THE ASSESSMENT OF ETHICS: LESSONS FOR PLANNERS FROM ENGINEERING EDUCATION'S GLOBAL STRATEGY

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ABSTRACT

This translational scoping study investigates how ethics learning is assessed in engineering education worldwide and interprets concepts and practices for relevance to educational planners at the postsecondary level. It provides insights on how engineering education has achieved a level of standardization globally, a calibration process that has facilitated infusion of prioritized abilities across engineering graduates broadly. The engineering education system is designed and maintained through a series of multi-jurisdictional accords that seek to prepare engineering graduates for a global marketplace of engineered products, goods, and services. This paper synthesizes existing literature (research and policy) related to engineering ethics education (EEE), providing a useful introduction to planners regarding ethics, understood to incorporate global responsibility and sustainability. Conclusions provide a foundation for a further systematic investigation of EEE at a global level, highlighting implications of this scoping study for teaching, research, and planning.

INTRODUCTION

To address global challenges, educators and planners need to work together to infuse ethics across all realms of educational planning (Chance, 2012). Ethics must underpin all educational offering from individual course/modules to program curricula, with consideration for formal as well as informal learning environments. Ethics also needs to become a core principle in planning, fundraising, operations, and maintenance (Chance & Cole, 2015). We understand ethics in a broad manner, to include aspects of professional and global responsibility, as well as social and environmental sustainability (Martin, 2020).

This article examines the assessment and evaluation of ethics in engineering education, focusing on how to transfer learning from engineering ethics education and research into educational planning beyond the field of engineering. Our aim is to help educational planners identify concepts and practices supporting the integration of ethics across a diverse range of academic activities and institutional practices, including curriculum design and assessment.

Engineering education has taken a multi-pronged approach that involves research, the scholarship of teaching and learning (i.e., applying research-informed pedagogies), and accreditation standards shared via multinational accords. As part of these efforts, the engineering ethics education community has been working together to promote and support the integration of ethics into engineering curricula. Most often, this has been achieved through the adoption of specific modules with targeted content, but the community is also advocating for more holistic approaches.

They debate the value of micro-inserts across the curriculum and institution wide and of dedicated ethics modules (Martin, Conlon, & Bowe, 2021a). Because this community is succeeding at sowing the seeds of ethics education in specific modules and now, increasingly, weaving these more broadly across programs, we believe their example will be of interest to experts involved in institutional or policy planning.

The study scopes the education literature on assessment and evaluation of ethics in engineering, to address one overarching research question: What aspects of engineering ethics education can be of use to educational planners?

We supplement this with three sub-questions:

1. In what ways are engineering students' abilities in ethics measured and assessed?
2. What new research could help us better assess the ethical abilities of students?
3. What existing tools and techniques can be used by planners to assess the ethical dimensions of their practice?

Our analytical review starts by explaining the nature of engineering as an increasingly globalized profession, to understand the particularities of engineering and how learning might be transferred to other fields. We then describe the role of accreditation systems and global accords in aligning the engineering profession across the world and we point to recent changes and suggestions for improving the formulation of accreditation criteria targeting ethics. Next, we address institutional aspects pertaining to quality assessment and physical planning, highlighting challenges and opportunities. We then discuss how educators assess ethics in education and the difficulty of measuring ethical development, providing examples of standardized tests and rubrics. We conclude with a list of recommendations for educational planners and developing research into the planning, assessment, and quality assurance of ethics education.

BACKGROUND INTO THE GLOBAL CONTEXT OF ENGINEERING

A broad and institution-wide implementation of ethics is crucial for educating students to practice responsibly and respond to global challenges (Truslove, Crichton, Chance, & Cresswell-Maynard, 2021). Engineering education is supported by research into the teaching and assessment of ethics and sustainability. Within this field, there has been focus on sharing ideas, terms, techniques, practices, and standards trans-nationally. Much of this work is conducted in English, as it is the language of global engineering practice, of the multi-national accords, and of a large community of engineering education researchers (Seargeant, Hewings, & Pihlaja, 2018).

Engineering students are seen as emerging professionals who will practice in a globalized industry (Lucena et al., 2008). Engineering graduates will ultimately design products, systems, and artefacts for a global audience. They receive education that will allow them to work in places all around the world. Even as students, they will be expected to work within highly diverse teams, with an international and cross-cultural composition (Giovannelli & Sandekian, 2017). This differentiates engineering from more localized professions, like law and architecture, where knowledge is tied to local contexts and practice is regulated at the state or national level (Andresen, Pattie, & Hippler, 2020).

