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

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Abstract

Despite the fact that engineering programs, accreditation bodies, and multinational corporations have become increasingly interested in introducing global dimensions into professional engineering practice, little work in the existing literature provides an overview of questions fundamental to global engineering ethics, such as *what* global engineering ethics is, *why* it should be taught, *how* it should be taught, and *when* it should be introduced. This paper describes the what, why, how, and when of global engineering ethics. This form is adopted from a 1996 article written by Charles Harris, Michael Davis, Michael Pritchard, and Michael Rabins, which has influenced the development of engineering ethics for over twenty years. In this paper, we begin by describing global engineering ethics as a response to the increasingly cross-cultural, international characteristics of contemporary engineering. To so do, we describe four fundamental approaches proposed by scholars and implemented in curricula: (1) global ethical codes; (2) functionalist theories; (3) cultural studies; and (4) global ethics and justice. Next, we explain the motivations for global engineering ethics: Neither educators nor practitioners can necessarily assume a shared nationality or culture among students or between coworkers. Third, we outline discussions about how global engineering ethics should be taught. One of the most prevalent approaches uses case studies with a cross-cultural and/or international dimension, or a form of case-study analysis that takes a "bottom-up" – versus "top-down" – approach. Finally, we identify spots within the engineering curriculum for global engineering ethics: standalone courses, integrated modules, micro-insertions, competence-based training scenarios, and extracurricular activities, such as study, research, service-learning, and humanitarian engineering programs abroad. As the world becomes increasingly cross-cultural and international, ongoing training in global ethics will be essential to both students and practicing engineers.

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 [1]–[3]. This has prompted calls to internationalize/globalize engineering education, including ethics [1], [4]–[7]. 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 [1], [3]–[16], there is little work in the existing literature providing an overview of questions fundamental to global engineering ethics. Of the work that does exist, there is considerable disagreement about if and how this should occur [3], [8].

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 a 1996 article by Charles Harris, Michael Davis, Michael Pritchard, and Michael Rabins [17]. That article and these 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 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, we first briefly summarize their answers and then delineate how their responses are being challenged by the distinctive nature of global engineering. This is neither an exhaustive nor a systematic survey but a rather a summary of some major trends to date.

What?

Harris and colleagues begin by describing engineering ethics as a "professional" ethics [17, p. 93]. Therefore, engineering ethics refers to particular duties and responsibilities that follow from the role of engineers as professionals but would not apply to everyone. This is understood 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 classroom. By the age of university, students would already possess commonsense notions of right and wrong comprising morality. Engineering faculty members would have nothing to teach students about this. Rather, the role of engineering ethics education would be to address facets of engineering as a profession, for instance, gaining familiarity with ethics codes. This conception of engineering ethics has contributed to educational goals – for example, fostering ethical understanding and reasoning among individual professionals, codified in ABET and Washington Accord student outcomes [18], [19]. The increasingly global environments of contemporary engineering present challenges to this understanding of engineering ethics and 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 [2], [3], [8]. 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 [9], [20], [21]. For example, it is not clear that engineering can be considered a profession outside the US, which has implications for engineering ethics [22]–[26], for example, the ability/desirability of practitioners separating personal morality from professional ethics [24].

Even if morality could be separated from engineering ethics, Saif alZahir and Laura Kombo have discovered that variations in the codes of ethics of professional engineering societies from different countries can be attributed to their unique sociopolitical and cultural contexts [12]. If engineering is a profession, then it is unlike other professions such as medicine and law, the practice of which is largely confined to a particular country, culture, and tradition. Although international medical and legal organizations exist, the ways individual practitioners treating/working with patients/clients from different countries and cultural traditions are not homogeneous. Practicing medicine across cultures can be difficult since cultural groups subscribe to different notions of health [27], [28].

Further, it is not the case that students are morally mature by the time they reach university. There is strong empirical evidence to suggest that university is an important formative period in ethical development [29], [30] – such that professional ethical and personal moral growth could go hand-in-hand – 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, Qin Zhu and Brent Jesiek have identified and described four main approaches to global engineering ethics: (1) global ethical codes; (2) functionalist theories; (3) cultural studies; and (4) global ethics and justice [8]. These four fall into two more general approaches, what could be termed "universalist" versus "particularist." Approaches 1, 2, and 4 are universalist in their aspirations, 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. Particularlist 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 [2], [14], [24], [31]–[35]. Universalist approaches have generally involved identifying/formulating (engineering) ethical principles that should hold across cultures and countries [9]. Michael Davis has argued that developing global engineering ethics is superfluous, since engineering is a *globalized* profession and, therefore, already sufficiently similar across cultures and countries [15]. Just as Chinese, French, Brazilians, and Egyptians, for instance, have their own national cultures, so too do engineers worldwide have their own professional culture [2], [9]. Heinz Luegenbiehl and Rockwell Clancy have proposed a relative synthesis of the particularist and universalist approaches [2].

