Engaging in Engineering Ethics: approaches to teaching moral reasoning to science and engineering students

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The extent to which ethics can be taught in order to have an impact on student's critical thinking capacities is an ongoing discussion among ethicists and spans disciplines from the social sciences, humanities, to fields that develop technical skill such as medicine and engineering. The possible benefits of engaging students in the area of ethical philosophy are thought to range from fostering moral improvement, to increasing analytic precision, argumentation and other reasoning skills, to raising awareness of alternative perspectives through questioning existing beliefs. Related to *value* is the fundamental question of how ethics can be taught to elicit any of these desired outcomes. In addressing the how and why, we report results of interviews from scholars of philosophy and other practitioners of ethics pedagogy as a backdrop for identifying several approaches and content that are applicable for engineering students. Perspectives on teaching ethics in conjunction with a communications course is the context for discussion of ways in which engineering programs at the university level can incorporate ethics into curricula. Finally, results of a small-scale student survey to evaluate student engagement and perception of usefulness in an engineering communications course that features ethics are reported.

Introduction

A multitude of approaches, content, and communication modes are used in ethics pedagogy to encourage students to question conventional wisdom and to reflect on the potential effects of their actions and their future participation in decisions and communications about technological impact. Effectively engaging engineering and science students in exploration of ethical dimensions of their field to some extent involves similar elements to teaching any other topic, but seems to often require extra effort to connect in order to evoke student enthusiasm for this area. Making ethics relevant and alive for these students, according to several faculty interviewed involves active discussion of current, challenging content to elicit thinking and engagement.

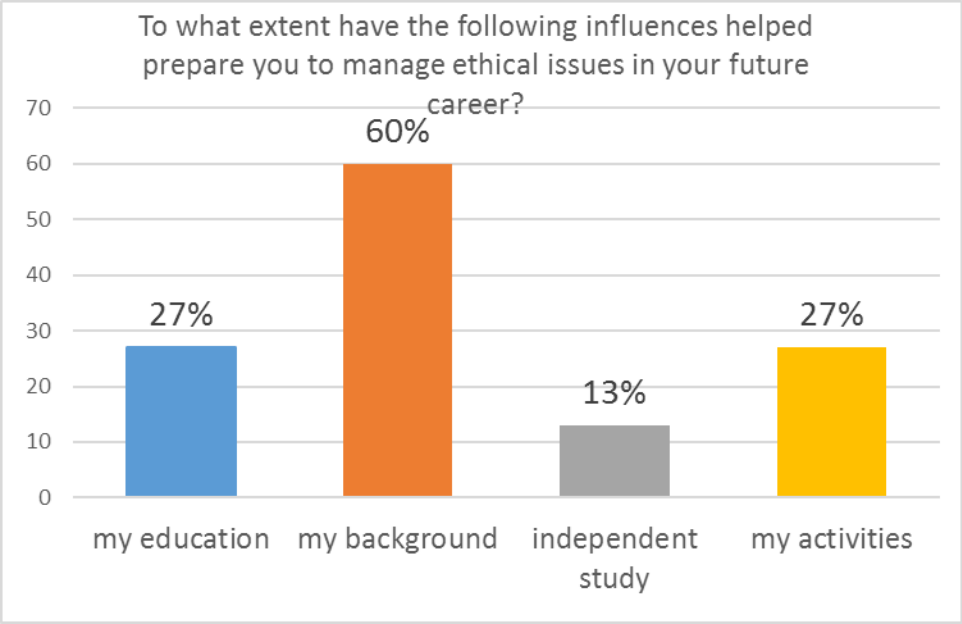
Can We Teach Ethics?

A survey of how moral philosophy is taught at major institutions across the U.S. and English-speaking institutions found that most faculty who were surveyed agreed that ethics, defined as moral reasoning can be taught with varying outcomes (Cooper, 2009). While most thought that

ethics instruction could result in changes in moral thinking, faculty interviewed were divided about whether ethics instruction could actually lead to changes in moral action. Outcomes are difficult to measure, but most believe it is a necessity for ethics to be taught to all students in university curricula. Simply discussing ethics in a classroom setting may not make people more virtuous, but it can possibly make them more considerate, thoughtful decision-makers.