Increasing mobility across workplaces exerts pressure on educational and professional bodies to expand agreed codes and expectations of professional competencies beyond national boundaries. A key indicator that expectations have been changing can be seen in the "efforts by engineering education organizations to extend themselves beyond countries" (Lucena et al., 2008, p.433). As a global profession, it has been necessary for engineering to develop means for aligning educational systems worldwide in ways that can ensure essential knowledge, skills, and values are developed uniformly (Lucena et al., 2008). Engineering education has developed a system for sharing teaching and evaluation techniques and standards at a more global level than most professions. Engineering education is complemented by research into learning and teaching, which has achieved notable success in getting ethics on the agenda of engineering educators worldwide (Martin, Conlon, & Bowe, 2021a). The standardized approaches underlying the sharing of ethics teaching and assessment tools and practices trans-nationally may be useful to educational planners and others working outside engineering.

METHODOLOGY

The literature scoped in this review has been interpreted and translated for relevance and use by educational planners. This translational research constitutes 'scholarship of integration' since we seek to bring discipline-specific knowledge and concepts, developed within the field of engineering education, to an audience of educational planners extending beyond engineering. Our novel contribution is to translate into educational planning implicit and explicit concepts used in engineering education.

We conducted a non-systematic literature review, guided by the methodological recommendations developed by Borrego, Foster, and Froyd (2014). For this, we first set research questions for the study and criteria for selecting relevant studies. Afterwards, we searched for relevant publications. The search was conducted in SCOPUS using the following search string: TITLE-ABS-KEY (accredit* OR evaluat* OR assess* OR quality) AND engineering AND ethics AND education). We included articles published in education and engineering education journals, book chapters, the proceedings of major engineering education conferences—such as those organized by the American Society of Engineering Education (ASEE) and the European Society for Engineering Education (SEFI) or the Frontiers in Education conference (FiE)—and policy documents issued by accrediting bodies. The rationale for including all three publication types was to identify key research and to highlight emerging trends and activities in engineering ethics education. The search was conducted in English, and solely sources published in English were considered.

The listing of research publications was screened for relevance for the research questions stated above. We also screened the collection of sources retrieved relative to a prior review on engineering ethics education conducted by one of the authors (Martin, 2020). We considered which of the sources held relevance to educational planners outside engineering. The process resulted in (1) eliminating sources generated through the search query that were overly specific or specialized and (2) adding sources located by Martin (2020) that held additional relevance.

We then analyzed the publications focusing on three levels of analysis which have been previously used in engineering education research by Lattuca and Stark (2009) and Martin, Conlon, and Bowe (2021a). As such, the review analyzed sources relevant for ethics assessment and evaluation at three levels: (1) the policy level, (2) the institutional level, and (3) the level of individuals.

RESULTS

In what follows, we present the results of the review focusing on each of the three levels on-by-one: policy, institutional, and individual.

Policy Level

The policy level is represented by academic accreditation. Here, we consider accreditation requirements, professional codes, and other complementary policies focused on ethics.

Engineers are taught specific knowledge, skills, and values as a part of their preparation to join the workforce. Accreditation standards attempt to ensure students master an appropriate range and depth of knowledge, skills, and values, irrespective of the location of their degree. Below, we investigate the role of accreditation systems and accords in promoting coverage of ethics in engineering curricula. Connecting individual higher education institutions and their engineering programs to the cross-jurisdictional accords and helping guide them in implementing actions that meet the spirit of the accords are various regional organizations. These include the European Network for Accreditation of Engineering Education (ENAEE) and the International Engineering Alliance (IEA), which jointly published a report on best practices in the accreditation of engineering programs (ENAEE & IEA, 2015).

Accreditation systems and accords

Three important multi-lateral accords have helped ensure some level of alignment across professional engineering degree programs, globally. These are the Washington Accord, Sydney Accord, and Dublin Accord. These formal agreements among professional agencies in various jurisdictions regulate engineering accreditation within each agency's geo-political boundaries.

The outcome of the globalization process (Sthapak, 2012) and of the domination exercised by the US in the engineering education landscape (Anwar & Richards, 2013), is that the Washington Accord has expanded and currently includes 20 countries with full rights as well as eight provisional signatories. As Klassen (2018) noted, since its inception over 30 years ago, the Washington Accord has grown in both scope and power.

