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Chapter 8
The Two Cultures of Engineering Education: Looking Back and Moving Forward

Diana Adela Martin and Madeline Polmear

Abstract: The prevalent historical model of engineering education is centered on a conception of engineering as a technical discipline. However, engineering students are increasingly expected to develop nontechnical competencies for their workforce preparation and professional responsibility. In particular, ethics are an important outcome of engineering education. Ethics have roots in the humanities and social science (HSS), creating a tension between the normative culture of engineering and its engagement with these disciplines. There is a persistent disconnection between the engineering and HSS cultures in ethics education, which impacts how the subject is integrated and treated in curricula. This chapter explores the dichotomy between how technical and nontechnical learning outcomes are addressed in engineering education and its implications for ethics. Drawing on two studies that were independently designed and conducted in the US and Ireland, this chapter synthesizes the perspectives of educators across the two national contexts. Educators in both countries completed semi-structured interviews to understand their practices and perceptions related to engineering ethics. The interviews uncovered four themes related to the deprioritization of ethics in engineering education: the weight assigned to ethics in accreditation, the piecemeal integration of ethics in the engineering curriculum, the perceived status of ethics as soft and ancillary, and the lack of faculty training. Based on these findings, the chapter concludes with recommendations to bridge the divide between technical and nontechnical learning outcomes and support the more cohesive and interdisciplinary integration of ethics in engineering education.

Keywords: engineering culture, engineering education, ethics

8.1 Introduction

The integration of ethical concerns in the curricula of engineering programs is a recent addition, primarily driven by the adoption of the Washington Accord in 1989 and the first introduction of ethics as a criterion for accreditation by the US accrediting body in 2000. Despite this external mandate, the engineering curricula and culture have been slower to adapt and embrace ethics education. To understand the integration of ethics, it is first important to understand the culture of engineering education. The culture defines the beliefs and practices of the discipline and educational environment, which in turn, influence how engineering students are socialized into the culture through the process of professional formation.

8.1.1 Culture of engineering education

Engineering is a distinctive culture defined by norms, values, and behaviors of the profession (Lundgreen 1990; Godfrey 2003; Godfrey 2009; Carberry & Baker 2018; Bucciarelli 2008). Research (Cech 2014, Dryburgh 1999, Jamison et al. 2014) has shown that engineering culture is built on depoliticization and technical prioritization. The cultural identity of engineering established over time is of a more rigorous, difficult and complex discipline, a masculine field, fit for those who excel in mathematics and the physical sciences, devoid of subjectivity, and with a lesser orientation towards societal issues (Tonso 1999; Godfrey 2010; Stonyer 2002; Stevens *et al*. 2007; Cech 2014; Carberry & Baker 2018). Herkert (2001) sums up the major characteristics of the prevailing engineering culture, which appears to be

> readily recognized from both inside and out. Engineers are no-nonsense problem solvers, guided by scientific rationality and an eye for invention. Efficiency and practicality are the buzzwords. Emotional bias and ungrounded action are anathemas. Give them a problem to solve, specify the boundary conditions, and let them go at it free of external influence (and responsibility). If problems should arise beyond the work bench or factory floor, these are better left to management or politicians.

This culture has important implications for ethics education and guides the way ethics are taught and valued in engineering programs, which in turn is seen to contribute to the professional identify of engineering students (Loui 2005; Adams et al 2011; Cech 2014).

8.1.2 Professional formation of engineering students

Individuals begin their professional socialization before entering practice, as engineering education provides a fertile ground for enculturation. According to Tonso (1996, p.218), engineering education provides an "enculturation into a well-established system of practices, meanings and beliefs" as students "learn what it means to be an engineer" and what is valued by the discipline. Brint *et al. (*2008, p. 394) agree that

> once students have begun to take classes in their majors, they are also socialized into the cultures of the disciplinary domains […] and come to understand what it takes to gain recognition in the humanistic fields and competence in the scientific fields.

In a similar manner, Meijknecht and van Drongelen (2004, p.448) highlight a monolithic identity of engineers, as "a tribe with its own traditional set of values that are transmitted to the new members in a symbolic way during their initiation. […] University is a place of initiation for the tribe of engineers." Academic enculturation is seen to lead to a specific dominant socio-historical engineering identity, as "nuts and bolts" technicists (Faulkner, 2007).