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 [2], [14]. This approach pulls heavily on insights from and methodologies associated with empirical moral psychology, concerning how people think about issues of right and wrong and why [36]–[38]. This is important since, to a certain extent, debates within global engineering ethics could be resolved empirically, for instance, the extent to which engineering functions as a culture, or if engineering is a globalized profession outside the US [22], [23]. 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 [17, pp. 93–94].

These outcomes are important because of the tremendous power engineers have to affect millions of lives, and since engineering students generally do not expect to encounter ethical issues and are not, therefore, capable of dealing with them effectively [39], [40]. Ethics education can help practitioners to anticipate and navigate the kinds of issues they are likely to encounter [14]. 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 [2], [41], [42]. Additionally, 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? More fundamentally, culture has been shown to affect psychological and social structures/phenomena, including self-concepts, ethical judgments, values, and so on [36], [43]–[47].

Despite high, 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 discussed 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 diverse ethical frameworks. 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 [48]. 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 [49]. These students will assume a critical role for the 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 [50]. Therefore, engineering educators who teach and mentor these international graduate students are facing two challenges: On the one hand, they are not aware of what kinds of engineering ethics education these students received in their own countries before coming to the US. On the other hand, most of the current graduate engineering programs do not provide systematic professional ethics education to these students.

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, understanding and application of concepts, taking responsibility for oneself, and so on [28], [47], [51], [52]. 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/culture, and so on [15], [22], [23]. By contrast, particularists assume the effects of national culture are stronger than those of professional guidelines/culture, technical education, and so on [24], [34], [35].

Fortunately, in recent years, a growing amount of research within empirical moral and cultural psychology [36], [43], [44], and experimental philosophy [45], [53], has examined the nature of ethical judgments and behaviors, and the effects of culture and education. Such findings and methods can mediate debates between universalists and particularists, improving engineering ethics. At present, however, the fields of engineering and technology ethics remain largely disconnected from this work, with some notable exceptions [40], [54], [55].

How?

As with other forms of applied ethics education, engineering ethics has tended to use case studies. Case studies are descriptions/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 [17, 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 their article, there has also been a proliferation of methods used for teaching engineering ethics. Michael Davis has pioneered the use of “micro insertions” for engineering ethics, ways of slightly altering engineering problems to give them an ethical dimension [56], [57]. Others have used role playing and games to teach engineering ethics [58]–[60]. These and other developments have been described in reports published by the National Academy of Engineering in 2008 and 2016 [61], [62]. Despite these developments, case-study analysis is still one of the most widely used ways to teach engineering ethics [63]. However, the nature of case studies and how they are used has changed.

Charles 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 [2], [31], [64], [65]. Joseph Herkert and colleagues have worked towards the integration of “macro” cases within engineering ethics, cases dealing 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 [66]–[68]. 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 [21], [63]. 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 cultural and regional contexts, case studies are 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 [2], [10], [14]. 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 a "top-down" approach, which begins with codes and/or ethical theories and then applies these to cases, a "bottom-up" approach should also be taken, which begins with cases and arrives at principles [2], [14]. 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 [36], [47], [69], [70]. 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 a subtle form of cultural bias into global engineering curricula [2]. 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 [9]. Engineering students and practitioners must be able to work with those from different cultures and countries.

Second, it is not clear that "applied" approaches to ethics are psychologically realist, that they are 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 [36], [37]. 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 [2], [9]. 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, 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 [22]–[26]. One way of addressing this bias would be to consider and include non-Western ethical theories [31], [32], [40]. 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 proper account of ethical judgments and/or behaviors, that they would be 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 [2], [14]. 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 [17, pp. 95–96]. Since this recommendation was made, teams have assessed the effects of these interventions.

Research has found that standalone courses are more effective in fostering ethics outcomes than integrated modules, but only courses concerned with engineering ethics specifically – not ethics in general or courses on technology and values – and that more exposure to ethics education does not necessarily result in better outcomes [40], [71], [72]. Other developments in engineering education more generally are significant for engineering ethics specifically.

Engineering education now includes service learning and corporate sponsorship, in courses and extra curricularly, encouraging students to take an interest in and become familiar with relevant stakeholders [73]. Some such programs have global dimensions, for instance, organized through Engineers without Borders. These initiatives attempt to suffuse the educational experience with engineering, making it more hand's-on and giving students more learning opportunities. Work in engineering ethics has followed a similar tack. For example, 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. Brent 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, scenario-based exercises, and forms of assessments [1], [74].

It has been widely acknowledged that the engineering curriculum is already packed. 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, a possible resolution would be "meta-integration." Meta-integration consists in creating integrated learning outcomes that cover multiple professional competencies (for example, global, ethical, communication) and then integrating these already integrative learning outcomes into educational modules. Doing so would be helpful in at least two ways: it would (1) not generate additional burdens on already packed engineering curriculum; and (2) provide more realistic and "spontaneous" learning environments for engineering students, much closer to their actual future working environments.

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, 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 future development.

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, 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 contexts. 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 judgment or moral intuition constitutes the foundation for 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 practice. 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 [55], [75], [76]. Therefore, global engineering ethics would benefit even those students whose future roles mainly serve local populations.

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