The United States Accreditation Board for Engineering and Technology (ABET) is part of these accords, as are institutions in other English-speaking jurisdictions (including Engineers Canada, the Engineering Council in the UK, Engineers Australia, Engineers Ireland, the Engineering Council of South Africa) and many non-English jurisdictions.

The International Engineering Alliance (2022), a global non-profit organization, explains that through "Educational Accords and Competence Agreements members of the International Engineering Alliance establish and enforce internationally bench-marked standards for engineering education and expected competence for engineering practice" (p.2). Members of this Alliance come from 29 countries and represent 41 jurisdictions. Members use seven existing international agreements to govern professional competencies and educational qualifications.

The accords provide mutual recognition and help ensure that the various jurisdictions that enlist will align their accreditation standards and criteria for graduates so that all exit university with an adequate level of preparation in essential areas (International Engineering Alliance, 2022). The adoption of global accords has led to the alignment of accreditation systems in signatory countries, and as such, to the formulation of accreditation requirements that, although not completely overlapping (Patil & Gray, 2009), nevertheless have a similar focus (Hanrahan, 2008). For the Washington Accord, ethical responsibilities and the societal role of the engineering profession are important, as graduates are expected to "apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice" (International Engineering Alliance, 2014, p.15).

The emphasis of global accords on ethical and societal considerations in engineering has led to the establishment of engineering ethics education as a mandatory accreditation requirement in signatory countries (Coates, 2000). Having an accreditation criterion dedicated to ethics contributed to the development and enhanced presence of ethics in the engineering curriculum (Lattuca, Terenzini, & Volkwein, 2006). The specifications of global accords now inform engineering curricula worldwide, and as a result, the accreditation standards and taught content in most areas of the world have become increasingly clear and aligned (Philips, Peterson, & Aberle, 2000).

More recently, several accrediting bodies undertook processes of reformulating their criteria for accreditation. Most of the changes reported target ethics. As such, Engineers Ireland introduced a new program outcome called Engineering Management and a new program area of Sustainability (Engineers Ireland, 2022). The latter requires covering data science, analytics, and the ethical use of data and technology; equality, diversity and inclusion related to professional practice; and teamwork and communication. Engineers Ireland's program outcome for ethics is now much more specific. Sustainability is now mentioned 15 times and diversity five times (Byrne, 2022), compared with five mentions for sustainability in the previous Accreditation Criteria (Engineers Ireland, 2014). In the UK, the most notable change in accreditation standards has been in "refining how global responsibility is presented and evolving the way it is taught" (Truslove et al., 2021, p.1). Changes implemented though the fourth edition of the UK's Accreditation of Higher Education Programmes (Engineering Council, 2020) also "recognize the responsibility and skills needed of engineers to create positive change to society and global challenges" (Truslove et al., p.1).

A new competence framework on sustainability has been recently developed by the European Commission. GreenComp comprises 12 desired competencies grouped into four themes: embodying sustainability values (valuing sustainability, supporting fairness, and promoting nature); embracing complexity in sustainability (systems thinking, critical thinking, and problem framing); envisioning sustainable futures (futures literacy, adaptability, exploratory thinking), and acting for sustainability (political agency, collective action, and individual initiative) (Bianchi, Pisiotis, & Cabrera, 2022, p.2). These competencies are correlated and specifically defined. For instance, political agency means "to navigate the political system, identify political responsibility and accountability for unsustainable behavior, and demand effective policies for sustainability" (p.15), whereas collective action requires one "to act for change in collaboration with others" (p.15). This type of specificity is needed as we move ahead toward creating more effective systems for collective action to address ethical breaches and shortfalls, across governments and engineering professional bodies (Chance et al., 2021).

Gwynne-Evans, Chetty, and Junaid (2021) advocate that engineering policymakers should integrate ethics across a wide range of graduate attributes, rather than limit ethics and sustainability to just a few criteria. They argue that, given that accreditation has been a primary motivator for change in engineering education, engineering accrediting bodies need to provide more specific definitions of what "ethics" entails. According to them, few accreditation systems require any level of student output or performance related to ethics, instead overemphasizing outcomes purporting to "awareness" or "understanding" to the neglect of demonstrating ethical behavior. Gwynne-Evans, Chetty and Junaid (2021, p. 11) assert that ethical behavior is "the *object of study* rather than its *objective*", in stark contrast to other accreditation elements. As such, they propose a model for integrating ethics across all graduate attributes in South Africa, a country which follows the Washington Accord. The model combines narrative descriptions with graphical depictions, to aid in reconceptualizing *how* and *where* ethics can fit into what is often called a "tightly packed" engineering curriculum. Incorporating this framework nationally, and requiring an integrated approach for accreditation, would foster quick adoption in South Africa. The proposal could be relevant in other national settings as well.