While current engineering education culture promotes the development of a technically rigid identity disengaged from societal and welfare concerns (Cech 2014; Monteiro *et al.* 2017), a socio-technical integrative model such as the one suggested by Jamison *et al.* (2014) can foster the "formation of a hybrid identity and the exercise of social responsibility."

8.2 Research methods

This chapter synthesizes the findings of two studies that were independently developed and conducted in the US and Ireland. The studies were designed to explore the practices and perspectives of engineering ethics educators in the two national contexts to understand the integration of ethics in the engineering curriculum and culture.

8.2.1 Participant selection and demographics

The participants in both studies were part of larger research projects examining ethics and societal impacts education in engineering. In the US, the study surveyed the landscape of engineering ethics education and identified potential exemplars of instruction through a mixed-methods approach. In the first phase of the study, approximately

1400 educators completed an online survey (Bielefeldt *et al*., 2016; Bielefeldt *et al*., 2018; Bielefeldt *et al*., 2019). For those who indicated they taught ethics and/or societal impacts to engineering students, they were prompted to indicate the topics, teaching methods, course types, and assessment strategies associated with their instruction. At the end of the survey, respondents could provide their email address if they were interested in completing a follow-up interview. Of the 230 who indicated willingness to continue their participation in the study, 35 US educators completed an interview between Fall 2016 and Spring 2017. Participants were selected based on the descriptions of their teaching practices and courses in the survey with the aim of identifying potential exemplars of engineering ethics instruction across a range of course settings and disciplines (additional information found in Polmear *et al*., 2018; Polmear *et al*., 2020).

The study conducted in Ireland examined through mixed methods the conceptualization, implementation, teaching and evaluation of ethics in engineering programs that underwent accreditation during Fall 2017 to Spring 2019. Upon the completion of the sampling stage, the study identified a total of 23 Honours[1] programs offered by 6 institutions. To examine in more depth the views on ethics and its role in the context of engineering education, the study proceeded to interview instructors teaching dedicated modules on professional responsibility offered by the 23 participant programs, as well as evaluators serving on the accreditation panels for these programs. This led to a total of 21 participants being interviewed, of which 16 were included in their teaching capacity and five as evaluators.

The demographic overview of the gender and specialization of the participants in both the US and Irish studies is available in Table 8.1. In this chapter, the participants are identified by their pseudonym followed by their country (US for participants from the United States or IE for participants from Ireland) and their discipline (eng for participants with an engineering specialization or HSS for participants with a specialization in Humanities or Social Sciences).

Demographic Category	**Participants (n=35, US)**	**Participants (n=21, IE)**
Gender	F: 12, M: 23	F: 7, M:14
Specialization	Engineering: 32, Humanities and Social Sciences: 4	Engineering: 18, Humanities and Social Sciences: 3

8.2.2 Data collection methods

In both studies, the interviews with instructors were designed to explore their instructional practices and perspectives related to teaching ethics, including challenges they encountered and perceptions of culture related to ethics education. In addition, the study conducted in Ireland included interviews with members of accreditation panels, which explored the process of evaluating ethics for the purpose of accreditation, the understanding of the ethical accreditation criterion, views on the implementation of ethics based on their experience both as evaluators and as educators, challenges

[1] In the Irish engineering education system, Honours programs confer Bachelor Degrees, and are a required entry standard for the professional title of Chartered Engineer, while Ordinary programs confer Diplomas, and are a required entry standard for the professional title of Associate Engineer (Engineers Ireland, 2007).

encountered and perceptions of culture. The semi-structured interviews were conducted via a combination of online platforms and in person interviewing.

8.2.3 Integration of the two studies

To integrate the two studies conducted independently in the US and Ireland, given the similarities in scope and methodological approach, the authors gathered their data in a single table. The data were coded under four categories, related to descriptions of the weight given to ethics in the engineering curricula, its methods of implementation, its role in the curricula, and educators' expertise and preparedness to teach ethics.

