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Guest Editorial: Overcoming Challenges to Infusing Ethics into the Development of Engineers: Contributions of an NAE Workshop on Teaching Ethics

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ABSTRACT

For more than 20 years, accreditation requirements have called on engineering programs to incorporate ethics education in their curricula and demonstrate the outcomes such education is achieving in graduates. In the current articulation, ABET¹ student outcome criterion 3.4 calls for “An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts” (ABET). Engineering educators are attempting to achieve this outcome using a variety of approaches. Among those educators are current and emerging leaders in ethics and engineering, representing a range of engineering disciplines, teaching levels, and institutions, who participated as members of 16 interdisciplinary research teams in a 2017 National Academy of Engineering (NAE) workshop on *Overcoming Challenges to Infusing Ethics into the Development of Engineers*. At the workshop the team members shared their work, discussed strategies for overcoming institutional and cultural challenges, and laid out plans for advancing efforts to infuse ethics into the development of engineers. This special issue of *Advances in Engineering Education* highlights the further development and outcomes of 7 of the 16 original projects, as reported in research papers that explain whether and how their activities have progressed in overcoming challenges to infusing ethics into the development of engineers. This editorial frames the seven projects in the context of both the 2017 workshop and a 2019 NAE

¹ Formerly the Accreditation Board for Engineering and Technology, this organization is now identified simply as ABET.



workshop designed for STEM faculty new to teaching ethics, and highlights the importance of continued work in ethics education.

Key words: Ethics, Engineering Education, ABET

INTRODUCTION

In 2016, the [NAE Center for Engineering Ethics and Society \(CEES\)](#) released the report *Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs*. This NSF-funded CEES project highlighted 25 activities and programs in higher education institutions in the United States as exemplary in their approaches to infusing ethics into the development of engineering students. In its review of the program applicant pool, the NAE-appointed selection committee looked for the following characteristics:

- Provides an interactive format that encourages active learning
- Occurs across multiple years of a student's education
- Includes an institutional faculty reward structure that supports ethics training
- Connects students' ethics learning to engineering practice
- Promotes improved ethical decision-making and problem-solving skills
- Addresses macroethics (the broader ethical and social issues that call for the collective response of the engineering profession and societal decisions about technology), microethics (ethical issues involving the interactions and individual actions of engineers in research and practice), or both
- Incorporates innovative or creative educational methods
- Has a demonstrated widespread or lasting impact on students
- Can be scaled up or easily replicated at other institutions.

The 25 programs identified in 2016 exhibited at least one, and typically more than one, of these characteristics.

As a follow-on activity, a 2017 NAE workshop convened leaders in ethics and engineering who were working to improve the ethical development of engineering students, to (1) share their work, experiences, and lessons learned; (2) discuss strategies for overcoming institutional and cultural challenges; and (3) develop plans and collaborations for advancing efforts to infuse ethics into the development of engineers. During the workshop 16 teams of two to four individuals—faculty, administrators, and professors of practice—were asked to describe their innovative activities, approaches, and strategies (current or planned) for overcoming institutional or cultural challenges to infusing ethics in the development of engineers.



The papers in this special issue of *Advances in Engineering Education* highlight the ongoing efforts, further development, and outcomes of 7 of the 16 projects presented at the 2017 NAE workshop. In the context of the workshop themes, all are making progress to one degree or another in overcoming challenges to infusing ethics into the development of engineers. Collectively, these papers reflect the ongoing challenges of incorporating ethics into engineering education – even two decades after ABET first required this content as part of its EC2000 accreditation criteria, and more than a century after the publication of the first textbook in the field (Mead, 1916).

TEAM EFFORTS ALIGNED WITH WORKSHOP THEMES

The 2017 NAE workshop included panel sessions to identify effective practices and scholarship that are (i) making engineering ethics relevant to students and/or (ii) supporting faculty in integrating ethics into engineering education. Participants also discussed the following nine themes that emerged from input solicited of the teams during the workshop application process, reflecting opportunities and potential next steps:

- Influencing the engineering mindset and culture
- Handling ethics in the classroom
- Approaches for building institutional buy-in and support
- Approaches for building and developing faculty capacity
- Addressing the false division between technical and nontechnical
- Strategies and approaches for evaluating ethics education
- Curricular approaches and issues of scaling up and across institutions
- Placing ethics within existing engineering tools and practices
- Teaching ethics to an international and multicultural group.

These themes illustrate the complications of work in a field that continues to be seen (counter-intuitively) as both important and peripheral to the core work of engineering. The challenges here are not merely pedagogical, but attach to the very heart of the subject: deciding not only how to teach, but also what to teach, and how to persuade colleagues and administrators of the value of the material and the outcomes.