Professional bodies

Professional bodies not only regulate the activities, duties, and expectations of the profession, but also play an important role in shaping engineering education. Lucena et al. (2008) compared shifting competencies standards across engineering education systems in the US, Europe, and Latin America, finding that US-based organizations were "attempting to expand directly from the country to the globe, relying upon prior acceptance of a redefinition of required competencies" (p.433). Europe and other parts of the world took longer to standardize because organizations first had to come to common agreement, regarding definitions of competencies, across diverse linguistic and cultural groups (p.440).

Membership in professional bodies requires long-term commitment to a set of values and behaviors that display specific standards of ethics and expertise. Professional codes of conduct can complement the formal third-level curriculum and help us identify "what counts" (Downey & Lucena, 2005, p.252) within the engineering profession, and how this has changed over time.

Professional codes are a key support for education, professional practice, and informing the public about the ethical principles important for a profession (Laas, Davis, & Hildt, 2022). They play a significant role for the professionalization of an occupational group because they represent "the external hallmarks testifying to the claim that the group recognizes an obligation to society that transcends mere economic interest" (Luegenbiehl & Puka, 1983, p.41). As such, codes typically highlight a profession's expected behaviors that may include one's conduct with guidelines for performing services, issuing statements, or avoiding specific acts (AlZahir & Kombo, 2014) as well as the desirable virtues and character traits of professionals, such as honesty, integrity, impartiality, or prudence (Frezza & Greenly, 2021). Cheville and Heywood (2015) found nine main areas of focus, pertaining to (1) the obligation for the greater good or public welfare, (2) the relation to those outside the profession, (3) professional roles and conflicts of interest, (4) relations with those whom the profession serves, (5) professional reputation, relationships, and responsibilities, (6) professional competence, (7) confidentiality, (8) continuing education, and (9) commitment for advocacy.

Educational planning efforts may benefit by inserting curriculum elements that introduce students to the role, content, and societal value of ethics, individual and collective responsibility, and professional codes. These can offer a common understanding of what a commitment to ethics implies (Li & Fu, 2012, p.340) and ways in which codes can be continuously improved to address societal needs and incorporate broader values, such as care and inclusivity (Warford, 2018).

Institutional Level

This section is focused on how the implementation of ethics is evaluated for quality within the larger institution. As this article is geared toward education planners, we also include reflections on how ethics can factor into physical planning.

Quality assurance and enhancement

In the United States, ABET accredits individual engineering programs, rather than conferring professional accreditation on an overall college or institution (ABET, 2021). This type of system holds true across most English-speaking countries and regions (Stensaker, 2011). This means that each separate degree program engineering college or faculty offers must periodically update or reaffirm its professional accreditation.

According to Kam (2011), the accreditation process for engineering programs typically involves three stages that nearly all accreditation bodies related to engineering, technology, or computing currently use: (1) the program's self-assessment, which is guided by the appropriate accrediting body's standards and expectations, (2) peer-assessment, which involves document review and a (typically face-to-face) campus visit where appointed experts review and assess evidence provided by the program, and (3) a review by the accrediting organization regarding the overall set of evidence and recommendations accumulated, leading to an official decision. These elements equate accreditation with quality assurance and enhancement (Kumar, Shukla, & Passey, 2020).

Historically, ethics has been the program outcome with the lowest scores for meeting the accreditation requirements (Martin, 2020). Additionally, measuring ethical development at the institutional and individual levels is difficult. Educators face dilemmas when preparing for engineering accreditation, in not knowing exactly when, where, and how they cover ethics in their modules and courses (Martin, 2020). Linked to this, a historical challenge faced by program administrators is to determine what "ethics" means in the context of the program they are delivering and to develop evaluation metrics assessing its attainment (Martin, 2020), as well as determining what type and amount of evidence should be collected (Ferguson & Foley, 2017).