8.3 The articulation of the status and perception of engineering ethics education

The status of engineering ethics education is articulated either in an explicit manner, by the participants themselves when commenting on how this subject is perceived by them or in the engineering academic environment, but also implicitly, by the characterizations they make of ethics when addressing other issues. The perception of the lesser status of ethics in the engineering curriculum is reflected on four levels: the weight given to ethics within the engineering curriculum, the integration of ethics, the description of the role of ethics in engineering education, and the expertise of those tasked with teaching ethics. These four themes were salient across both studies, suggesting that the challenges and perceptions detailed in the following sections transcend national boundaries.

8.3.1 The weight of ethics in engineering education

The lesser presence of ethics in the engineering curriculum was acknowledged both by participants from Ireland and the US. As Tom (US, HSS) observed,

> when we looked at the curriculum... the biggest portion in terms of course numbers is engineering science courses. And really ethics and broader social impacts are almost completely invisible in the biggest portion of an engineering curriculum.

Lochlan (IE, eng) agrees that, "how ethics is addressed is weak, one of the weakest points of every program." Neal (IE, eng), who has served as an evaluator on accreditation panels, considers that "the amount of course content dedicated to it would be minimal." Commenting on the weight given to ethics in the engineering programs evaluated, Neal considers that only "a couple" of modules cover ethics, while "most subjects probably are not covering it." According to Donald (IE, eng), "this is mostly the case everywhere," while George (IE, eng) declares himself "a bit disappointed with how little coverage there is."

The low weight given to ethics is cast in opposition to the centrality of technical subjects. As such, the engineering curriculum appears to be "very jam packed with technical content" (Luke, US, eng).

8.3.2 The integration of ethics in engineering education

Looking at how the integration of ethics is described, the studies conducted in Ireland and the US noted several similarities, according to which ethics appears as an add-on in the engineering curriculum, whose presence is justified by appeal to accreditation requirements, lacking a systematic implementation at the program level.

8.3.2.1 Ethics as an add-on

The presence of ethics in the engineering curriculum is not explained in terms of its essential character for the practice of engineering but is considered to be due to the requirements set by the accrediting body. As such, Leo (US, eng), describes the implementation of ethics in terms of compliance with the requirements set by the accrediting body, noting that "in many engineering programs you'll see the minimal compliance… accreditation is a driver but at least at [institution], minimal compliance is the rule." Donald (IE, eng) also considers that the introduction of ethics in the engineering curriculum is a response to accreditation requirements, stating that "a lot of engineering programs go 'well, we need to do something about it,' so they do something, and that is good, but it is seen as an add-on."

Patricia (IE, HSS) encountered a similar perception of ethics as an add-on, noting that "there is a sense this is not core to engineering, this is kind of an add-on that the professional association wants us to do". Cahill (IE, eng) describes the role given to ethics in similar terms, stating that "for the colleges putting the course together, ethics always is a bit like an add-on for a car." According to Bill (US, eng), "every time we try to teach ethics, it's seen as an add-on, a bolt-on to the program, it's outside students' purview of what engineering should be." This attitude seems to be linked to the students' "knowledge hierarchy, where engineering sciences are on top, engineering designs below that, their core courses like foundation courses in chemistry and physics below that, and then humanities and social sciences even below that" (Tom, US, HSS).

8.3.2.2 Unsystematic implementation

Given the perception of ethics as an add-on, its implementation in the engineering curriculum is not considered to be conducted in a systematic manner, but as a "box-ticking" exercise. According to Dan (US, eng), "by ABET standards we are required to do engineering ethics… per the accreditation, we are nominally ticking that box… but more confined to safety culture and intellectual integrity."

Patricia (IE, HSS) mentions a sense in which programs are not invested in the systematic development of engineering ethics education. Engineering programs are seen to have lower standards and expectations when it comes to the implementation of ethics, as opposed to the implementation of technical outcomes. According to Patricia, the perception within the academic environment is that the delivery of ethics can be outsourced to one person, through a fit for all pedagogical intervention:

> We are always the ethics work package and the work package is happening somewhere else. It is very difficult to integrate… because there are different expectations and ethics is often seen as a burden and something that is just annoying, and you have to take the tick the box approach, but it does not really matter. […] People outside of ethics seem to have a sense 'oh that is just kind of this general ethics course that you can plug it in everywhere. […] I have been asked 'can you not just give us this kind of ethics component that we can plug into everything?' I cannot.