Cultivating student's abilities to think more deeply about ethical problems is a value that can be supported by injecting ethical inquiry into course material. As described below, including discussion about ethical dimensions of technology as part of an engineering communications course appears to support student's reflection on the role of engineering in society and their own responsibilities to communicate to improve general understanding. This seems to be the case for the ethics-related communications activities detailed here. In sum, this coursework constitutes a very small part of the typical engineering undergraduate's curriculum, yet it appears there has been positive impact nonetheless. In our informal survey of student's perceptions of the influences that have helped shape their ethical compass, a student's background is the most important influence, with education and extracurricular activities holding a distant second position as shown below.[1]

Figure 1: Student's Background is Most Significant Influence in Ethical Development



[1] Student survey results reported here represent 2 semesters, 3 courses of WRIT 340 students at the University of Southern California, (2015-2016). Each course had approximately 18 students and the response rate was on average 85%.

When students were further asked to what extent ethics has been included as part of their engineering curriculum, the majority (over 80%) claim to have had none or some amount of coverage of ethical issues in their coursework. This student-impression mirrors recent reviews of the state of ethics instruction for engineers in Europe and the US (Zandvoort, Borsen, Deneke & Bird, 2013) who conclude that on the whole, there are few indications that universities adequately prepare engineering students to understand social responsibility. A recurring theme is the lack of time in the academic curriculum to devote to ethics. They note that given the magnitude of ethical issues related to technology and science that exist on a global scale, the amount of curriculum time devoted to ethics-based topics is very minimal. These claims are not easy to substantiate however, as there is little precise information on the quantity of ethics-related education which includes stand-alone courses or instruction that is embedded in a larger course such as physics or materials science, nor is there a great deal of assessment in terms of effectiveness.

Efforts that have grown can in some cases be linked to external resources, such as the National Institute for Health (NIH) or the National Science Foundation (NSF) which requires researchers understand the responsible reporting and carrying out of research. Hence, programs for teaching about the responsible conduct of research have grown in popularity (Zandvoort, et.al., 2013). ABET, (the Accreditation Board for Engineering and Technology), has influenced teaching programs in the US and Europe, compelling departments to enhance or set up instruction in ethics and moral philosophy. The program mandates student outcomes that exhibit enhanced ability to understand the following issues: understanding of professional and ethical responsibility, and understanding the impact of engineering on the global economic and environmental system. ABET criteria has been used as the basis for expanding engineering education outside the US in France, Ireland, Turkey and elsewhere, but few measureable outcomes are yet available (Ozaktas, 2011, Conlon, 2013, and Didier & Derouet, 2011).

Current Approaches to Teach Moral Ethics

Many forms of instruction and activities are used to teach ethics in major English-speaking institutions: posing provocative questions for discussion, various techniques that promote live thinking in the classroom, reading materials, videos and images, websites, case studies, current news reports and news articles, and hypothetical situations for discussion. Case studies based on disasters such as Chernobyl or the Challenger are used to instruct students on decision-making and individual responsibility (Wilson, 2013). Given the large amount of data available, there is a wealth of information to substantiate a comprehensive view of ethical challenges. Some argue that this approach is removed from student's day-to-day experience resulting in a disconnect. There is some consensus that although technology and other tools can provide additional resource, the traditional in-class discussion, and teacher-student interactions are the key supportive activities that promote critical thinking and articulation of ethical positions and issues (Cooper, 2009).

Others suggest that connected devices and social media are relevant platforms for today's undergraduate students and can be effectively employed to instruct students about ethics in

today's world (Voss, 2013). Cooper's survey of ethics professors at major US institutions shows consensus that although technology and other tools can provide additional resource, the traditional in-class discussion, and teacher-student interactions are the key supportive activities that promote critical thinking and articulation of ethical positions and issues (Cooper, 2009). This modality does allow instructors to gauge effectiveness first hand.

Analysis of Ethics Instruction Within an Engineering Communications Course

The University of Southern California, Viterbi School of Engineering embeds instruction in ethics for students in a required communications course, WRIT 340. Enhancing student's understanding of ethical reasoning and the importance of engagement with the ethical implications of engineering is supported through written and oral communication skills: assignments bring together communications and collaboration with technical understanding. Variance in emphasis and content exists between instructors, but generally, after acquainting students with basic philosophical approaches, efforts are made to apply models to an issue that is technology/science or engineering-related. Students write an analytical paper and give an oral presentation on the technical information and ethics-related debates surrounding their topic and position.

Building on this ethics-specific assignment, many instructors have students complete a final collaboratively written report that examines the social, economic and political implications of an emerging technology such as fusion, carbon sequestration, etc. and links solutions to the primary global issues (e.g. resource depletion, climate change, etc.) that these innovations will address. The starting point for topic selection is the National Academy of Engineering's "Grand Challenges, www.engineeringchallenges.org/challenges.aspx. A list of 14 technical "challenges" that include solar energy, medical innovations, virtual reality, informatics and other tools, methods and approaches to acquire new information and provide opportunity in the future are listed. Students must explore the issues that these promising technologies are intended to address and understand the societal, economic, and political dimensions that underlie the need for technical solutions. The accompanying ethical dimensions of scarcity, unequal distribution of resources and power inequity are a few of the immediate realities that complicate and challenge positivist technical progress.