The self-assessment stage of the accreditation process is especially prone to mistakes in ensuring the consistency among self-assessment scores, the supporting evidence provided, and the realities of classroom teaching (Martin, 2020). As Deegan (2021) found, organizing and archiving evidence online may carry distinct advantage for planners. The benefits range from increased accessibility and efficiency, to ensuring consistency and creating opportunities for review and dialogue among academic teams. For Deegan (2021), the online process was more accessible for the assembly and participation of external stakeholders such as industry representatives and alumni panelists. Due to its success, this online review approach has been adopted as the model for evidence preparation and presentation by Engineers Ireland for subsequent accreditation activities. It may be useful for educational planners in others context struggling to organize the evidence related to ethics for accreditation or inspection by external bodies.

Furthermore, feedback received by programs from accrediting bodies in the past has sometimes been either lacking or not constructive to the evaluated programs (Barry & Ohland, 2012, p.389; Murphy, O'Donnell, & Jameson, 2019). This may impede the accreditation process from fostering improvement of a program's educational offerings. Looking at how these policies are enacted in specific sub-disciplines, Byrne (2022) pointed to wording from the Institution of Chemical Engineers (2021), which is directing accreditation assessors to evaluate the appropriateness of a given university's policies in the areas of health and safety, sustainability, ethics, diversity and inclusion; the attitude and level of adherence of the university's staff to these policies; and the extent to which students are engaged in the policies (p.51). All these challenges point to the need for developing robust quality metrics and success criteria for the provision of ethics education, to maximize the quality assurance and enhancement role of accreditation processes.

Physical planning

Ethics should be at the core of an educational planner's work at every stage—from conceptualization and brief-writing for all new projects, programs, curricula, and facilities, to the detailed design, implementation, operationalization, and monitoring and assessment of each of these. Empson, Chance, and Patel (2019) question if any design can be considered creative if it fails in responding to Sustainable Development Goals (SDGs). Considering the topic of evaluation and assessment, one wonders how performance in these realms ought to be measured and assessed (Antes et al., 2009).

Regarding physical planning and the development of buildings and infrastructure to run our campuses, planners can reference the United Nations' SDGs. Planners can strategize using recommendations from the Leadership in Energy and Environmental Design (LEED) Green Building Rating program, the Building Research Establishment's Environmental Assessment Method (BREEAM), and the International WELL Building Institute. Using established and emerging software tools, planners can predict future performance on measurable outcomes (such as water and energy use), select efficient options, construct, and install sustainable structures, and measure eventual performance outcomes. These programs and tools can facilitate water use reduction, land erosion reduction, habitat and culture preservation, reductions in embodied energy and carbon footprint, material recycling, construction waste reduction, improved daylighting, reduction of toxins in our interior spaces, and enhanced energy performance.

Raworth's (2017) "doughnut model", environmental footprint calculators, the LEED, BREEAM, and WELL programs all focus on environmental sustainability. The green building programs also promote wellbeing of people at a local level. For instance, promoting design that is healthier and more pleasant for occupants. Designs that provide good daylight, for instance, can facilitate higher levels of learning as verified by increased test scores (Barrett, Davies, Zhang, & Barrett, 2015). Buildings can be designed to impart lessons about the environment and how to value it (Chance, 2010; Chance & Cole, 2015; Orr, 1999). Planners and designers can use green rating systems to improve community connectivity and decrease the reliance on cars and long-distance shipping.

Although these green rating programs offer subtle forms of support for social justice, their focus is environmental. Regarding benchmarking, tracking, and assessing improvement in the realm of planning, the SDGs provide the best recognized tools. Each SDG focuses attention on items where humans need to improve their performance, to become more fair, equitable and sustainable about social, environmental, and economic longevity and justice.

Planners have viable criteria for making our buildings and grounds, and even operations and maintenance just and sustainable and for assessing performance over the long-term (although few campuses do this well). We lack, however, sufficient tools for assessing ethical decision making in other realms of planning. We also currently lack physical infrastructure for operating higher education institutions sustainably (and thus ethically), and we lack adequate delivery of ethics education to the students at our campuses, as discussed below.

Individual Level

This section discusses approaches to measuring and assessing ethical development, presenting popular standardized student assessments and the factors considered. It then shifts to the need to continuously assess ethics throughout an engineer's career following graduation, via Continuing Professional Development programs and support measures.