Dervla (IE, eng) adds to this impression of the lower expectations set for ethics education, considering that "ethics seems to be kind of brushed over" in the engineering curriculum. Based on his extensive experience as an evaluator for the accrediting body, George (IE, eng) agrees that "many institutions still regard it as a sort of troublesome program outcome and they have to go looking for 'is there anything that we are doing that actually meets it?', rather than really building it in the design of the program". While technical outcomes are implemented in a systematic manner in the curriculum of engineering programs, according to George, ethics does not receive the same treatment. He considers that,

> if you take technical subjects, like structures or signal processing, the academics will make sure that the design of the program incorporates these, and in a logical and coherent way. But they do not take the same approach about the ethical material.

Cahill (IE, eng) confirms that it is common for programs to give a low priority to the implementation of ethics. According to Cahill, ethics "sometimes might appear like it is tagged on a bit at the end. […] It is not quite an afterthought, but it is there probably not given as much importance." Neal (IE, eng) shares this opinion, stating, "ethics is way down the priority list" and is "mainly there just to cover the requirements of Engineers Ireland."

The lack of a robust implementation of ethics conducted at program level is reflected also in the remarks that programs typically have only one individual who oversees this outcome. Reflecting on his extensive experience as an evaluator, George remarks that

> programs were all relying on this person to show that ethics has been integrated into the program. […] So I think that institutions have to be made aware that ethics is not something you can just put into a pigeon hole and say 'right, you are the one doing it' and that is enough going to get us through. It needs a lot more attention from everybody, and it need only be to a relatively small degree.

Looking at the perception of ethics within engineering institutions, the chasm between technical outcomes and ethical outcomes is further revealed. Ethics is not perceived to be essential for engineering practice and an integral part of engineering education. The presence of ethics in the curriculum, rather than being organic, is linked to the pressure exercised by the accrediting body, through its formulation of mandatory program outcomes. As such, ethics appears to be an "add-on", whose implementation can be "brushed over."

8.3.3 The perceived status of ethics in engineering education

Across both studies, educators described two prevailing perceptions of the role of ethics in engineering education: ethics as a "soft skill" and ethics as ancillary to the core of engineering.

8.3.3.1 Ethics is a "soft" skill

Within the Irish sample, ethics was regarded as a soft skill by the participants themselves (Dervla, Margaret) or within the institutional environment of the participants (Catrina; Patricia; Brendan). Describing the perception of ethics encountered in the

engineering academic environment, Patricia (IE, eng) considers that ethics is "always soft and always optional." Brendan (IE, HSS) adds that ethics is seen as a "soft skill because you have to know to build the bloody bridge first before getting into ethics. So you have to know your mathematics, your geometry and your trigonometry and all that good stuff." These comments suggest the prioritization of technical knowledge while reinforcing that ethics are a secondary consideration.

Furthermore, "soft" skills are seen to diminish the quality of an engineering educational program. According to Margaret (IE, eng), "some of the colleagues would think you were dumbing down the actual engineering content to make room for these softer skills, not just ethics, but what else has gone in there, teamwork."

Within the US sample, the participants themselves did not ascribe to the notion that ethics is a soft skill but described the prevalence of the dichotomy between soft and hard skills in engineering education. This dichotomy contributed to resistance from students and colleagues to ethics in the engineering curriculum. Leo (US, eng) described challenges in gaining acceptance of his engineering ethics courses from other members in the department and noted,

> The faculty generally believe that all engineering knowledge is technical, they seem not to understand that engineering ethics is part of the nontechnical knowledge that engineers need to have… there's this feeling that if it's not technical, then it's not something we want to be teaching in the department.

Similarly, Kim (US, eng) found that "it's going to be really hard to get buy-in across the faculty to make sure that it's taught where you think it should be taught," while according to Luke (US, eng), "some argue that these courses like mine are superfluous."

Lindsey (US, eng) described the evolution of how engineering educators perceive ethics and its problematic implications for the curriculum.

> People used to call them soft skills… then people started calling them professional skills, but I think we need to call them engineering skills because they're all engineering skills… every time we do that separation, the technical and social, we're creating this false separation and we keep reinforcing it in different ways.