Approaches to implementing these ethics-based assignments vary among the Engineering Writing Program's (EWP) faculty, but over the past 10 years of evolving these core assignments, general observations are possible. Among faculty teaching this course, consensus is that student interest in the societal implications of engineering can be cultivated, and cannot be assumed. Survey results below indicate moderate enthusiasm for further study of ethics surrounding the field of engineering. Nonetheless, the majority of students also expect to face ethical issues in their future lives as engineers.

Assessing Ethics Instruction: Student and Faculty Feedback

Encouragement of each student's individual exploration of a topic of their own choosing appears to enhance effort and enthusiasm. Trends in topic selection tend to mirror media attention on current hot issues: autonomous vehicles, military and individual use of drones, fracking, Apple's stance to the FBI's request for unlocking an iPhone, and the CRISPR/Cas system.

Less successful topics include those that focus on individual decision-making or micro-ethical issues e.g. how an engineer in an organization might respond to ethical challenges. Such efforts are problematic in part because they are not anchored in literature, and perhaps reflect a lack of experience with workplace situations.

Management of student's topic selection and research process entails varying degrees of individual guidance from the instructor—feedback during the research and writing process is a critical element that supports student engagement and a more successful paper/presentation. Discussion with other students via peer review, class discussion and direct dialogue with the instructor all reinforce student understanding.

Students primary issues include difficulty identifying the actual ethical dimensions of their topic, selection of a topic that lends itself to a successful discussion of ethics, developing their own position on their topic and over-emphasis on description of the technical aspects of the topic. Students often note the "nebulous" nature of ethics in engineering, and a preference to focus on "concrete" aspects of their topics.

Although WRIT 340 includes numerous other objectives in addition to the ethics component, there is nonetheless some evidence that the ethics-based activities, discussions, and assignments have contributed to greater awareness of implications, broadened perspectives and improved abilities and interest in communicating in ethical areas of their field.

Assessing Ethics Instruction: Student and Faculty Feedback

The success of WRIT 340 efforts to convey ethical consideration to undergraduate engineering students has been measured in a few ways, including an ongoing program-wide survey over 10 semesters, that has been carried out for ABET purposes, individual informal surveys, and faculty assessment of student efforts. Figures 2 and 3 represent about 2,500 students. Below, Figure 2 shows that over 50% of students believe that WRIT 340 has helped them develop their understanding of professional and ethical responsibility.

Figure 2: Students in All Fields of Engineering Surveyed Agree That WRIT 340 has Aided in Developing an Understanding of Professional and Ethical Responsibility