Assessment approaches

Although educators aim to teach students about social and environmental sustainability and how to make responsible and ethical decisions, we still have a weak understanding of how to define, measure, and assess students' abilities and learning gains. Being abstract, ethics is a difficult subject to cover during the university years at any level higher than "awareness" or "understanding" (Gwynne-Evans, Chetty, & Junaid, 2021). Ethical behavior and character development are particularly challenging (Clancy & Gammon, 2021).

There are multiple approaches and variations in the assessment of ethics in engineering education. Some of these refer to the use of assessment procedures (Bielefeldt, Canney, Swan, & Knight, 2016; Goldin, Pinkus, & Ashley, 2015). Others focus on the learning outcomes that are being evaluated (Martin, Conlon, & Bowe, 2021a), sometimes considering whether ethics should be assessed numerically or via standardized instruments (Keefer, Wilson, Dankowicz, & Loui, 2014), and at which point during a course to conduct the assessment (Gwynne-Evans, 2021). These approaches to assessment may be influenced by how ethics learning outcomes are conceptualized and articulated, as focused on knowledge and skills or attitude and values (Gwynne-Evans, 2021, p.178). At the same time, it is acknowledged that the ethical components of technical courses often remain unassessed (Keefer et al., 2014).

Instructors' unfamiliarity with evaluating and grading ethics (Davis & Feinerman, 2012), coupled with the limited guidance on what assessment methods can be used for nontechnical subjects (Keefer et al., 2014) contributed to variation in approaches. Moreover, the personal influence of instructors' teaching approaches and their views on ethics (Goldin, Pinkus, & Ashley, 2015) are relevant factors in the delivery and assessment of a student's level of understanding and/or ability regarding ethics.

These challenges have led to the development of standardized assessment instruments, scoring rubrics and instruments. Standardized tests have played a central role in the assessment of individual students' understanding and ability regarding ethics (Table 1).

Nevertheless, there are difficulties in tracing causal connections between some of the experiences included in the surveys and an individual's actions, as to attribute them a formative role in the development of students' ethical behavior. Similarly, ethical awareness cannot be said to necessarily lead to ethical behavior (Haidt, 2001). As it stands, there is no consensus on the best way to assess the instruction of engineering ethics and the development of the moral awareness or ethical behaviors of students.

Table 1. Standardized assessment instruments for ethics education

Test	Ethical competences or aspects measured
DIT–Defining Issues Test (1979) DIT2 (Rest et al., 1999).	The maturity of reflection on ethical issues when asked to evaluate several ethical dilemmas
SEED-Student Engineering Ethical Development (Finelli et al., 2012; Harding et al., 2015),	The influence of formal and informal ethical experiences on social behavior
EPRA-Engineering Professional Responsibility Assessment (Canney & Bielefeldt, 2016).	Views on social responsibility
TESSE-Test for Ethical Sensitivity in Science and Engineering (Borenstein et al., 2008)	Ethical sensitivity and the ability to identify and recognize relevant ethical issues emerging from a situation
ESIT-Engineering and Science Issues Test (Borenstein et al., 2010).	Ethical reasoning and contemplation of technical dilemmas
University of Pittsburgh and Colorado School of Mines test (Sindelar et al., 2003)	The ability to address ethical dilemmas, focused on five attributes of attainment: recognition of an ethical dilemma, argumentation, analysis, perspective taking, and resolution
Colorado School of Mines rubric (Moskal, Knecht, & Pavelich, 2001)	Identification of needs in design projects brought by industry stakeholders
EERI-Engineering Ethical Reasoning Instrument (Zhu et al., 2014)	Individual ethical decision-making in a project-based design context
EDM ethical decision-making instrument (Mumford et al, 2006, Bagdasarov et al., 2016).	Ethical decision-making in real-world scenarios

Continuing Professional Development (CPD)

As new ethics knowledge, technologies, policies, and frameworks for action emerge after engineering students graduate, CPD represents an important way to support the ethical development of the profession and to update the skills and display of ethical values (Chance et al., 2021). Despite its significance, there is still little known about the effectiveness of CPD ethics training (Steele et al., 2016).

Developing a holistic ability in ethics is necessary for the ethical practice of engineering in complex contexts that involve shifting and competing forces. It requires more time than a standard degree course can provide (Chance et al., 2021; Committee on Education, 2019). CPD is an integral component for enhancing the knowledge and abilities of existing practitioners and for scaffolding the development of newly graduated engineers as they are entering engineering practice. The ASCE stated that graduate engineers must be able to: recognize ethical behavior as important; identify and explain ethical responsibilities related to civil engineering; and comply with ethical codes (Committee on Education, 2019). These are seen as basic abilities.

