

"In my view at least, Cork’s students are being prepared for a world that is increasingly connected and increasingly collaborative; for a fulfilling and successful public and private life."

Byrne & Fitzpatrick
Ed’s Journey:

‘Our capacity for analysis sometimes leads us to an arrogant illusion: that we are so special and unique that nature isn’t connected to us. But the fact is, we’re inextricably tied.’ (Gore, 2006).

It soon became baldly apparent to me that the pillars of environmental engineering and engineering ethics were also closely linked, for as Gore put it as his academy speech:

‘we need to solve the climate crisis: It’s not a political issue; it’s a moral issue.’
Who was responsible for the Challenger disaster?

Society and its economic, social and political structures?

Professional Bodies

The Engineering profession and its values?

Workplace organisation and culture..at Morton Thiokol, NASA?

Micro Objective
organizational culture and processes

Micro Subjective
consciousness and will power of individual engineers

Individual

..An individual or individual actors?

Macro Objective
social, economic and political structures and public policy

Macro Subjective
goals and values of the profession

Ed’s Journey:

MA in Teaching and Learning in Higher Education (2008); helped facilitate development of a personal understanding of learning in terms of constructivist approaches, something alien to the traditional modernistic worldview as espoused by classical engineering education, but which is essential to effectively engage with sustainability issues and associated narratives, including education for sustainable development (UNESCO, 2015, p. 15).

Constructivist teaching and learning is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction, as opposed to passively receiving information. Learning always builds upon knowledge that a student already has, and learners are the makers of meaning and knowledge. Constructivist teaching fosters critical thinking, and creates motivated and independent learners.4
John’s Journey:
- Over time, had the niggling feeling that the big challenges to moving humanity towards sustainability lay within economic and social domains.
- Indeed these are possibly the “game-changers” or critical levers for change (Fitzpatrick, 2017)

John’s Journey:
- Also had niggling feeling of being complicit in producing ‘technically competent barbarians’ who were not fit-for-purpose for contemporary sustainability challenges.

Technically Competent Barbarians?

“The major role in this was played by the universities, the academics. I keep returning to the question of whether we have indeed learnt anything, whether we do not still keep producing technically competent barbarians in our universities” (Bauer, 1998; emphasis added).

The ‘barbaric’ logic of modern neo-classical economics is destroying people and planet.

John Barry
(Queen’s Univ.
Belfast)
1. Introduction

2. The Journey

3. A Process of Directed Chance

4. International recognition; A Staging post

5. Conclusion and Learnings

ISEE2010: Educating Engineers for a Changing World; Leading Transformation from an Unsustainable Global Society

EESD Conference Series:
PE3011 Sustainability in Process Engineering (ex 2010/1)

- Broad view taken; not just socio-technical (e.g. LCA), but also making explicit underlying values and paradigms around sustainability narratives and the nature of complex systems
- Essentially aiming to develop the generic competencies, including integrative approaches and critical thinking skills necessary for and that correspond with education for sustainable development (ESD) more generally (Bourne & Neal, 2008; UN, 2012; Byrne, 2014)
- e.g. Learning Outcomes include:
  - Demonstrate understanding of contemporary frameworks, concepts, constructs, models, and values and ethics around sustainability and sustainable development
  - Develop an ability to understand different perspectives, framings, paradigms and worldviews and work collaboratively with others in seeking (through inter- and transdisciplinary approaches) to propose useful interventions and potentially transformative outcomes
  - Develop and refine capacity for critical reflective analysis and integrative and systems thinking

On our call for ‘The Need to Embed Sustainability’:

- Sustainability thread developed within other modules with support of colleagues (below).
- Macro environment facilitated by professional accreditation bodies (e.g. IChemE, Engineers Ireland Accreditation requirements, sustainability related prizes/initiatives, Code of Ethics (EI, 2018))
- Positive sustainability ethos & leadership in our university provides positively oriented context.

<table>
<thead>
<tr>
<th>Primary Sustainability Modules</th>
<th>Secondary Sustainability Modules</th>
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<tbody>
<tr>
<td>PE1006 Professional Engineering Communication &amp; Ethics</td>
<td>PE1003 Intro. to Process &amp; Chemical Engineering</td>
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<tr>
<td></td>
<td>PE2005 Introduction to Biochemical Engineering</td>
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<td></td>
<td>PE2011 Plant Design and Commissioning</td>
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<tr>
<td>PE3011 Sustainability in Process Engineering</td>
<td>PE3001 Applied Thermodynamics and Fluid Mechanics</td>
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<tr>
<td>PE3008 Safety &amp; Environmental Protection I</td>
<td>PE4004 Safety &amp; Environmental Protection II</td>
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<td>PE4006 Design Project</td>
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<tr>
<td>PE4004 Safety &amp; Environmental Protection II</td>
<td>PE4001 Advanced Process Design</td>
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</tbody>
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Final Year Design Project

