An Examination of Broadening of the Engineering Curriculum in Ireland

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Background

- This talk is based on material from a chapter in a forthcoming book:
  - "The Engineering-Business Nexus - Symbiosis, Tension and Co-Evolution"
    - Philosophy of Engineering and Technology Series
    - Scheduled for publication in Fall 2017

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This day in history …

"It was unknowable then, but so much of the progress that would define the 20th century, on both sides of the Atlantic, came down to the battle for a slice of beach only 6 miles long and 2 miles wide."

Barack Obama

Critique of Engineers & Engineering

The True Grand Challenge for Engineering: Self-Knowledge

"Neither engineers nor politicians deliberate seriously on **the role of engineering in transforming our world**. Instead, they limit themselves to celebratory clichés about economic benefit, national defense, and innovation."

Prof Carl Mitcham

Perspectives

"The material welfare of the community is unreservedly bound up with the due working of this industrial system, and therefore with its unreserved control by the engineers, who alone are competent to manage it."

Veblen, Thorstein, 1921. The Engineers And the Price System. Batoche Books, Kitchener.

The greatest engineering challenge, according to Mitcham, is to cultivate "deeper and more critical thinking … about the ways engineering is transforming how and why we live".

ibid, Mitcham

Perspectives

"From early times, [engineers] have answered the needs of people not by building sentences, but by constructing machines or water … systems, organizing … transport of goods and food supplies, offering cities the conditions to grow and make life good and comfortable."

Meijknecht, T., van Drongelen, H. (2004). How is the spirituality of engineering taught or conveyed? International Journal of Engineering Education, 20(3), pp 447-451.

"Relatively few engineers, when invited to reflect on their professions, can do much more than echo libertarian appeals to the need for unfettered innovation to fuel endless growth."

ibid, Mitcham

Engineering Identity in crisis?

- **Perhaps more than one identity crisis:**
  1. **Nature of engineering knowledge: theory or practice?**
  2. **Nature of engineering role: scientist or manager?**
  3. **What values underpin engineering decision making?**

    Dias, P. (2013). The Engineer's Identity Crisis: Homo Faber or Homo Sapiens? Chapter 11 in Philosophy and Engineering: Reflections on Practice, Principles and Process. Springer Science+Business Media: New York.

- **I-shaped versus T-shaped graduates?**

- **Predictions that engineers need to adopt a hybrid educational model or risk being consigned to purely technical work**

    – Williams, R (2003). Education for the profession formerly known as engineering. The Chronicle of Higher Education. Issue January 24th.
    – Heywood, J. (2008). Philosophy and Engineering Education. A review of certain developments in the field. Frontiers in Education Conference 2008. FIE 2008. 38th Annual, pp. S4H-7-S4H-12, ISSN 0190-5848.

What did we set out to discover?

In Ireland:

- **How does engineering education broaden the engineering student?**

- **What kinds of non-engineering courses are reflected in engineering curricula?**

- **Is there evidence of space within engineering curricula for self-reflection and critical thinking?**

Hierarchical Classification:
Engineering Program Enlightenment

	Justification	Description	Effect
1	No justification	Engineers transform the world because they can	Engineering education is through the core disciplines of engineering
2	Instrumental justification	Engineers transform the world and they can communicate it clearly	Social Sciences courses can improve the communications skills of engineers
3	Enhanced Instrumental justification	Engineers transform the world and they can justify it rationally and contextually	Social Sciences courses can locate engineering projects within their broader social context
4	Intrinsic Value justification	Engineers transform the world and they can reflect on what it means for all of us	Social Sciences courses enable critical self-reflection on the meaning of life in a progressively engineered world

Adopted from Mitcham, *ibid*

Approach

a. Review of readily available programme information

b. Review of accreditation reports

c. Interviews with heads of business schools

d. Review of Irish Student Survey data

Scope: All professional engineering degree programmes in Ireland

Review of content of accredited professional engineering programs

- **The objective of the review was to examine the extent and nature of non-core disciplinary modules or elements of modules contained in programs.**

- **The review was limited to readily accessible information: print, websites**

- **Caveats, Caveats, Caveats!**
  - **e.g. content vs delivery**

Broadening Content

1. **Core business content: management, finance, law, marketing, economics, etc.**

2. **Professional and ethical development**

3. **Critical thinking, team working, personal effectiveness, etc.**

   – **Work placement / service learning modules**

4. **Other broadening non-technical disciplines: arts, humanities, etc.**

Accredited Programs Reviewed

	Number of programs offered			Modules listed	Full syllabus provided
	Level 8	**Level 9**	**Total**		
University	29	12	41	39	6
IoT	21	7	28	25	7
Total	50	19	69	64	13

Notes:

1. 94 in-scope programmes; but only 69 currently offered
2. 5 programs provide no module listings
3. 2 programs have hybrid titles (business, management)
4. 62 programs reviewed (45 BE/BSc - Level 8, 17 MSc - Level 9)

4-Year BE/BSc Programs

No. of Level 8 (Hons Bachelor) Programs containing:	Professional & Ethical Development		Generic Skills		Core Business Topics		Other-Humanities etc.	
	No.	%	No.	%	No.	%	No.	%
0 modules	16	36%	12	27%	17	38%	45	100%
1 module	27	60%	17	38%	24	53%	0	0%
2 modules	2	4%	14	31%	4	9%	0	0%
3 modules	0	0%	0	0%	0	0%	0	0%
> 3 modules	0	0%	2	4%	0	0%	0	0%
Total	45	100%	45	100%	45	100%	45	100%

5-Year MSc Programs

No. of Level 9 (Masters) Programs containing:	Professional & Ethical Development		Generic Skills		Core Business Topics		Other-Humanities etc.	
	No.	%	No.	%	No.	%	No.	%
0 modules	13	76%	11	65%	5	29%	17	100%
1 module	4	24%	6	35%	9	53%	0	0%
2 modules	0	0%	0	0%	1	6%	0	0%
3 modules	0	0%	0	0%	0	0%	0	0%
> 3 modules	0	0%	0	0%	2	12%	0	0%
Total	17	100%	17	100%	17	100%	17	100%

Relating results to Hierarchical Classification

	Justification	Description
1	No justification	Engineers transform the world because they can
2	Instrumental justification	Engineers transform the world and they can communicate it clearly
3	Enhanced Instrumental justification	Engineers transform the world and they can justify it rationally and contextually
4	Intrinsic Value justification	Engineers transform the world and they can reflect on what it means for all of us

- **General lack of broadening evidence:**
  - Programs are designed to produce "I-shaped" engineers
- **Evidence points to limited "instrumental justification"**
- **No compelling evidence that locates engineering within broader social context**

Engineers Ireland Accreditation Criteria

The program outcomes required to satisfy the criteria for professional (chartered) engineer are as follows:

(a) Advanced knowledge and understanding of the mathematics, sciences, engineering sciences and technologies underpinning ….

(b) The ability to identify, formulate, analyse and solve complex engineering problems.

(c) The ability to perform the detailed design of a novel system ….

(d) The ability to design and conduct experiments ….

(e) An understanding of the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession to-wards people and the environment.

(f) The ability to work effectively as an individual, in teams and in multi-disciplinary settings, together with the capacity to undertake lifelong learning.

(g) The ability to communicate effectively on complex engineering activities with the engineering community and with society at large.

Findings (1)

- **All reports examined were for successfully accredited programs**
  - **This suggests that publicly available information is insufficient in describing program strengths**
  - **For example: "Professional Engineering & Communications … examines 'wicked', multi-faceted problems requiring an examination of societal, political, technical, etc. issues to be recognised – assignment requires ethical reasoning to be emphasised."**

Findings (2)

- **No evidence of systemic attention to a broadening agenda**
  - **Often the same (few) courses within a program provide all of the (e), (f) and (g) evidence**
  - **Evidence often found in arbitrary and non-rigorous forms:**
    - **E.g., on "the multi-disciplinary aspect, the programme benefited from the fact that students came from different backgrounds"**
    - **E.g., "Evidence supporting this programme outcome [e] in the formal submission is weak with an over reliance on issues relating to plagiarism."**

Findings (3)

- **No clear themes reflecting an institute-wide focus across its accredited programs with respect to criteria e, f, and g.**
  - **In other words, we could not find evidence that any institution or university used these criteria to set itself apart, or differentiate its programs and graduates as different and unique.**

Findings (4)

- **Accreditation Panels accept less robust evidence for criteria e, f, and g, than a-d:**
  - **"Consideration should be given immediately to securing opportunities for teamwork in multidisciplinary situations"**
  - **For "future review exercises, the provision of explicit evidence of where these skills are being addressed should be provided"**
  - **"formal assessment of ethics [should be] conducted in the service modules (non-engineering modules)"**

Issues explored with Leaders and Heads of Business Schools

- There is wide variation with regard to both the intention and the practice of collaborative design and delivery of engineering programs

- Engineering programs are 'highly prescribed with very little elective choice'

- 'Curriculum space issues, different vocational cultures, and dis-interest among engineering students and staff result in a 'chiselling out' of non-core engineering courses over time

- Programs that at one stage may have been designed to offer a broader curriculum have been subject to a normative effect over time

Primary reasons offered by Heads of Business Schools

1. **Perception of business among engineering students and staff**
   - Prevailing view that engineering students view business and management courses as 'easy options of little interest', which lack credibility and are not taken seriously leading to reduced effort.