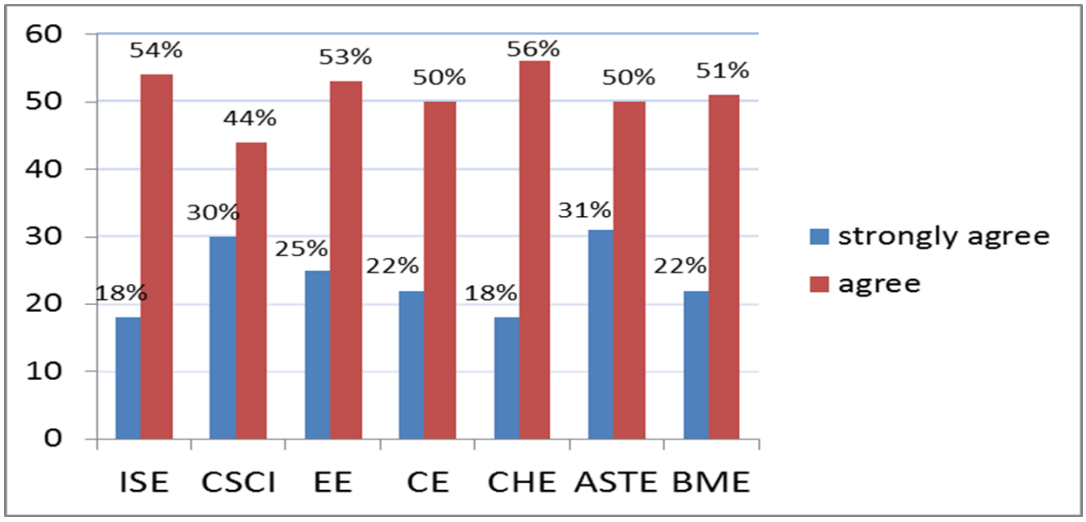
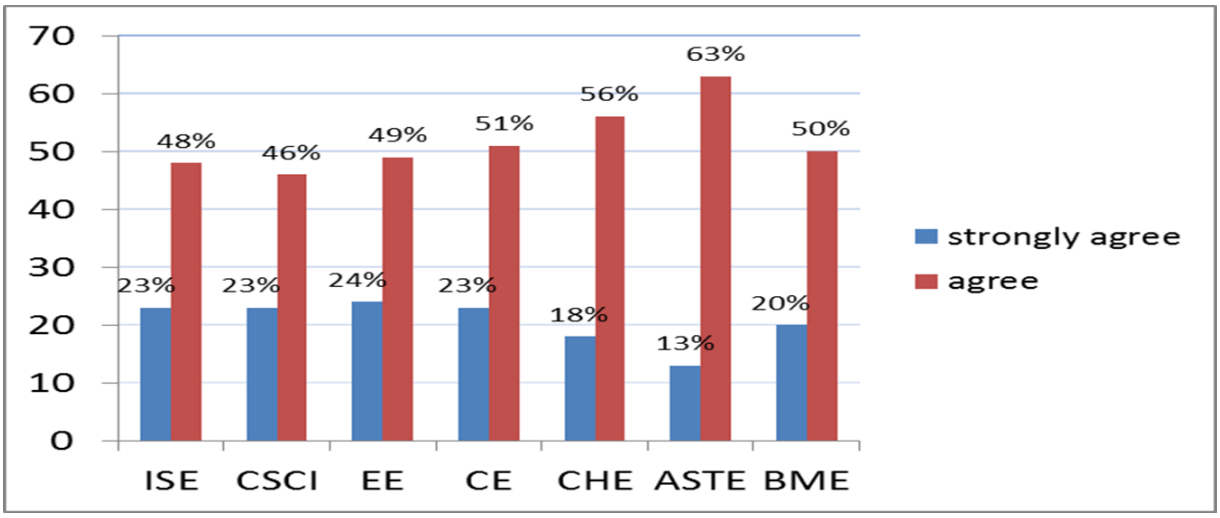


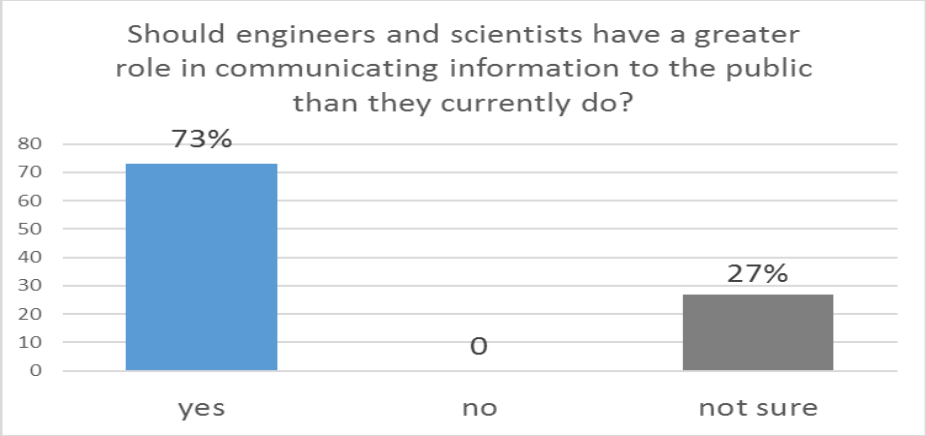
Figure 3: Respondents Beliefs that they Developed Understanding of Engineering's Impact in the World



Faculty review of papers and presentations generally note that successful efforts are often linked to well-chosen self-selected topics which supports motivation and application of the topic to a philosophical approach which forces broader thinking beyond the particulars of the topic itself. Assignment grades are used by most faculty use as the primary measure of success; critical thinking of engineering ethics in a particular area are demonstrated through written and oral assignments. Nonetheless, students with less strong writing and presenting skills have also been exposed to and have practiced moral reasoning which hopefully contributes to their future development and decision-making abilities.