Engineers must, therefore, extend their abilities in this realm post-graduation. ASCE has specified that this should happen via mentored experience early in each engineer's career, so that the individual has support in handling increasing levels of responsibility and complexity in ethical decision-making (Committee on Education, 2019). Dealing with complex ethics issues embedded in professional practice can help an early career engineer internalize abstract concepts—but if the individual engineer is not supported in addressing dilemmas, s/he can be swept away by existing currents, social, and business pressures. Without good scaffolding and support, the individual may not be able to convert ideal ethical concepts into discrete behaviors. Structured learning and guided mentorship can help engineers as they are confronted with slippery contextual issues and ethical dilemmas that do not have easy or straightforward answers.

Ultimately, each engineer will need to apply appropriate reasoning to analyze the ethical dimensions of complex situations, assess options, and determine ethical courses of action. Engineering operates at such a scale that any individual is a tiny cog in an enormous system, and developing ways to support individuals in sounding alarms, blowing whistles, and helping engineering (as a profession) and society (at large) address harmful tendencies and patterns will be central to achieving continued life on this planet. The Committee on Education (2019) has identified several very-high level abilities that engineers need to develop later in their careers—normally after their structured mentorship ends. These high-level abilities include advocating for ethics in engineering practice and assessing courses of action to resolve ethical dilemmas in complex situations.

CONCLUSIONS

To conclude, we return to the research questions. Addressing, above, two sub-questions, we have seen that engineering students' abilities in ethics are measured and assessed via individual modules, sometimes using standardized instruments, and that accreditation and global accords are major drivers toward having ethics included in the engineering curricula and formally assessed. Furthermore, we have discussed existing tools and techniques, including the SDGs and various green rating programs, which can be used by planners to assess ethical dimensions of their practice. Following on, we now identify several possible paths for research that could help us better assess the ethical abilities of students, under implications for teaching and research. Lastly, we return to the overarching question: What aspects of engineering ethics education can be of use to educational planners? We address this below, under implications for planning.

Implications for Teaching and Research

Engineering ethics education and research are reaching a point of maturity that facilitates the rigorous collection and analytical review of prior studies. In the growing field of engineering education research, meta-analyses and systematic literature reviews provide viable methods for generating new knowledge from previous work (Hess & Fore, 2018; Martin, Conlon, & Bowe, 2021a). In this section, we draw from the scoping review above to identify knowledge gaps and make recommendations.

As a result of this scoping review, we see the need for two separate studies on assessment of engineering ethics education and encourage the research community to consider taking these on board. First, an imperative has emerged to map the varied approaches to assessment and offer insights on the role and empirical benefits of each approach as reported in the literature. Gaining an understanding of the landscape of assessing ethics education can contribute to curricular alignment (Borrego & Cutler, 2010), given that alignment is "still a weakness" (Keefer et al., 2014, p. 259; Li & Fu, 2012; Martin, Conlon, & Bowe, 2021a, 2021b). This scoping study has highlighted the need for additional research on this topic. We therefore propose, as a next step, to conduct a systematic literature review providing a **meta-synthesis** of studies on the topic of assessment, engineering and/or technology, education, ethics, and responsibility "in order to locate key themes, concepts, or theories that provide novel or more powerful explanations for the phenomenon under review" (Siddaway, Wood, & Hedges, 2019, p.756). This review would rigorously investigate:

1. The assessment methods used in undergraduate engineering ethics education and their distribution.
2. The learning goals (competences, skills, attributes/traits, emotions, behaviors, or attitudes) evaluated.
3. The theoretical perspectives informing the use of assessment methods.
4. The empirical benefits, challenges, lessons learned, and/or recommendations reported in connection with the assessment methods used.
5. How assessment is described to align with the teaching methods or the institutional strategy and vision.

Second, we notice what appears to be a piecemeal implementation of ethics, with a low curricular weight given to learning outcomes related to ethics (Barry & Ohland, 2012; Martin, 2020) and a lesser focus on the societal responsibilities of engineers (Bielefeldt et al., 2016). The justification that engineering programs usually provide for incorporating ethics centers on accreditation requirements (Martin, Conlon, & Bowe, 2021a). This is an extrinsic source of motivation that can lead to less robust responses translating into half-hearted approaches that have low-level buy-in across the engineering faculty. In many cases, ethics has been described as a "box ticking" exercise (Flynn & Barry, 2010, p.2; Martin, 2020). Truslove et al. (2021) assert that addressing sustainability, global responsibility, and SDGs requires more complexity in students' learning process than engineering curricula currently provide.

