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Global Engineering Ethics: What? Why? How? and When?

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RESEARCH

Global Engineering Ethics: What? Why? How? And When?[1]

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Introduction

Engineering is more cross-cultural and international than ever before, evident in the rise of international supply chains, multinational corporations, and knowledge and educational exchanges, among many examples (Luegenbiehl & Clancy, 2017; Wong, 2021; Zhu & Jesiek, 2017). This has prompted calls to internationalize or globalize engineering education, including ethics (Barakat, 2011, 2015; Barry & Herkert, 2015; Borri, Guberti, & Melsa, 2007; Jesiek et al., 2014; Del Vitto, 2008; Wang & Thompson, 2013). Ethics is central to engineering, since technology is never value neural. It exists to make peoples' lives better and, therefore, inevitably involves normative issues of right and wrong, central to ethics, even if only implicitly (Luegenbiehl & Clancy, 2017; van de Poel & Royakkers, 2011; Verbeek, 2006). Despite the fact that engineering programs, accreditation bodies, and multinational corporations have become increasingly interested in introducing global dimensions into professional engineering education and practice, there is little work in the existing literature providing an overview of questions fundamental to global engineering ethics.

Although engineering ethics textbooks have recently included discussions of the international and global dimensions of engineering, these have been largely afterthoughts (Luegenbiehl & Clancy, 2017). For example, Harris and colleagues' *Engineering Ethics* now includes a chapter discussing issues engineers might encounter in international contexts, such as exploitation, bribery, and corruption (Harris et al., 2018, Ch. 8), and Fleddermann's *Engineering Ethics* has descriptions of non-Western ethical theories (Fleddermann, 2012). However, engineering ethics must be rethought more fundamentally, since national cultures and technical regulations affect technologies and, therefore, the extent to which engineering serves different stakeholders (Clancy, 2021; Luegenbiehl & Clancy, 2017; Zhu & Jesiek, 2017).

[1] Portions of this article were adapted from Clancy & Zhu, "Global Engineering Ethics: What? Why? How? and When?", ©2021 American Society for Engineering Education, Virtual Annual Conference.

Even if students and practitioners have no interest in working internationally, training in the global dimensions of engineering ethics helps to develop moral sensitivity and empathy, including to help professionals discern and address values underlying even the domestic contexts of national engineering (Taebi, 2021). Further, the landscapes of emerging technologies are increasingly global. National engineering takes place in the contexts of an ever more globalized world, such that, to engineer well nationally, one must remain cognizant of these broader global contexts. For instance, the development and deployment of AI-enabled technologies often involves and affects peoples from non-Western and developing countries. In fact, labelling tasks central to AI algorithms are frequently completed by those in developing countries. Additionally, socially disruptive technologies – such as geoengineering and gene editing – which are underdiscussed in the current literature on engineering ethics, have the potential for global impacts that call for collaboration across cultures and countries. Of the work that does exist on global engineering ethics, there is considerable disagreement about if and how such collaborations should occur (Wong, 2021; Zhu & Jesiek, 2017).

To address these debates and promote reflection on global engineering ethics, this paper considers the what, why, how, and when of global engineering ethics. This form is adopted from an earlier article by Charles Harris, Michael Davis, Michael Pritchard, and Michael Rabins (Harris et al., 1996). That article and its authors have been influential to the development of engineering ethics during the last twenty-plus years. Therefore, using it as a point of reference provides an ideal way to survey the development and nature of global engineering ethics, noting similarities and differences. This article is organized according to the same questions Harris and colleagues pose. Under each question, their answers are briefly summarized, after which it is explained how these responses are challenged by the distinctive nature of global engineering. Whereas the first two sections about the what and why of global engineering ethics concern theoretical reflection and conceptual clarification, the next two sections (how and when) concern educational practices. We contend that educational practices and theoretical reflections/conceptual clarifications should mutually strengthen and reinforce each other, the how and when of educational practices needs to develop in terms of the what and why of theoretical reflections, and vice versa.

