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Integrating ethics across the curriculum through sustainability topics

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Abstract

The paper explores the coverage of sustainability in Engineering programmes in Ireland in the context of increasing calls for integrating ethics across the curriculum. It is part of a broader study examining engineering ethics education conducted in cooperation with the national accrediting body, Engineers Ireland, including 23 Engineering programmes from 6 institutions. We begin by describing the current empirical research about the implementation of ethics education across the curriculum, which is predominantly US based, before moving to the presentation of the research methods employed in our study. We then focus on two major findings of our study. First, we examine the views about the implementation of ethics expressed by evaluators appointed to accreditation panels of Engineering programmes.. Building on the preference expressed by evaluators for integrating ethics across the Engineering curriculum and on some of the challenges highlighted by them as well as by existing research, we proceed by examining the implementation of Engineering ethics education through sustainability related coverage. We argue that sustainability related coverage might be a good candidate for integrating ethics across the curriculum, concluding with insights and examples that can serve as guidance in the implementation of ethics.

Introduction

Recent years have witnessed a greater call for integrating ethics across the Engineering curriculum, in modules with both a technical and non-technical orientation (Cruz and Frey 2003; Newberry 2004; Drake *et al* 2005; Ocone 2013). There are several advantages mentioned in connection to teaching and assessing ethics in several modules throughout an Engineering programme, such as providing a holistic and interdisciplinary approach that "mirrors the ways in which ethical issues arise in day-to-day engineering practice" (Cruz and Frey 2003, p. 545), thus allowing students "to see ethics in action" Ocone (2013 p. e114). The integration of ethics across the curriculum also helps students become aware of the intrinsic connection between ethical concerns and technical content, by rectifying the preconception that ethics is just an "add-on material" (Newberry 2004, p.346). As such, this approach is considered to be more effective in improving engineering students' moral reasoning and sensitivity to ethical issues than solely having dedicated modules on ethics (Drake *et al* 2005, p. 223). Nevertheless, there are also significant challenges reported about the method of implementing ethics across the Engineering curriculum. The most significant challenges relate to the background of Engineering

lecturers and their lack of familiarity with societal and ethical related topics (Newberry 2004), but also students' reticent attitude towards ethics (Bielby *et al* 2011).

Our paper examines the integration of ethics across the curriculum in Engineering programmes in Ireland through the prism of sustainability related coverage. Sustainability falls under one of the seven criteria listed by Engineers Ireland (2007) that Engineering programmes have to demonstrate for accreditation. Programme outcome E dedicated to ethics requires graduates to show "knowledge and understanding of the social, environmental, ethical, economic, financial, institutional, sustainability and commercial considerations affecting the exercise of their engineering discipline", as well as "knowledge … of engineering practice, and the impact of engineering solutions in a societal and environmental context" and "commitment to the framework of relevant legal requirements governing engineering activities, including environmental" Further, some have argued that a focus on sustainability may provide a focus for broadening engineering ethics beyond a micro ethical approach (Conlon and Zandvoort 2011; Byrne 2012).

Our contribution is based on a study supported by the national accrediting body in which 23 Engineering programmes from 6 higher education institutions in Ireland participated. Our research employed document analysis of module descriptors and interviews with lecturers and evaluators. Based on the modules deemed by the participant programmes to have the strongest contribution to meeting outcome E for the purpose of accreditation, our study points to sustainability as the topic most employed in the teaching of Engineering ethics in Ireland.. Our findings suggest that sustainability is the topic falling under outcome E that is most present across the curriculum of the participant Engineering programmes in Ireland.

In light of these findings, we aim to address the need for guidance on implementing ethics across the Engineering curriculum (Byrne et al, 2012; Mesa 2017), by presenting some examples on how sustainability related content has been put in practice in the participant programmes, which can be adapted within other programmes.

2 Research Methods

In order to determine the implementation of ethics in Engineering programmes in Ireland, two research methods have been employed: (a) document analysis of the documentation which was either prepared by the programmes for accreditation or is available online on the website of all participant programmes and (b) interviews with lecturers from the participant programmes teaching a professional formation module and evaluators who served in the accreditation panel during the events observed. The two methods are seen as complementing each other in order to develop a comprehensive insight into the implementation of ethics education in the participant programmes.

The scope of the study was limited to Engineering programmes that underwent accreditation between 2017-2019. Twenty three programmes offered by 6 institutions are included. Our present analysis focused on the modules that the programmes themselves have deemed to have the highest contribution to meeting programme outcome E. To identify these modules, we relied on a mandatory rubric in the documentation submitted by the programmes for accreditation, in which the programmes self-assess how they meet each of the seven programme outcome. Thus, the modules that were assessed by the

participant programmes with the highest contribution to outcome E were singled out for a documentary analysis of the topics and learning outcomes employed in connection to ethics instruction.