Furthermore, engineering programs report the lack of "consistent, accurate, and reliable methods of teaching ethics and measuring its outcome" (Bairaktarova & Woodcock, 2015), pointing to issues related to quality assurance. Three key impediments in the quality assurance and enhancement of engineering ethics education pertain to the unconstructive feedback following accreditation events, the lack of guidance on how to operationalize ethics related outcomes in the engineering curriculum, as well as the limited evidence as to what constitutes quality criteria for engineering ethics education (Bombaerts, Doulougeri, & Nieveen, 2019; Murphy, O'Donnell, & Jameson, 2019).

We recommend developing a rigorous study that responds to the need for deeper reflection on quality mechanisms and criteria for engineering ethics education, as well as on the role of various internal and external stakeholders in processes related to quality assurance and enhancement of the implementation of ethics at institutional or program levels. The purpose of the study would be to provide a critical overview of the state of the art in engineering education research on quality assurance and enhancement criteria, mechanisms, and procedures overseeing the implementation and institutional evaluation of ethics in undergraduate engineering education.

The study would enable the engineering education and assessment communities to identify how quality is discussed in relation to the provision of engineering ethics education in the existing literature and regarding criteria, as well as the challenges and deficits encountered, with quality assurance and enhancement processes. An outcome could be to use the findings reported in the literature to propose a quality framework for engineering ethics education. It could include quality standards and a specification of the responsibilities of key internal and external stakeholders in the quality assurance and enhancement process. We propose that this study could also take the form of a systematic literature review aiming to identify:

1. The current criteria, standards, procedures, and mechanisms reported regarding quality assurance and enhancement of ethics education.
2. The main internal and external stakeholders involved in quality assurance and enhancement in ethics education, and the roles they play.
3. The challenges, deficits, and recommendations reported in connection with setting and enforcing quality criteria for ethics education.

Implications for Planning

Educational planners need to account for the effects of construction and resource consumption on campus, and the values imparted to students. Responsible practices should be visible in all facilities and activities – from classrooms, laboratories, and dining halls to sports facilities, planned events, faculty and student travel, and extracurricular clubs and societies.

Summarizing implications of the above content for use by educational planners, some important lessons are that (1) achieving sustainability is one aspect of ethics and (2) not all professionals at work today will have encountered formal education on this topic (Chance, Direito, & Mitchell, 2021; Chance et al., 2021). Licensure and CPD provide means and incentive to learn about ethics, but new approaches, such as structured mentorship, may be necessary to help support individuals navigate complex situations and confront ethical dilemmas.

Engineering, as a globalized community of practice, has set up systems for ensuring some level of alignment across legal jurisdictions worldwide. Alignment is achieved through the development and uptake of various accords which inform individual accreditation systems around the world. There is a great deal of interaction among engineering accreditation systems, with ABET exercising a strong influence globally. Effects are evident in a move toward greater specificity in definitions and competency requirements currently emerging in individual countries.

Findings of this scoping study hold relevance for practice at: (1) the level of accreditation frameworks and policies, (2) the institutional level pertaining to quality assurance and physical planning, and (3) the level of individual students and engineers. First, we described a model for integrating global priorities based on the current success of engineering accreditation systems to improve definitions to achieve increasingly holistic coverage. Second, we highlighted various approaches to conveying ethical values to students (including discrete modules and more integrated curriculum approaches) that planners might apply in their own organizations. Third, we presented standardized models for assessing various ethics competencies that can be used by instructors beyond engineering where ethics needs greater operationalization. We complemented this with measures for scaffolding students' ethical development post-graduation, through CPD and structured mentorship.

The global community of professional and education bodies in engineering is increasingly aligned. Accreditation, assessment, and accords have been important parts of this shift, as has input from the engineering ethics education research community. This community uses research-informed methods to advocate for change and translate policy into practice, seeing the development of engineering ethics education as a distinct realm of study. Educational planners might transfer learning from the engineering education community of practitioners and researchers as they seek to integrate and evaluate ethics across their own organizations.

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