Furthermore, the ways in which engineering ethics are described affect how they are framed in the curriculum. Although "soft" implies easy, Dixon (US, eng) expressed that "those skills are much harder to learn", which can produce resistance from students especially when ethics is taught as a secondary concern after technical skills. Dina (US, eng) also described how the language of "soft" does a disservice to the complexity of ethics and their inherent interconnection with engineer.

> I automatically react to anyone referring to recognizing the relationship between engineering and human kind as a soft skill because to me that's the most technical skills, to be able to know what's right to do when.

The framing of ethics as "soft" in engineering education creates a tension with the reality of engineering practice and by drawing a line between engineering and its ethical and societal implications, the curriculum can reinforce this dichotomy. Tom (US, HSS), who teaches in an engineering program that integrates ethics across the

curriculum, described that countering this dichotomy was the motivation behind the program's design.

> We see technical-social dualism as a barrier to rendering visible broader social impacts both in and around the curriculum. And technical social dualism just means that you make a mental split between the technical and the social. And you put one over here, and the other over here. And in your mind it's not like a Venn diagram where there's overlapping section. It's that they are separate. So, I'd say that technical social dualism is reinforced throughout the curriculum.

Tom's experience reveals an acute awareness of the prevailing split in engineering education and an effort to counteract this cultural and curricular norm, although he acknowledged his program was atypical.

8.3.3.2 Ethics is not core to engineering

Across both national contexts, educators expressed that there is a perception that ethics is not a core skill for engineers, framed in opposition to the fundamental role of technical skills. Ethics is described as a type of "support", "complimentary", or "ancillary" skill that is "other" than technical skills. This theme emerged both in the participants' personal perspectives and their understanding of the engineering education culture more broadly. In this regard, Conan (IE, eng) describes ethics as a "support skill for engineering." Samuel (IE, eng) shares the same opinion, adding that

> ethics does not really fit naturally into these hard technical subjects. […] you can argue about the support skills that they are not directly a skill that an engineer needs. […] One could lock all these things up in a different category and call them 'support skills' or some similar title.

Similarly, Margaret (IE, eng) described ethics "are not the technical skills, they are the other skills." Furthermore, she noted the problems raised by a crowded curriculum and a qualitative compromise that engineering programs have to do in order to meet the accreditation criteria. According to Margaret,

> to fit ethics in, you have to take something out, and a lot of my colleagues would think there is less room now for content that has to do with engineering, the fluid mechanics, thermodynamics, that kind of things, because you cannot keep the amount of contact hours the same.

Describing a similar attitude encountered in the academic environment, Enya (IE, HSS), noticed the perception that

> in a crowded curriculum, […] my instinct is that this might be how ethics is viewed. 'We do not need to do it, we can do our job without it. We can do our job successfully and be successful professionals without this part. In fact these hours here are taking away from hours where we could actually be engaged in something that is more important for our professional development. Why do we have to do this?'

Jarlath (IE, engineering) also remarks on the negative reaction generated by the introduction of ethics, as "there would have been people who would have been skeptical and they would have thought 'oh, ethics, why are we doing this?'" The presence of ethics in the engineering curriculum is seen to generate skepticism rooted in the view that it is a non-essential component for the professional formation of engineers. Karena (US, eng) described a similar resistance from her students: "I've definitely had

people even at the end of the course that I teach just ask what was the point of this, they don't really see it as being relevant to what they're going to do."

Ethical concerns were not seen as an integral part of the profession compared with other professions. Cahill (IE, eng) offers an explanation of why ethics is not considered a core engineering skill. According to Cahill, engineering practice is divorced from ethical concerns, compared to the prevalence of ethical considerations in other professions such as pharmacy and insurance. For him, "in pharmacy you have life and death situations. But in engineering? […] For engineers the consequences are not so severe." Similarly, "for insurance and all the rest, ethics must be a very very important consideration in education, but in engineering we are a little bit isolated from it."

8.3.4 Expertise of educators teaching engineering ethics

Educators in both countries who were tasked with teaching ethics described varying levels of familiarity and preparation. Similar to the perception that despite ethics being "soft" it is hard to learn for students, educators noted that ethics is "a harder subject to teach because it is softer" (Dervla, IE, eng). There was an apparent tension between the perception of ethics and the challenge of teaching it. The difficulty for educators stemmed in part from a lack of training. Lindsey (US, eng) noted, "we haven't done the faculty development that we need to do for folks to be ready to teach engineering ethics… I don't think we have people that are really prepared." The inherently interdisciplinary nature of engineering ethics created a challenge in which engineering educators are not "trained in the social sciences or liberal arts for the most part so they lack the kind of nuanced understanding of how to bring ethics into the classroom" (Bill; US, eng).