The seven papers in this issue each address at least one of these nine themes in some way. Notably, only the first theme, “influencing the engineering mindset and culture,” did not explicitly emerge, and yet all of the projects described in this volume are informed by existential questions about the place of engineering ethics in contemporary engineering curricula. Which faculty (or non-faculty partners) should be engaged in teaching ethics? Should ethics be considered



a first-year subject or integrated into engineering sub-disciplines? To what extent are ethical standards and decision-making shaped by culture, perception, and interpretation? The fact that such questions remain unresolved after a generation of dedicated effort and scholarship indicate that the very nature of the discipline and its place in the engineering curriculum more broadly remains unclear.

Kim, Jesiek, Zoltowski, Loui and Brightman describe establishment of an academic-industry partnership aimed at overcoming challenges to infusing ethics into the professional development of engineers at Purdue University. Identifying best practices and action items to strengthen industry-academic relationships, the team seeks to foster insights and applications for ethics education in engineering. In their assertion that ethics education requires direct conversations between academia and industry, the effort they put forth seems to be congruent with the workshop theme of building and developing faculty capacity.

Challenging the social and psychological barriers of disciplinary silos, Hitt, Holles, and Lefton of the Colorado School of Mines are pursuing interdisciplinary integration through two courses that incorporate ethics in the first-year engineering curriculum. At the heart of their course design is the intention to fuse engineering problem solving with value-sensitive analysis and design. Quite intentionally, the team is addressing the false division between technical and nontechnical that persists in engineering education.

As a catalyst to improving the ethical culture of research, Laas and Miller, Brey, Taylor, and Hildt report on engaging students at the Illinois Institute of Technology in ethics discussions related to their everyday research practices and experiences. In conversations between students and their principal investigators about ethics rules and norms in daily research practice, the team incorporates ethics in existing engineering tools and practices to change the culture of research environments.

A strategy and approach for evaluating ethics education is presented in the efforts of Katz, Reid, Riley, and Van Tyne, who reviewed the first-year engineering course sequence at Virginia Tech. They note that while progress has been made, structural barriers continue to present challenges to learning outcomes in engineering ethics education. They offer innovations to address those challenges as well as an assessment matrix.

The paper by Taraban, Marcy, Lacour and Koduru, Prasad and Zasiakin is not specifically about teaching ethics to an international and multicultural group but is closely aligned with that theme. The authors describe their work helping students at Texas Tech University understand the nature of ethical practice across regional and cultural boundaries. They designed a website for worldwide participation of students in a cross-cultural exchange of commentary on ethics in their engineering education, and a significant outcome is the formation of an international network.



One way of handling ethics in the classroom is through teams. Grohman et al. doing research at the University of Texas-Dallas, note that most ethical decision making that students will encounter in their professional lives will arise in team settings and be influenced by team members. Their paper explains the results of a research project concerning how teams of engineers make such decisions. The findings suggest that ethics advisors have an important role to play in how team-based ethical decision-making processes may be learned.

Efforts to address curricular approaches and issues of scaling ethics up and across institutions are described in the work of Tang et al. at Penn State University. Believing that students need learning experiences that are integrated systematically across the engineering curriculum, they set out to infuse ethics into the curriculum of biological engineering as a “model process” for implementing curriculumwide ethics education in other engineering programs. Their faculty-driven process involves engagement of, and implementation by, a biological engineering faculty working team.

WORKSHOP FOR STEM FACULTY NEW TO TEACHING ETHICS

Ethics education is an integral element of the effort to transform the culture of research institutions in the United States, and the [Online Ethics Center for Engineering and Science \(OEC\)](#) is an essential, dynamic resource for that education. It provides quality STEM ethics education resources and connects practitioners, researchers, and educators to promote learning and advance understanding of responsible research and ethical practice in science and engineering.

More than a website, [the OEC](#) is the hub for a global community of stakeholders committed to excellence in ethics education. As a digital knowledge library, its extensive collection of resources is available to faculty, students, and researchers at postsecondary educational institutions across the United States and around the world. Researchers and practitioners with NSF support have developed many of the resources on the site.

In addition, since its inception, the OEC has steadily evolved to meet the needs of its community and keep pace with rapid, continuous advances in digital media technology. Under its current NSF funding, the OEC is focused on project activities in support of STEM faculty new to teaching ethics. Its efforts to equip and motivate engineering faculty to teach ethics in their courses is contributing to improved ethical cultures at engineering education institutions and to an institutional capacity to fulfill ABET outcome criterion 3.4.