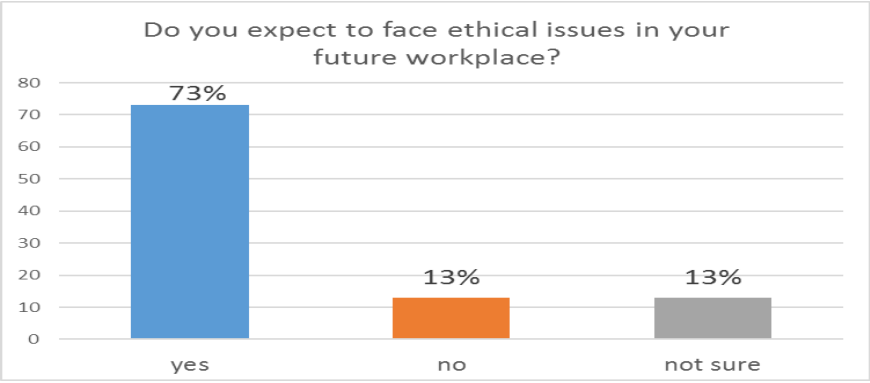
Below, Figure 4 reveals that students who have taken WRIT 340 indicate overwhelmingly that engineers and scientists should have a greater role in communicating scientific information to the public than they currently do. Students answering this question comment that engineers have the technical knowledge that is needed by the public to evaluate choices and positions about issues that are influenced by technology. When asked the follow-on question: do you think engineers should play a role in public debate about policy issues that have a technological or scientific basis? (e.g. climate change, online privacy, etc.), students unanimously reported "yes." Students report that technical information is important in making a correct and educated decision, and it makes sense for people who actually know what is going on would be involved in the debates. Nonetheless, nearly a third of the students responded that they were "not sure" that scientists should participate in public debate. The reason given for this response was the feeling that engineers often lack the communication skills needed for this activity.

Figure 4: Overwhelming Majority Think Engineers and Scientists Should Play a Larger Role in Communicating to the Public



Below, the majority of respondents expect ethical issues will crop up in their jobs. Given that many illustrations of ethical dilemmas that were discussed in the course were based on current developments involving well -known companies, this view is not surprising. In class case studies included Facebook's experimentation with user's feelings, Instagram's decision to sell user's content to third parties, Apple's use of low wage labor and factory conditions abroad among other cases that were used to define the precise nature of ethical issues and how they could be evaluated through ethical frameworks.

Figure 5: Majority Expect to Face Ethical Issues in Future Workplace

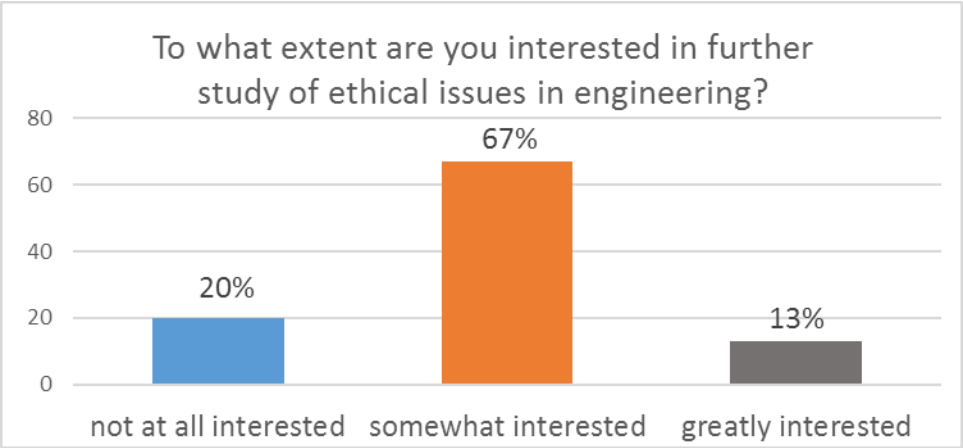


Given the need that student's see to understand ethics in a general way as well as day-to-day existence, students anticipate future ethical issues in their workplace. The kinds of issues that

they anticipate mainly involve trade-offs: safety vs. saving costs/time, profit vs. the general good, and making the best decision vs. making the right decision.

Finally, as seen below in Figure 6, despite the fact that students believe that engineers should take part in public debate around issues involving science and technology, and that they will face ethical issues in their careers, they have only moderate interest in pursuing further study of ethics in their curriculum.

Figure 6: Most Students Have Moderate Interest in Further Study of Ethical Issues in Engineering



Conclusion:

Although instruction in ethics occupies only part of the communications class profiled in this paper, students did report benefitting in their understanding of engineering ethics. In addition, classroom experience has shown that it is possible to generate greater enthusiasm for the topic than is initially present, although students do not express a strong intent to continue further study. A variety of topics and teaching techniques are used in the WRIT 340 program and elsewhere; face-to-face discussion to support writing assignments appears to be an effective mode for supporting students' thinking about ethics in the field of engineering. This initial effort suggests a need for further assessment and experimentation with ways to effectively teach ethics to engineers. From this investigation, it is tentatively possible to say that it is possible to cultivate student's abilities to think more deeply about ethics in their field.

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