Without sufficient training, engineering faculty can feel "intimated" (Bart; US, eng) to teach ethics, leading programs to different approaches to fulfilling the accreditation requirement. Patricia (IE, HSS) noted the recalcitrance to teaching ethics and that it "can always be farmed out to the youngest staff member". Dervla noted that despite her lack of familiarity with the topic, she was chosen to teach the ethics course due to her professional experience in the private sector. Dervla considered that "if there was someone more expert in the field in my school, they would be teaching it. Now I am not saying that I am better than them, but we are all on a similar par." Similarly, Peadar (IE, eng) noted, "I was told to teach it, of course." Samuel (IE, eng) stated that he is teaching ethics because "somebody needed to do it", while Lochlan (IE, eng) was assigned this type of course "when I got here", and "did not ask for it." Among the 16 instructors interviewed in Ireland, ten admitted that initially they were not interested in teaching ethics, but there was no one else that could teach the subject. Those who were assigned to teaching ethics often did so through self-education due to the lack of formal training. For example, Margaret relied on a popular TV show and described her preparation process:

> I watched YouTube clips […] very short little videos on the ethics element of the Good Place and how it relates to the different philosophers, Kant and utilitarianism and rights and all the rest. And I found them very useful, because it was somebody, an academic, taking what was in the Good Place and distilling it down into an ethical snippet. […] The books were a bit too high level for me. […] I still find getting my head around ethics pretty tough.

The US sample was composed of engineering educators who were tasked with teaching engineering ethics, either due to the program requirement or their personal interest. Bart noted,

> I'm happy to teach this course because some of them [colleagues] would be intimidated by trying to teach that. The question of who teaches the class really is - is there someone like me who was an engineer, who has interest because I not only teach this but I write research articles on this topic and so it's something that comes easily to me. Whereas other of my colleagues who haven't done a lot of reading or writing on these topics are a little intimidated by the prospect of teaching it.

Two instructors in Ireland similarly described a personal motivation for teaching ethics. Conan and Donald aimed to introduce ethical content in the curriculum of their engineering program, and to attain this, had to pursue what they describe to be an institutional battle. Conan (IE, eng) recalls that

> I have to fight harder for this particular content in the course and I have fought an ongoing battle to retain it. Despite my efforts it has been pared down over the years, so I have been fighting a rear-guard action for some time.

Having looked at the preparation to teach ethics of the participant instructors, two situations stand out. On the one hand, a majority of the participants in Ireland were teaching the subject due to the fact that there was no one else in their home institution who could teach it, despite lacking an explicit interest or expertise in ethics. On the other hand, there were instructors across both studies who were very interested in ethics but faced institutional challenges to introduce a course dedicated to ethical content. These two extreme attitudes are revealing of the status of ethics in the engineering curriculum, highlighting that ethics is a subject for which there appears to be a lack of expertise and institutional support.

8.4 Engineering education: Need for culture change?

To put in perspective the findings presented above, it is important to pinpoint a structural explanation about the generative mechanism that lies at the basis of the current state and status of engineering ethics education. Reaching a diagnosis of the state of engineering ethics education is a prerequisite for suggesting strategies for change. As Rover (2008, p. 389) notes, the key to change is first understanding "what we are", before taking steps towards "what we are capable of becoming." Several of the participants interviewed pointed to cultural issues as the root of the current status and state of engineering ethics education. These cultural issues are represented by the traditional view of engineering as a "nuts and bolts" profession (Faulkner, 2007), as well as the primacy of technical skills perpetuated by engineering education (Wicklein, 1997; Stevens *et al.*, 2007).