This article began as a conference paper, handling sources familiar to the authors from their own research and teaching (Clancy & Zhu, 2021). Based on audience feedback, and to ensure adequate representation of the existing literature, additional searches were carried out using "global engineering ethics" and "international engineering ethics" in Google Scholar, Web of Science, MEDLINE, and Scopus, as suggested by Bramer et al. (2017). The abstracts of the top twenty hits from each database were reviewed, identifying 25 additional journal articles, conference papers, and organization reports which were read in full. The contents of these reports, papers, and articles were then integrated into the framework of the conference paper, either citing the article when it dealt with a topic already handled, such as Verharen et al. (2021), or adding text and discussion when it had not, such as Powers (2016). The aim of this paper is to raise issues fundamental to global engineering ethics, by reviewing the existing literature and stating our own positions as researchers and educators who have spent their professional lives working in the field of global engineering ethics, including across numerous cultures, countries, and continents.

What?

Harris and colleagues begin by describing engineering ethics as a "professional" ethics – "engineering ethics" refers to particular duties and responsibilities that follow from the role of engineers as professionals but would not apply to everyone (Harris et al., 1996, p. 93). This is described in contradistinction to matters of right and wrong in general, which belong to the sphere of "personal morality." Morality should be of general concern to all people, whereas engineering ethics would only concern engineers, given their roles as professionals.

Based on this characterization, claim Harris and colleagues, ideally, engineering students would be "morally mature" by the time they enter the college or university classroom. By that age, students would already possess commonsense notions of right and wrong comprising morality, about which engineering faculty would have nothing to teach students. Rather, the role of engineering ethics education would be to address more specific facets of engineering as a profession, for instance, gaining familiarity with ethical codes maintained by professional organizations. This conception of engineering ethics has contributed to educational goals – for instance, fostering ethical understanding and reasoning among individual professionals, as codified in ABET and Washington Accord student outcomes (ABET, 2016; International Engineering Alliance, 2014). Yet the increasingly global environments of contemporary engineering present challenges to this understanding of engineering ethics, as well as corresponding educational approaches.

In the broadest sense, "global engineering ethics" refers to the recasting of engineering ethics in response to the increasingly cross-cultural, international characteristics of contemporary engineering (Luegenbiehl & Clancy, 2017; Wong, 2021; Zhu & Jesiek, 2017). This is important, since engineering ethics began in the US and has been based on assumptions about engineering and ethics that do not necessarily hold across countries and cultures (Davis, 1995; Herkert, 2000; Luegenbiehl, 2007, 2010; van de Poel, Zandvoort, & Brumsen, 2001). For example, it is not clear whether engineering can be considered a profession in many countries, which has implications for engineering ethics (Davis, 2009; Davis & Zhang, 2017; Didier & Derouet, 2013; Iseda, 2008; Luegenbiehl, 2004), for instance, the ability/desirability of practitioners separating personal morality from professional ethics (Luegenbiehl, 2004).

Even if morality could be separated from engineering ethics, alZahir and Kombo have argued that variations in the codes of ethics of professional engineering societies from different countries can be attributed to their unique sociopolitical, cultural contexts (AlZahir & Kombo, 2014). If engineering is a profession, then it is unlike other professions – such as medicine and law – the practice of which are largely confined to particular countries, cultures, and traditions. Practicing medicine across cultures can be difficult precisely because cultural groups subscribe to different notions of health, for example (Leeman, Fischler, & Rozin, 2011). Such difficulties beset engineering and technology. For instance, data exists across and can be used by individuals and organizations from different cultures and countries, raising both legal and ethical concerns – for example, understandings of and the importance attached to privacy (National Academies of Sciences, Engineering, and Medicine, 2018, Ch. 1).

Further, it is not the case that students are morally mature by the time they reach tertiary education. There is strong empirical evidence to suggest that this is an important formative period in ethical development (King & Mayhew, 2002; Schlaefli, Rest, & Thoma, 2008) – such that professional ethical and personal moral growth could go hand-in-hand – and thus requiring a reconsideration of Harris and colleagues' account. Various suggestions have been made for how to address the increasingly global environments of contemporary engineering, although there has been little agreement about what global engineering ethics should be.

Within these debates, Zhu and Jesiek have identified and described four main approaches in terms of how global engineering ethics has been conceived and taught: (1) global ethical codes – outlining principles for ethical engineering that would hold across cultures and nationalities; (2) functionalist theories – where engineering is conceived as a profession, such that it "functions" as a culture with a common ethical framework; (3) cultural studies – exploring how engineering and technology vary by culture, and the ethical implications of these differences; and (4) global ethics and justice – similar to global ethical codes, but concerned with ethical principles, in general, rather than ones specific to engineering (Zhu & Jesiek, 2017).