The OEC recognizes and supports the role of engineering faculty in infusing ethics across the engineering curriculum. These faculty are essential for building institutional buy-in and support for the endeavor. However, to do so they need skills and course development support, especially if they are inexperienced



with teaching ethics. To this end, a 2-day OEC workshop, *Bringing Ethics into the Conversation: Introducing STEM Faculty to Teaching Ethics*, was held at the National Academies in Washington in October 2019.

Workshop applications were received from STEM faculty who wished to identify opportunities to integrate ethics in their courses and research environments. Together with workshop presenters, 30 participants, including 21 engineering education faculty, explored a variety of hands-on tools and approaches, both formal and ad hoc, including the use of the OEC as a teaching tool and as a resource for instructional materials.

The workshop opened with remarks by Faye Korsmo, senior advisor at the National Science Foundation, followed by a keynote address by Stephanie Bird, a consultant on engineering ethics education policy. Pedagogy presentations and demonstrations were provided by scholars Jason Borenstein, Joseph Herkert, Yvette Pearson, Marshall Thomsen, and Qin Zhu. Based on these presentations, participants were asked as “homework” on the first day, to consider their own classes (including class plans and course syllabi) and devise pedagogical approaches and course materials to create or enhance a learning activity in ethics. The next day they presented their results.

In postworkshop feedback participants offered the following comments, both favorable and indicating unaddressed needs:

The fact that you created a space for interaction and discussion among a group of individuals who are passionate about teaching of ethics is very important and I really appreciate that. I also appreciate the thoughts and time of the speakers to develop and design activities for the participants. The other thing is that to have influential scholars like Joseph Herkert was very, very exciting for me. I should also really like having presenters with different backgrounds and in different fields.

I always have a disconnect when it comes to understanding teaching and decision making on topics like ethics. To me, it feels like the workshop discussed how to get students to recognize ethical issues (case studies), offered tools for how to have students think about ethics / participate in class (active learning), and covered assessment efforts. But there is a gap to me—once students are recognizing that ethical issues exist, what is the process they should go through to actually make good ethics decisions? That decision making process was not something I thought the workshop covered and it was the area I most wanted assistance with.

I think getting to a more realistic picture of what happens in class as much as possible would be really helpful and this demands more time for the participants who are beginning to develop modules and courses.



The presenters were great but there is room for improvement, perhaps inviting administrators, a president of a university, other scholars who have published extensively in the field, and those who can reflect on their struggle in developing lesson plans at earlier stages of their teaching/faculty positions. It is also good to think about representation of individuals with different backgrounds.

It would be great to get to the details of facilitation strategies. This is a really challenging task and unless we think about the plan and individuals that will participate in the session, the outcomes may not be what we expect.

Input from other participants suggest that racial and ethnic diversity must be attended to in guiding STEM faculty in their incorporating ethics into their teaching. Furthermore, the matter of anticipating the practical application of what is learned by the students, and how the students will make decisions, is important. Faculty also want specific guidance on how to facilitate class discussions and anticipate learning outcomes. And because engineering instruction and ethics instruction in engineering institutions of learning tend to be approached quite differently, those differences should probably be factored into the OEC's efforts to support engineering faculty in this endeavor.

In a workshop at the 2019 ASEE annual meeting on using the OEC as a resource for teaching ethics in engineering (also targeted to STEM faculty new to teaching ethics), participants asked if ready-made teaching plans and course materials might be provided for them to use in their particular engineering disciplines. The request reflected both a willingness to try and a frustration over the difficulty of bringing ethics into their technical courses. In response, OEC is actively inviting submission of syllabi and teaching notes and plans for bringing ethics into engineering courses. In the meantime, a forum on teaching ethics has been launched on the OEC to provide support for STEM faculty aiming to include ethics in their teaching portfolio. When workshop participants were asked how such a forum might be useful to them, they cited the need for:

- “practical classroom materials that are relevant to my current situation”
- “advice on how to speak with the people at my university about these topics—advocating for the value and place of ethics in the curriculum. (how do i talk about this, what examples of success can i offer them?)”
- “opportunities to join with others from outside my university to partner on testing methods and potentially collaborate on future RFPs or joint papers on these topics in higher ed.”

The OEC Forum on Teaching Ethics (currently under development) will provide a place for engineering faculty new to teaching ethics to communicate both with one another and with seasoned engineering ethics scholars in an exchange of ideas, Q&A, and teaching resources.



The OEC and the seven projects represented in the papers of this issue are putting forth efforts to change the culture of engineering education to meet the challenges of successfully developing engineering students with the capability to recognize ethical and professional responsibilities in engineering situations, and to make informed judgments that consider global, economic, environmental, and societal contexts. This volume also represents a call to the engineering education community to continue these efforts.

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