According to Enya (IE, HSS), the diminished role of ethics in the engineering curriculum is "structural, it is not about my colleagues, it is coming from somewhere else". Donald (IE, eng) considers that the structural problem is represented by "a traditional mode, perhaps a reductionist scientific method, which divorces values and ethics from technical problems". Furthermore, Donald considers that instructors concerned with the integration of ethics are "fighting for a broader societal perception of ethics." For Jarlath (IE, eng), this is due to the "traditional conception that still exists,

[…] a traditional engineering perspective of that we have solved the problem technically and that is it." Tom (US, HSS) articulates that

> technical social dualism is reinforced throughout the curriculum, but especially in two large areas of the curriculum, in engineering science courses and humanities and social science courses. So, while the technical engineering science courses focus and privilege the technical, the humanities and social science courses in many universities do just the opposite. Based privilege and the social divorced from the technical. It's kind of like the same problem only inverted.

The challenges experienced in the implementation of ethics are traced to the way in which current instructors have been taught. As Cahill (IE, eng) states, "that is what we learned", adding that "maybe it will take a while for this to change". He highlights the role of education in shaping the mind set and values of engineering graduates, as well as passing on the message of what engineering amounts to. In this regard, Cahill further notes that "the current students will produce the future engineers and will have a better understanding of ethics because they have been brought up with it, compared with those of us who have been through the system a long time."

Patricia (IE, HSS) agrees that engineering instructors "are enculturated in a particular discipline," which influences how ethics are perceived within an engineering program. Patricia considers "important that the way they are being enculturated is the right way", and to achieve this there is a need to change how engineering education is conceptualized. For this, Patricia considers important to ask "how do you change culture?", and points to the pressure exercised by social circumstances in enabling this change. "I think culture changes when the circumstances change", concludes Patricia.

Aengus (IE, eng) also highlights the contributing role of education in shaping the attitude towards engineering ethics education. According to Aengus,

> the existing crop of academics were taught engineering in a very different way to the way we are teaching engineering now, and so getting people to think more holistically in their approach to engineering education is a slow process that is filtering its way through the programs in this country right now. But it is not quite there yet.

The traditional model of engineering education that prioritizes the acquisition of technical skills at the expense of ethics and socially oriented skills is considered to perpetuate a similar hierarchy by the current instructors. Sean (IE, eng), who is an industry representative with extensive experience sitting on accreditation panels, considers that the downplaying of ethics in the engineering curriculum "is coming from academic purity, from their own environment. That is the environment they have lived in, that is the environment they know, and that is the environment they focus on."

Reflecting on this model of engineering education that shaped him as an instructor, Peadar (IE, eng) considers that "in some ways, I have a very traditional view and I would defend the technical outcomes. I do not want to compromise that". Nevertheless, Peadar thinks that "a transformative thing is needed", which is linked to the development of a holistic model of engineering education. As such, Peadar notes that "I would like to see the engineering profession as a whole stepping up to that. I guess that begins in education". For Patricia, to achieve a transformation of engineering education, there is a need for "a little bit more collaboration, a little bit more integration" of the technical and ethical aspects.

Although "there is an increased consciousness by a lot of the colleagues" (Malachy, IE, eng), nevertheless there is some resistance encountered at institutional level

in effecting this change. For this reason, George (IE, eng) thinks that "it is much easier to engage students than staff." Dervla (IE, eng) agrees that

> although the more senior instructors are great at helping and are really friendly, they have been lecturing the same subjects for maybe a decade and they do not want to change them as it has been working perfectly fine for them for a decade. So they are not too eager to adapt and change.

Reflecting on the resistance to change, Patricia notes the ambivalence between the aspirations expressed in codes of ethics and accreditation requirements, and the actual implementation of ethics in the engineering curriculum. According to Patricia,

> the profession itself is ambivalent. They want to show how as a profession they take ethics seriously, but when they think about themselves as a profession, they think about themselves as people with a lot of technical skills. So there is the societal accountability element of the profession, that yes, it needs to show to society that they are taking concerns seriously, but that can quite heavily conflict with all the technical skills that people think would maybe need to be sacrificed if you give more space to the ethical side. So I think that the profession itself needs to be clear of what they want.

The interviews conducted in both Ireland and US point to the existence of a link between the diminished presence of ethics and its lesser status in the engineering curriculum on the one hand, and on the other hand, the engineering educational culture, characterized by the valorizing of technical knowledge, in which the current generation of instructors has been formed (Martin, 2020).