These four approaches fall into two more general ones that could be termed "universalist" versus "particularist." Approaches 1, 2, and 4 are universalist in their aspirations, focused on formulating codes of ethics, theories, and curricula that would apply across cultures and nations, whereas approach 3 could be described as particularist, tailoring their form and contents to different national and cultural traditions. Particularist approaches have involved including more geographically and topically diverse case studies, discussions of culture/values and how these affect engineering, and non-Western philosophical and cultural perspectives (Cao, 2015; Clancy, 2021; Downey & Lucena, 2005; Downey, Lucena, & Mitcham, 2007; Luegenbiehl, 2004; Luegenbiehl & Clancy, 2017; Ma, 2021;

Masten et al., 2021; Verharen et al., 2021; Zhu, 2018). Universalist approaches have generally involved identifying ethical principles for engineering that should hold across cultures and countries (Luegenbiehl, 2010; Peirson & Barakat, 2009; Powers, 2016). Some have argued these efforts are superfluous since a common basis for such principles already exists. For example, Davis and colleagues have claimed engineering *is* a globalized profession, and therefore is already sufficiently similar across cultures and countries (Davis, 2015). Yet others argue, just as there are distinct national cultures, so too do engineers worldwide have their own localized professional cultures (Luegenbiehl, 2010; Luegenbiehl & Clancy, 2017).

However, both universalist and particularist approaches could be problematic. Ess has pointed out the ways that particularlism can denigrate into "balkanization," an unjustified fragmentation of ethical perspectives and guidelines, while universalism can denigrate into "homogenization," an unjustified melding of these perspectives and guidelines (Ess, 2020). To address these problems, Luegenbiehl and Clancy have proposed a synthesis of the particularist and universalist approaches. Their approach begins with broad ethical principles derived from the values of engineering and evolved nature of human cognition, which are then applied to and further refined in relation to case studies representing different technologies and cultural concerns, a "bottom-up" approach further discussed below (Clancy, 2021; Luegenbiehl & Clancy, 2017).

Powers has recommended a similar methodology, beginning with descriptive facts characteristic of engineering across cultures, and then deriving normative principles on this basis (Powers, 2016). This approach pulls heavily on insights from and methodologies associated with empirical moral psychology, concerning how people *actually* think about issues of right and wrong and why, rather than how they *should* think about issues of right and wrong and why – questions that belong to the domain of normative and applied ethics (Greene, 2014; Haidt, 2012; Henrich, 2015). This is important since, to a certain extent, normative debates within global engineering ethics could be resolved empirically, for instance, by investigating the extent to which engineering functions as a culture, or if engineering is a globalized profession outside the US (Davis, 2009; Davis & Zhang, 2017). Such questions open onto the why of global of engineering ethics.

Why?

To reduce the likelihood of engineering tragedies and disasters, Harris and colleagues list eight outcomes of engineering ethics education: (1) stimulate ethical imagination; (2) identify ethical issues; (3) analyze and apply concepts; (4) take responsibilities seriously; (5) develop ethical sensitivity; (6) learn about technical, professional standards; (7) improve ethical, technical judgments; and (8) increase ethical willpower (Harris et al., 1996, pp. 93–94). These outcomes are important because of the tremendous power engineers have to affect millions of lives, and since evidence suggests that engineering students generally do not expect to encounter ethical issues and are not, therefore, capable of dealing with them effectively (Balakrishnan & Tarlochan, 2015; Clancy, 2020b; McGinn, 2003). Ethics education can help practitioners to anticipate and navigate the kinds of issues they are likely to encounter (Clancy, 2021). These same outcomes are important in global engineering ethics, although additional circumstances related to the cross-cultural, international environments of engineering motivate the importance of *global* dimensions specifically.