‘Embedding Sustainability’ into the final year capstone Design Project (rather than as ‘bolt on’)

Revised approach to placing sustainability as context of design project requires:

a) Considering sustainability throughout a (semi-open ended) design process
   - Thus feed into design decisions from start, including framing

b) Environmental aspects
   - Employ scientific/engineering tools & methods which can directly influence the design (e.g. LCA, EIS, material and energy balances)

c) Socio-economic aspects
   - More difficult but could be argued that the key sustainability ‘game-changers’ lie in this domain; consider/identify key problematic issues?

Required output for the groups is a proposed entry into the IChemE’s Macnab-Lacey final year Sustainability Design Project Prize (awarded annually by IChemE ‘to the undergraduate student design project team whose design project submission best shows how chemical engineering practice can contribute to a more sustainable world’)

Macnab-Lacey Prize Submission: University College Cork

Waste to Food-Energy – A Circular Economy Concept

Overview of the project
Biofuel is a proposed facility to be located in Shanbally, Co. Cork utilising a circular economy concept to produce food and energy from existing waste products. This document highlights the key aspects in the design and operation of the facility. The economic, environmental and safety analyses for the plant are also encapsulated in the document.
Supported by broader University ‘Green Ecosystem’:

- **University environment** encouraging; University College Cork was first university in world to receive **Green Flag** for environmental friendliness.

- **Practicing Transdisciplinarity**: ‘**Sustainability in Process Engineering**’ module coupled with ‘**Sociology of the Environment**’ module; group assignment helps students ‘walk the walk’/hear other disciplinary languages/problem solve.

- **Transdisciplinary** Environmental Citizenship **Research** Priority Area (‘**Sustainability in Society**’): seeks to (re)consider sustainability in a way which both draws from disciplinary contexts and knowledge but also transcends and builds on new contexts.

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**Student Feedback; Seen as positive/valuable**

Imperial College London research: *‘make a difference to the world’* (Alpay et al., 2008) in their careers was a key driver in choosing engineering, especially among females.

Our experience also; Students very positive about both ethos and the respective modules.

e.g. **Sustainability in Process Engineering** module feedback:

- ‘A major learning point of this was taking on board alternative perspectives of problems, outside of engineering solutions.’

- ‘[The] transdisciplinary approach was enlightening – an engineering solution isn’t always the only option.’

- ‘Working in a team with vastly different opinions is hugely valuable to our careers in the future.’
Sustainability ethos as soft marketing tool to attract potential students to the programme. Inspired by the IChemE’s visionary 2007 ‘Roadmap’, strategic plan for the profession for the century ahead.
International Recognition; A Staging post

Inst. of Chemical Engineers instigated **Sustainability Teaching Award** (in 2015) to encourage ‘development of better approaches to integrating sustainability principles and values into undergraduate teaching’.

We entered for the second iteration in 2016 and won!

IChemE: ‘particularly impressed by your integration of sustainability teaching across the curriculum, with good examples of interdisciplinary projects and varied assessment with student comments indicating their appreciation of the approach.’

‘University College Cork demonstrated that they could integrate sustainability teaching principles across the curriculum, which will provide their chemical engineering students with a set of values to apply to their future careers.’

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In Conclusion...

• We’ve found the journey from a traditional programme whereby sustainability is envisaged narrowly (e.g. boosting efficiencies, improving environmental emissions) to one where it explicitly seeks to add value (and values) to contemporary chemical engineering education, to be both fascinating and rewarding.

• This means recognising that ‘the key ingredient required ..is an aspiration to enable and empower learners to meet their full potential by developing the necessary skills and aptitudes (critical, reflective and complex thinking, self-awareness and empathy, teamwork, listening and communication skills) to be fit-for-purpose’ (Byrne, 2014) contemporary chemical engineers.

• As we’ve attempted to push various doors (via students, colleagues, accreditation bodies, industry, peers), we’ve found that they’ve swung open with surprising ease, opening altogether new and exciting vistas.

• We see this as ‘core’ chemical engineering, to educate fit-for-purpose graduates in addressing contemporary, emergent 21st century challenges, able to contribute meaningfully towards authentic societal sustainability and human flourishing.

Come join us and share your experiences of the journey at:

Engineering Education for Sustainable Development

EESD2020
UCC, 7-10 June 2020