2. **The issue of curriculum space**
   - Continual tension in including non-core engineering courses within the curriculum. The intensive, focused and prescribed nature of undergraduate engineering programs mitigate against the allocation of adequate curriculum space to deliver business/management content.

3. **Apparent different educational approaches for the two disciplines**
   - Perception of engineering and business as coming from two distinct and different cultures. Whether the view is valid or not the influence is evident.
   - The early formation of an engineering identity among students reinforces the perception.

4. **This status of the 'engineer identity' is perhaps the greatest inhibitor to the broadening of the engineering curriculum to include non-core engineering courses:**
   - "Like the medical, the educational and the juridical professions, **engineers constitute a tribe**, with its own traditional set of values that are transmitted to the new members in a symbolic way during their initiation. **Studying is a kind of initiation.**" (Meijknecht, T., van Drongelen, H. (2004). How is the spirituality of engineering taught or conveyed? International Journal of Engineering Education, 20(3), pp 447-451)

Hybrid Programs

- **Hybrid programs address Accreditation Criteria e, f, and g more comprehensively:**
  - **Engineering with Business**
    - **"the … program is unique in the country and staff and management must be commended for identifying this opportunity to support Irish industry.**
  - **Engineering with Management**
    - **"there is strong evidence of the building of interdisciplinary skills within the programme especially with the Business School"**
  - **Product Design**

DIT Product Design (1)

- **4-year multi-disciplinary program, with substantial creative and business content**

- **Conceived and designed *ab initio* as a collaborative program**

- **Managed in a multidisciplinary manner, with engineering, arts and business acting as equals**

- **There is no 'core' and 'non-core'**

- **It is not accredited by Engineers Ireland**

Irish Student Survey of Engagement

- **In 2015 Ireland implemented a national higher education student survey:**
  - **Students from the first year and from the final year of all programs are surveyed**
  - **Nine engagement indicators (EIs) are measured including:**
    - **Reflective and Integrative Learning,**
    - **Quantitative Reasoning, and**
    - **Collaborative Learning**
  - **Each Engagement Indicator was scored on a 60-point scale**

DIT Product Design (2)

Engagement Index	DIT Product Design	All DIT Engineering Programs	All DIT Programs	All Irish Engineering Programs	All Irish Programs
Reflective and Integrative Learning	34	27.8	28.9	27.6	30.7
Quantitative Reasoning	22.9	22	18.9	23.6	18.8
Collaborative Learning	37.2	32.9	31.4	33	30.5

DIT Product Design (3)

Selected Student Survey Questions	DIT Product Design	DIT: Engineering	DIT: all Disciplines	National: all Disciplines
Connected your learning to problems or issues in society	33.3	22.7	24.9	28.0
Examined the strengths and weaknesses of your own views on a topic or issue	34.0	27.8	28.3	30.0
Tried to better understand someone else's views by imagining how an issue looks from their perspective	37.3	28.6	29.4	32.0
Solving complex real-world problems - (How much has your experience at this institution contributed to your knowledge, skills and personal development in the following areas?)	42.2	34.7	29.2	30.0
Being an informed and active citizen (societal / political / community) - How much has your experience at this institution contributed to your knowledge, skills and personal development in the following areas...	27.4	22.2	22.4	36.0

General Observations

- **Engineering Program Leaders might better describe both the content and strengths of their programs**

- **Accred Panels might benefit from greater guidance on how to assess e, f and g**

- **"Core-periphery" distinction ensures that attempts to broaden the curriculum are doomed to fail** (Christensen, S.H. (April 2015). Issues in Science and Technology.)

1. We could reject Carl's arguments:

- **Let engineers be engineers**
  - **Society will mediate the technology that engineers produce**

Engineering   Liberal Arts

- **Reinforces the current orthodoxy**

2. **We could accept his premise and leverage social sciences in instrumental support of engineering education:**

Value of Liberal Arts Education

The values and strengths of a liberal arts education, include how to write clearly, how to express oneself convincingly, and how to think analytically.

Addressing Mitcham's Arguments (3)

3. Embrace Hybrid Programs:

– **Increase 'non-core' engineering courses within the engineering curriculum**

– **Use accreditation criteria e, f and g as a positive requirement to broaden the curriculum**

– **Engage in identity discussion regarding 'hyphenated engineers'**

- Address 'them versus us' arguments
- "Engineers, like all of us, should be able to think about what it means to be human" (Mitcham *ibid*).

"Things fall apart; the centre cannot hold;
Mere anarchy is loosed upon the world,
The blood-dimmed tide is loosed, and everywhere
The ceremony of innocence is drowned;
The best lack all conviction, while the worst
Are full of passionate intensity."
The Second Coming

Education is not the filling of a pail, but rather the lighting of a fire.

William Butler Yeats