Since engineering occurs across different cultures and countries, engineers are further removed in space and time from the effects of their work with technology. As a result, it becomes more difficult to discern the effects of this work on human life, the environment, and so on, as well as to assign responsibility for such effects (Luegenbiehl & Clancy, 2017; van de Poel, Royakkers, & Zwart, 2015; Zhu, Martin, & Schinzinger, 2022). Bielefeldt and colleagues found that traditional engineering education fails to address the kinds of issues engineers are likely to encounter working with marginalized global communities, such as poverty, sustainability, and uncertainty (Bielefeldt et al., 2021). These circumstances motivate the importance of what van den Hoven terms “comprehensive engineering,” to address “problems concerning vast ‘systems of systems,’ comprising both socio-technical systems and eco-systems” (van den Hoven, 2019, p. 1790).

Further, disagreements can arise about appropriate courses of action, what should or should not be done, based on different regulatory schemes. Since technical and professional standards vary by country, improving technical judgments through ethics education would become more difficult in international environments – for example, the technical standards of which country should apply (Zoltowski et al., 2014)? More fundamentally, culture has been shown to affect psychological and social structures and phenomena, including self-concepts, ethical judgments, values, and so on (Henrich, Heine, & Norenzayan, 2010; Nisbett, 2010).

This raises questions of inclusivity and diversity in engineering education. Despite high and increasing rates of foreign enrollment – and more engineering schools developing programs and experiences that focus on the global dimensions of engineering – ethical issues arising from global and cross-cultural engineering practice are far from sufficiently handled in current curricula. The diverse cultural and educational experiences of students have been overlooked in US engineering ethics education. Given that an increasing number of US students will have chances to work with peers from other cultures within and outside the US, incorporating global dimensions into engineering ethics education is critical for preparing US students for future employment opportunities fueled by the global economy. More specifically, an engineering ethics curriculum with global dimensions can broaden students’ ethical perspectives, enrich their learning experiences, and enhance their moral sensitivity and imagination. Creative solutions to increasingly challenging ethics scenarios often call for the use of diverse ethical frameworks (Zhu & Jesiek, 2020). In general, a culturally diverse engineering ethics curriculum will increase the engagement of underrepresented student populations – particularly international students – in discussions. Global engineering ethics, therefore, goes hand in hand with, and can help to promote, greater diversity and inclusion in engineering practice (Taebi, 2021). Given these considerations, international graduate students warrant particular attention.

Studies have shown that close to half of all engineering graduate students in the US are international students, and the majority of them will remain in the US after graduation (Newberry et al., 2011). These students will assume a critical role for technological and economic development in the US. Nevertheless, these students often do not receive formal and systematic professional ethics education (including diversity and inclusion education) in graduate school (Gu, 2016). Different teams have begun to address such concerns, including Austin and colleagues who have developed ethics training to acculturate foreign graduate students at Texas Tech, Baylor University, and University of Texas, Austin (Austin et al., 2011). At Delft University of Technology and University of California, Berkeley, Sunderland, Taebi and colleagues have piloted ethics training focused on the global dimensions of engineering practice (Sunderland et al., 2014; Taebi & Kastenberg, 2019).

Nevertheless, engineering educators who teach and mentor international graduate students tend to face two challenges: On the one hand, they do not know the kinds of engineering ethics education these students received in their own countries before coming to the US. On the other hand, most graduate engineering programs in the US do not provide systematic professional ethics education.

For these reasons, culture and globalization would be relevant to the outcomes Harris and colleagues list. For example, it would be important to understand how culture affects the development of ethical imagination, ethical understanding and the application of concepts, taking responsibility for oneself, and so on (Buchtel et al., 2015; Feinberg et al., 2019; Markus & Kitayama, 1991). As was mentioned above, tacit assumptions about the relative strength of culture and/or education in shaping judgments and behaviors lead to differences between the particularist and universalist positions described above. Universalists such as Davis assume the effects of education (or professional formation) are stronger than those of culture, such that cultural differences between people and groups would be offset by technical education, professional guidelines and culture, and so on (Davis, 2009, 2015; Davis & Zhang, 2017). By contrast, particularists assume the effects of national culture are stronger than professional influences (Downey & Lucena, 2005; Downey et al., 2007; Luegenbiehl, 2004).