The documentary analysis relied on two main data sources: a rubric present in the documentation submitted by the participant programmes for accreditation, by which the programmes describe how they meet programme outcome E, and the module descriptors provided either as an annex to the documentation submitted for accreditation (6 programmes) or part of the evidence presented during the accreditation events observed (11 programmes) or posted online on the programmes' website (6 programmes). At the end of this stage, there was a total of 83 unique modules with a strong contribution to meeting programme outcome E. The next research stage was dedicated to analysing the content inputted in the previous stage, following two iteration stages. First, a codebook was generated with 28 initial codes covering curricular content purporting to ethics informed by the standard description of topics falling under outcome E (Engineers Ireland, 2007) and the literature about the content of engineering ethics education. It was followed by a second iteration stage, which grouped the initial thematic codes under broader categories.

Having established the major themes employed to teach ethics in the participant programmes, we sought to get a more in-depth exploration of the topics and methods used to teach ethics. This was achieved through a series of interviews. Sixteen lecturers of professional formation modules were questioned about the topics and methods employed in teaching ethics. Six evaluators who served on the panels of Engineers Ireland during the accreditation events of 3 institutions observed by the researcher, were also interviewed. The evaluators were questioned about their views on engineering ethics education and its implementation in the evaluated programmes.

3 Implementing Engineering ethics education across the curriculum: the evaluators' perspective

All six evaluators interviewed for the study showed a preference for seeing ethics integrated across the curriculum rather than in dedicated modules. This approach is considered to foster the development of holistic engineering graduates that do not divorce ethics from the technical solutions they pursue. As one evaluator claims, "that's the way it has to go if we want to produce engineers that consider ethics as part of their direct logical reasoning." Another evaluator argues that "it has to be across, we don't just want to see it in the professional development modules, you'd like to see some mention of it elsewhere in the other modules as well. […] You can't just be ethical in one module, there should be an element of it everywhere." This opinion is shared by a third evaluator who considers that "ethics possibly should be brought into more modules as opposed to just being covered in a module". The reasoning behind this preference is that having ethics addressed in a dedicated module could contribute to the perception of the topic as an add-on, "just to get it in the course", and thus minimizing its importance in the Engineering curriculum.

Based on the interviews conducted, there is a sense that technical and ethical issues need to be "combined and fused in real life situations." Nevertheless, evaluators consider that Engineering programmes in Ireland are not yet at the stage of implementing ethics across the curriculum. "It's not

quite there yet. I don't see any programmes where it is permeating throughout", states one evaluator, while another evaluator agrees that "most modules do not cover ethics. In any module that has a high technical content, probably ethics is not covered there."

A challenging aspect according to one of the evaluators is that "for some modules it's going to be hard to bring it into light". This point is expanded by another of the evaluators questioned. According to him, "it's very difficult because of the way the existing crop of academics were taught engineering was in a very different way to the way we're teaching engineering now", which leads to a "slow process of getting people to think more holistically in their approach to engineering education". There is an agreement among the evaluators for the need for more guidance on how to implement ethics more effectively, especially in the case of technical modules.

4 Sustainability in Engineering ethics education

When analyzing how ethics is being integrated in the curricula of the participant Engineering programme from 6 HEIs in Ireland, we found that sustainability is the most popular theme employed in connection with meeting programme outcome E for accreditation. Table 1 shows that 49 (59%) modules deemed to have a high contribution to outcome E incorporate sustainability related topics. The topics mentioned in connection to the teaching and assessment of the theme of sustainability are the principles of sustainable development, environmental impact and protection, climate change, carbon management, energy efficiency, renewable energy, life cycle analysis, waste management, sustainable economic growth and eliminating poverty traps. There is a higher emphasis on the environmental dimension of sustainability than on its social and economic dimension.

Table 1: The distribution of sustainability related coverage across module types (n=83 unique modules)

Technical Modules (n=36)	**Design modules (n=15)**	**Professional formation modules (n=12)**	**Capstone Projects (n=8)**	**Work Placement (n=2)**	**Business studies modules (n=6)**	**Legal studies modules (n=3)**	**TOTAL (n= 83)**	**%**
19	10	8	5	1	4	2	49	59%

The theme of sustainability is covered in a wide variety of module types, such as technical modules, design modules, professional formation modules, capstone projects, work placement programmes, business studies modules as well as legal studies modules. An exception, considered insignificantis for the only module categorized as a personal development module, which does not offer coverage related to sustainability. More so, as seen in Table 1, sustainability related coverage is present in more than half of the modules with a strong contribution to outcome E from each module type. This suggests that sustainability might be a good candidate for integrating ethics across the curriculum.

From the perspective of lecturers, sustainability has the advantage of being a theme that suits the technical expertise of Engineering faculty members. As one lecturer states, sustainability coverage has "the potential" to be integrated in technical modules. According to her, ethical questions about energy efficiency and waste production "did resonate because people could see how they might be involved in something that could be problematic". Sustainability is also found to be appealing to students, who were found to show "a real interest." Reflecting on her classroom experience, one lecturer noticed a real focus on the Sustainable Development Goals, with students commenting that "this was something they really enjoyed".

These observations seem to address two common challenges highlighted by current research on Engineering ethics instruction. One such challenge is the Engineering faculty' lack of familiarity with the topic, which that hinders the linkage of ethical concerns with technical subject matters (Sinha *et al*, 2007; Harding *et al*, 2009; Walczak *et al*, 2010; Romkey, 2015; Monteiro, 2016; Polmear et al, 2018). A second challenge is the students' negative reception and engagement with nontechnical content (Harding *et al*, 2009; Romkey, 2015; Polmear et al 2018).