8.5 Conclusion and recommendations

The two studies conducted separately in the Irish and US system of engineering education point to similar key findings about how the dichotomy between technical and nontechnical skills is reflected in the engineering curriculum. First, ethics have a lower weight in the engineering curriculum compared to technical outcomes. Second, ethics are implemented in a non-systematic and uneven manner in the engineering curriculum. Third, ethics are perceived as "soft" and ancillary to the core of engineering. Fourth, it seems that there are fewer instructors specialized in teaching ethical content, compared with instructors specialized in teaching technical content, to the point that expertise in this subject is highlighted as a challenge. The similarity between the two explorations of the state of engineering ethics education points to a certain robustness of the findings about the existence of two cultures in engineering education. It would warrant additional research in other geographical contexts, with different accreditation requirements, to further determine similarities or points of difference. This is especially important given that the findings presented in this chapter originate in English speaking countries that have a dedicated accreditation criterion.

The findings are congruent with those by McGinn (2003), Flynn & Barry (2010), Fabregat (2013), Miñano *et al*. (2017), Lönngren (2020) and Sucala (2019), which revealed the diminished presence and lower status of ethics in the engineering curriculum. Instead of a systematic implementation, Flynn & Barry (2010, p.2) note the temptation of a "tick box approach to the teaching of ethical issues." More so, courses with a strong emphasis on ethics are regarded as "soft" and have a marginal role in a technically dominant curriculum, with fewer exams and assignments (Stonyer, 1998; Miñano *et al* 2017, Fabregat, 2013). As such, ethics is perceived as a "fuzzy"

discipline (McGinn, 2003), that is "something other" than engineering, "not very important" and of "inferior quality" (Lönngren, 2020).

Considering the weight given to ethics in the engineering curriculum, the instructors interviewed highlighted its low presence, confirming existing research (Colby & Sullivan, 2008; Barry & Ohland, 2012; Ocone, 2013; Monteiro *et al.*, 2016). In this sense, participants noticed a dichotomy between the lower attention and status given to ethics compared to technical outcomes. This is confirmed also by the numerical assessment of how courses meet each of the accreditation criteria that engineering programs in Ireland undertake for the purpose of accreditation (Martin *et al*. 2019). As Wicklein (1997, p.74) remarks, "historically, educators within technology education have given an exorbitant amount of instructional time to this area while slighting many of the other facets of the curriculum," such that humanities and social science requirements are often limited to "little more than a semester's worth, spread over an eight-semester degree program crammed with science and engineering" (Mitcham, 2014). To support the development of a socio-technical model of engineering education, such as the one envisioned by Jamison *et al*. (2014) and van den Hoven (2019), which aims to transcend the dichotomy between technical and non-technical skills and learning outcomes, we propose the following recommendations:

(i) introduce ethics as an accreditation criterion and develop continuing professional development (CPD) training programs for members of accreditation panels targeting the evaluation and formulation of recommendations on ethics
(ii) establish or foster interdisciplinary groups in engineering programs, bringing together philosophers, social scientists, and engineers,
(iii) encourage the integration of Science and Technology Studies and Liberal Arts in engineering education,
(iv) develop networks of engineering ethics educators to share best practices and develop new teaching initiatives,
(v) foster the development of repositories, teaching resources and materials,
(vi) develop a more intentional integration of ethics with technical content and a more thorough inclusion throughout the undergraduate curriculum, so ethics is not perceived as compartmentalized.

Acknowledgements

The authors would first like to thank the editor Eddie Conlon for recognizing the similarities between our approaches and for his generous initiative of connecting us and inviting us to be part of this book project. The US study is based on work supported by the National Science Foundation under Grant Nos. 1540348, 1540341, 1540308, and 1755390. Polmear thanks the research leadership team: Drs. Angela Bielefeldt, Nathan Canney, Chris Swan, and Daniel Knight. Access to data for the study conducted in Ireland was supported and facilitated by Engineers Ireland. The findings presented are part of Martin's PhD study, who wants to thank her supervisors and examiners team for their support and feedback: Eddie Conlon, Brian Bowe, Kevin O'Rourke (TU Dublin), Donal Holland (University College Dublin and Harvard School of Engineering) and Carl Mitcham (Colorado School of Mines). We also want to thank all instructors who participated in our study. Any opinions, findings, and

conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or Engineers Ireland.

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