Fortunately, in recent years, a growing amount of research within empirical moral and cultural psychology (Haidt, 2012; Henrich et al., 2010; Nisbett, 2010), and experimental philosophy (Gold, Colman, & Pulford, 2014; Machery, 2017), has examined the nature of ethical judgments and behaviors, and the effects of culture and education. For example, Chinese are more likely than US participants to make ethical judgments based on the outcomes of actions rather than the intentions of actors – in other words, actions are judged good or bad because of their good or bad outcomes rather than the good or bad intentions of actors (Feinberg et al., 2019; Gold et al., 2014; Machery, 2017). Other studies have found that hospital administrators are more likely than physicians or the public to make sacrificial decisions, deciding that harming a few is okay to help many (Ransohoff, 2011). Such findings and methods could mediate debates between universalists and particularists, improving how engineering ethics is conceived and taught.

At present, however, the fields of engineering and technology ethics remain largely disconnected from this work, with some notable exceptions (Beever & Pinkert, 2019; Clancy, 2020a; Clancy & Hohberger, 2019). Researchers from Turkey, China, Japan, Malaysia, and Chile have undertaken empirical work to understand the ethical perspectives of non-US/Western engineering students and instructors (Balakrishnan & Tarlochan, 2015; Zhang & Zhu, 2021), although only some of this work has been systematically comparative in nature – in other words, conducted with the intention of comparing cultural differences (Balakrishnan, Tochinai, & Kanemitsu, 2018; Clancy, 2020b; Murrugarra & Wallace, 2015).

How?

As with other forms of applied ethics education, engineering ethics has tended to use case studies. Case studies are descriptions or narratives of events or scenarios with contents specific to a given field, for example, business, medicine, law, or engineering, in relation to which participants must think critically and answer questions. Harris and colleagues recommend the use of case studies to teach engineering ethics, outlining two broad approaches to case-study analysis: (1) drawing the line; and (2) resolving a conflict (Harris et al., 1996, pp. 94–95).

In the first, participants consider controversial cases, where a right course of action would be unclear. Participants then consider decisions that would be clearly right and clearly wrong, arriving at a better sense of why this would be, and then applying this knowledge to the controversial case under consideration. In the second, participants consider cases with conflicts, where two competing obligations cannot be met at once. According to Harris and colleagues, this requires imagination, creatively navigating different goods.

Since the publication of the original article by Harris et al. (1996), there has also been a proliferation of methods used for teaching engineering ethics. For example, Davis has pioneered the use of "micro insertions" for engineering ethics, ways of slightly altering engineering problems to give them an ethical dimension (Davis, 2006; Riley et al., 2009). Others have used role playing and games to teach engineering ethics (Lau, Tan, & Goh, 2013; Lloyd & van de Poel, 2008; Prince, 2006). These and other developments have been described in reports published by the National Academy of Engineering in 2008 and 2016 (National Academy of Engineering, 2008, 2016). Despite these developments, case-study analysis is still one of the most widely used ways to teach engineering ethics (Herkert, 2000; Hess & Fore, 2018). However, the nature of case studies and how they are used has changed.

Harris and others have called for the development of more diverse case studies, focusing on not only engineering disasters but also aspirational ethics and design work (Harris, 2008; Harris et al., 2018; Luegenbiehl & Clancy, 2017; Verbeek, 2006). Canary, Herkert, and colleagues have worked towards the integration of "macro" cases within engineering ethics that deal with greater numbers of people, places, technologies, and periods of time than "micro" cases, typically concerning the behaviors of a few individuals confined to incidents surrounding disasters (Canary et al. 2012; Herkert, 2000, 2001, 2005). The case study approaches recommended by Harris and colleagues have generally come to rely on professional codes and/or philosophical ethics, using principles from professional codes of ethics and/or normative ethical theories to draw a line or resolve a conflict (Hess & Fore, 2018; van de Poel et al., 2001). As with what engineering ethics is and why it should be taught, however, the global environments of engineering and technology affect *how* engineering ethics should be taught.

Given the importance of contextualizing ethical issues in different cultures and regions, case studies are still likely one of the best ways to teach global engineering ethics – perhaps even more appropriate in these contexts. However, as with the push to expand case studies to include aspirational and design contents, those used in global engineering ethics must involve a broader range of geographies and topics, for instance, not only disaster cases in the US, but also ones about emerging technologies in Asia, or engineering practices spanning multiple countries (Clancy, 2021; Hess, 2013; Luegenbiehl & Clancy, 2017; Verharen et al., 2021). Such cases can focus on the various impacts of technologies on different countries and peoples, diverging laws and values, and so on. Methods used to study cases would also have to be changed accordingly.