5. Sustainability across the curriculum in practice

Sustainability is present in the curricula of the participant programmes both in taught components and assessments. In what follows, we describe some of the evidence of sustainability coverage in both these components. Table 2 shows that the participating programmes incorporate sustainability topics through various taught components, such as lectures, case studies, community service, online polling systems and documentaries.

Table 2 Teaching methods incorporating sustainability issues

Type	**Example of content**
Lectures	Principles of sustainable development The relationship between a country's CDP and associated energy use Wealth inequality Local and/or international environmental policies Environmental ethics in different traditions of thought
Case studies	Ethical dilemmas about waste water treatment technologies
Community service	Developing environmentally-friendly and/or socially-conscious building retrofits based on needs identified through direct interaction with a non-profit entity
Online polling systems	Asking students to input the moral decisions they made in their lives for tackling climate change
Films and documentaries	Watch a documentary on progress from a critical perspective, looking at the interlink between ecological environmental, social and economic aspects of sustainability

Some examples of topics introduced in lectures are the principles of sustainable development, environmental policies and standards, environmental and ecological theories representative of the Western, Buddhist and Native American traditions and the role of engineering in addressing wealth inequality. The topics included through lectures show a concern with both the environmental and socio economic dimension of sustainability.

The case studies used by the lecturers interviewed aim to foster students' reflection on the implications of developing technologies that fail to meet environmental standards. For example, a case study about wastewater treatment explores the "certainty of knowing" that the discharge from the respective technology is "actually polluting the environment or was it just that we took one sample and that sample is inaccurate?" Students are exposed to the various type of ethical concerns that arise, such as "the rigor and integrity of their data collection and management, the cost benefit of different solutions, and the impact of one solution over another solution."

We see that the integration of several various teaching approaches leads to a more holistic approach to the topic of sustainability, which incorporates its three pillars of environmental protection, economic viability and social equity. This seems to suggest that a hybrid approach to the incorporation of sustainability in the Engineering curricula is needed in order to offer students a more rounded understanding of the topic

In order for the integration of ethics across the curriculum to be successful, it was argued that the inclusion of ethics in taught components is insufficient by itself if it is not accompanied by an assessment of the ethical components of technical modules (Bairaktarova and Woodcock 2017, p. 1132). In what follows, we present several examples of the integration of sustainability aspects in the assessment methods employed by the participant programmes. As seen in Table 3, sustainability was found to be included in exam question, reports, presentations, research projects, design projects and capstone projects.

Table 3 Assessment methods incorporating sustainability issues

Type	**Example of content**
Exam questions	discussing the ethics of landfilling
Research projects (incorporating reports, posters and presentations)	about the sustainable development goals about the state of energy legislation in Ireland and the EU,
Design projects	Projects that incorporate the design for environment approach
Capstone project	Mandatory rubric discussing the ethical implications and issues arising in the final year project

One of the lecturers interviewed gave the example of an exam question they introduced, which asked students to discuss the ethics around landfilling, and "whether it is a problem or an opportunity, whether you can generate energy and actually recover things from it and turn it into a positive, or whether the negatives do outweigh that".

Research projects are a popular method of incorporating sustainability topics in assessment. Some of the examples mentioned by the lectures interviewed revolve around asking students to present or write a report on the sustainable development goals. A lecturer described how their report assignment is asking students "to put the context of why the chosen goal was a challenge, and then to discuss what progress had been made so far and to critique that, whether that was sufficient progress, whether they were on a good trajectory, and then what environmental engineers could do in the next decade in order to be able to meet that 2030 target". Another example of a research project asks students to analyse energy policies across a number of countries, with a focus on their impact of the adoption of bio-energy technologies "that could lead to sustainable, cyclic energy systems".

The majority of capstone projects incorporate a mandatory rubric that requires students to include a section in their thesis where they reflect at the ethical implications and issues arising in their projects. This rubric is found to explicitly mention sustainability as one of the implications to be considered. For the programmes that do not yet have this requirement for the final year project, evaluators mentioned its absence and suggested the introduction of an ethics section.

Conclusion

Lambrechts et al. (2013, p.64) argued that higher education institutions are "far from reorienting themselves towards sustainability", as sustainability appears to be "integrated in a piece-meal fashion". While we can't say that the implementation of sustainability is carried in a systematic and even manner

in the programmes in the study, what does emerge is a desire to address ethical issues through the prism of sustainability Sustainability appears to be the most popular topic used to meet the accreditation outcome purporting to ethics. Sustainability might be a good candidate for the integration of ethics across the curriculum, as it can be tailored to the expertize of Engineering faculty and is appealing to Engineering students. The downside of this is that sustainability becomes associated with its environmental dimension and less the social and economic dimension. An issue then is how we can use this desire to focus on "ethics as sustainability" as a mechanism for broadening engineering education and more fully integrating the technical, the social, and the environmental dimensions of engineering in one comprehensive form of education. (Nicolaou et al 2018).

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