Rather than "top-down" approaches, which begin with codes and/or ethical theories and then apply these to cases, a "bottom-up" approach should also be taken, which begins with cases and arrives at principles (Clancy, 2021; Luegenbiehl & Clancy, 2017). This approach has a number of advantages. First, as mentioned previously, disagreement exists regarding what it means to be ethical, both culturally and across fields (Buchtel et al., 2015; Haidt, 2012; Ransohoff, 2011; Stappenbelt, 2013). As a result, choosing any one code or ethical theory is problematic. Western codes and ethical theories have generally been used in engineering ethics education, which risks introducing cultural bias into global engineering curricula (Luegenbiehl & Clancy, 2017). Western codes and/or ethical theories could and have been swapped out for others, but this simply shifts the problem, recreating the impasse in different terms (Luegenbiehl, 2010). Engineering students and practitioners must be able to work with individuals from different cultures and countries, necessitating flexibility and an awareness of different values (Zhu & Jesiek, 2020).

Second, it is not clear that "applied" approaches to ethics are psychologically realist, i.e., based on accurate assumptions about how people think and behave. A growing body of work provides evidence that human beings are moral pluralists, and that ethical judgments are not exclusively/primarily the result of rational processes (Greene, 2014; Haidt, 2012; Roeser, 2018). This means that people conceive of ethics as being about many things (pluralism) rather than only one (monism), and that "intuitions," which are closer to emotions than rational reflections, play a crucial role in making ethical judgments.

Third, a bottom-up approach better motivates the importance of ethical codes and principles, potentially increasing adherence. Rather than appearing as the imposition of an external authority, a bottom-up approach demonstrates the origins and importance of ethical principles, where the principles come from and why they would be important (Luegenbiehl, 2010; Luegenbiehl & Clancy, 2017). As a result, students and practitioners would be more likely to take seriously and adhere to ethical guidelines if they understand and feel ownership of these principles, including by reflecting on and formulating them in case-study analysis.

Fourth, this approach bypasses problems that can arise in attempting to address the parochialism of engineering ethics. As was mentioned above, engineering ethics began and has developed in the US, possessing characteristics perhaps not readily applicable to different national and cultural groups. One way of addressing this bias would be to consider and include non-Western ethical theories (Clancy, 2020b; Harris et al., 2018; Zhu, 2018). Although a significant step beyond consequentialism, deontology, and virtue ethics alone, this raises problems similar to the use of Western ethical theories: It is not clear that these theories provide a more satisfactory account of ethical judgments and/or behaviors, or that they are more descriptively or normatively correct.

Finally, a bottom-up approach can help to better identify the nature of ethical disagreements and, therefore, resolve them. Ethical disagreements can result from either differences in normative judgments, about what people should or should not do, or disagreements about descriptive claims, concerning how things are. It can be difficult to identify the nature and sources of such disagreements. The bottom-up approach described here addresses the nature and significance of normative issues versus descriptive claims at different steps in the case-study procedure (Clancy, 2021; Luegenbiehl & Clancy, 2017). This helps participants to practice identifying the sources of such disagreements, whether they are normative or descriptive in nature.

When?

Harris and colleagues recommend including as much ethics in the curriculum as possible, as often as possible, in the form of standalone courses, integrated modules, guest lectures, and so on (Harris et al., 1996, pp. 95–96). Since this recommendation was made, various groups of scholars have assessed the effects of such interventions. To begin, research has found that standalone courses in engineering ethics are more effective in fostering ethics outcomes than integrated modules. However, this is only the case when the standalone courses deal with engineering ethics specifically. Studies suggest that standalone courses are not more effective than integrated modules if they concern philosophical ethics in general, or technology and values (Clancy, 2020a; Drake et al., 2005). Additionally, more exposure to ethics education alone does not necessarily result in better outcomes; it likely depends on the nature of the curriculum (Mulhearn et al., 2017).

Other developments in engineering education more generally are significant for engineering ethics specifically. For example, engineering education now often includes options for service learning and industry-sponsored projects, in courses and through extracurricular experiences, encouraging students to take an interest in and become familiar with relevant stakeholders (Zoltowski & Oakes, 2014). Some such programs have global dimensions, for instance, organized through Engineers Without Borders (EWB). These initiatives attempt to suffuse the educational experience with engineering, making it more hands-on and giving students more learning opportunities. Work in engineering ethics has followed a similar tack, using problem- and service-learning-based opportunities to introduce and assess ethical understanding (Berdanier, Tang, & Cox, 2018; Poursharif et al., 2021). Similarly, ethics-across-the-curriculum programs aim to suffuse engineering education with ethics.

All of these places in the curriculum could be candidates for the inclusion of global engineering ethics education, altering the contents and form of education to add cross-cultural and international dimensions. Jesiek and colleagues have begun such work, outlining global competencies in engineering and developing education to foster these, including ethical decision-making through educational videos and scenario-based instructional exercises and assessments (Jesiek et al., 2014; Zhu & Jesiek, 2020).

It has been widely acknowledged that the engineering curriculum is already packed. While some engineering educators are eager to integrate various technical and non-technical competencies, the list of professional competencies to integrate is now getting much longer. Some critics may argue that integrating global dimensions into engineering ethics will bring challenges to the already packed curriculum and, thus, increase the workload of both students and faculty. Although such a worry is valid, there are numerous ways to respond to this worry.

First, learning outcomes could be "meta-integrated." Meta-integration consists in creating activities that fulfill multiple learning outcomes and serve different professional competencies simultaneously and then integrating such learning activities into educational modules. An example of this this would be the presentation of an international capstone project that addresses learning outcomes related to communication, global, and ethical competencies. Doing so would be helpful in at least two ways: it would (1) not generate additional burdens on already packed engineering curricula; and (2) provide more realistic and "spontaneous" learning environments for engineering students, much closer to their actual future working environments. Second, engineering curricula could be modelled on design curricula. Design curricula typically identify and track the effects of technology on different stakeholders throughout the design process (Norman, 2013; Zoltowski & Oakes, 2014). The effects of technology on stakeholders are central to engineering ethics. As a result, if engineering curricula were modelled on design curricula, then ethics would be included at the beginning and throughout the engineering curricula (Civjan & Tooker, 2020; Spiekermann & Winkler, 2020; Van Grunsven et al., 2021). Third and finally, all engineering ethics could be conceived and taught in terms of global engineering ethics. Global engineering ethics is motivated by the increasingly cross-cultural and international environments of contemporary technology, as noted above. Assuming these environments continue to expand, engineering will become ever more global. As a result, national conceptions of engineering will become less representative. To begin to address this gap, engineering ethics could be presented from a global perspective – global rather than national engineering ethics would become the pedagogical and professional standard.

Conclusion

Engineering ethics began in the US and has largely evolved as a Western phenomenon, based on assumptions that might not hold across different cultures and countries. However, engineering is more global, cross-cultural, and international than ever before, and engineering ethics must follow suit. But disagreements exist about if and how this should occur, i.e., what it would mean for engineering ethics to be "global." To introduce and promote these debates, the foregoing has outlined the what, why, how, and when of global engineering ethics, surveying trends within the field and directions for possible future developments.

Global engineering ethics can be beneficial for and benefit from engineering ethics education programs developed in domestic contexts. On the one hand, traditional pedagogies and assessment tools can inspire and inform teaching resources for global engineering ethics. On the other hand, these pedagogies and assessment tools can be strengthened through their broader use, for instance, by exploring the validity and reliability of assessment tools in cross-cultural contexts. Most engineering ethics pedagogies and assessment tools have been developed in domestic contexts for US students, and more empirical exploration is needed to examine the extent to which these resources would be valid in cross-cultural settings. Research and practice in global engineering ethics can provide findings that inform domestic engineering ethics and even more fundamental ethical questions (for instance, what it means to be a professional engineer, and whether moral judgments or intuitions constitute the foundations of ethical decision-making).

Ideally, integrating global dimensions into engineering ethics would not simply teach students practical skills that allow them to competently navigate ethical issues arising from international and cross-cultural engineering practices. It would also allow engineering students to broaden their scope, develop awareness of interconnectedness, and cultivate moral sympathy and creativity. Curricula in global engineering have been shown to increase ethical knowledge, reasoning, and intuitions among engineering students in general (Chung, 2014; Clancy, 2020a; Newberry et al., 2008). Therefore, global engineering ethics would benefit even those students whose future roles mainly serve local populations.

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