

Teaching Ethics in the Context of Engineering Courses: A Blended Approach of Theory and Practice

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Teaching Ethics in Engineering: A “Blended” Approach of Theory and Practice

Introduction

Though accrediting boards such as the Accrediting Board for Engineering and Technology (ABET) require engineering programs to offer education in applied ethics, engineering faculty are often at a loss for how to teach this important topic to their students. This is in part because they often do not feel as though they have the proper background and training in ethics education and also in part because faculty are hard pressed to find time in their courses to teach ethics while also trying to get to all of the technical knowledge that their students need to learn in their classes (Van De Poel, Zandvoort & Brumsen, 2001; Herkert, 2000; Haws, 2001; Bird & Sieber, 2005). Nevertheless, many engineering faculty do recognize the importance of teaching ethics. Not only because doing so is to fulfill their commitment to accrediting boards, but also because they recognize that students need such training given that ethical considerations will be a major component in their everyday professional lives once they enter the workforce.

One of the standard ways ethics is taught to engineers is to use case studies relating to large-scale disasters like the Space Shuttle Challenger, Bhopal, Chernobyl, and so forth (Haws, 2001; Lynch 1997). The problem that we see with these types of case studies is that they have little to no connection to the students’ actual experience or to the kinds of things they will likely experience in their everyday professional lives. Further, although in-class discussions of student opinions of “right and wrong” behavior are valuable, it is important for the students to understand that there are multiple well-developed ethical theories that lead to completely

different “correct” decisions that are equally valid (based on the theories), regardless of what the student believes is “unethical.” There is often little background in ethical theory given to the students as a way to think through the case studies and choices people made in the past and/or might make (Haws, 2001).

The goal of this effort is to develop sustainable methods for including ethics in engineering programs which reduce the barriers for engineering instructors aid student learning of ethical theories and to have students apply their knowledge in a structured manner to case studies relevant to everyday engineering practice.

Methods

For four years, four teams of students and faculty have been involved in a project seeking to address issues ethics education at Worcester Polytechnic Institute (WPI). In the first year, a team of junior-level students from multiple technical disciplines created a systematic method to analyze ethics case studies in the context of engineering courses and a handbook with step-by-step instructions to aid engineering instructors in their efforts in include ethics in their course. In the second year, the team piloted a “joint-venture” approach to teaching ethics in engineering where philosophy faculty at WPI volunteered their time and expertise in engineering courses to give a single class ethics training to students combining some education around philosophical ethical theories and then also the application of these theories to case studies that were closely connected to course content.

The team decided on the “joint-venture” method after a first study in which they had an engineering professor teach an ethics lesson and then also had a philosophy professor teach a

similar lesson. Results from data collected on this first study indicated that the majority of students preferred the lecture/discussion led by the philosophy faculty member. Further, from interviews, the student team found that the engineering professor (second author) also preferred the lecture/discussion led by the philosophy faculty member; he thought the philosophy faculty member was better able to discuss the ethical theories. Further, 80% of students said that they had learned something new from the lecture led by the philosophy faculty member (Jackson, Jasensky, Liang, Moore, Rogers, Pfeifer & Billiar, 2015). This finding is consistent with those reported in other studies which also found, as mentioned at the outset of this paper, that many engineering faculty feel that ethics is better taught by those with expertise in such matters (Haws, 2001). But this work also pushes beyond such divisions in disciplines in that it seeks to pair experts in engineering with experts in philosophy and ethics in order to 1) better teach both the theoretical aspects of ethical thinking in the context of the course and engineering case studies, and 2) reinforce student perceptions of the importance of ethics education by bringing such experts into the technical classroom.

After this initial study, the team implemented a series of similar modules across a number of courses wherein a lecture/discussion by a philosophy professor was paired with a case study and an assignment that was tailored to the content of each individual technical course. In all, this study hit 200 students of various years (freshman through senior) in a variety of biomedical engineering courses. The findings in the study were overwhelmingly positive with the majority of students in these courses reporting gains in confidence with ethical thinking, helpfulness of the lectures/discussions in thinking through the issues raised in the case studies, increased interest in ethics, and belief that more such modules would be good to see in other technical courses (Jackson et al, 2015).

One problem with the “joint-venture” method is that it relies on the goodwill of philosophy faculty as they are not paid for their time constructing lectures and coming to classes. It also relies on availability of philosophy faculty for such guest-lectures. Scalability of this method is an issue as philosophy faculty are also teaching their own classes and pursuing their own research agendas; any work they did for this project was above and beyond the work they are already required to do as a part of their jobs. The next student team sought to address this problem by constructing and piloting a “blended” online and in-class approach. The team worked with philosophy faculty to create a series of videos that discuss philosophical ethical theories in much the same way that faculty did in the classes in the second year of the project. Students then viewed these videos, read a case study and then engineering faculty led discussions of the case studies. The team hypothesized that this method would be at least as effective in getting students to engage with and be interested in ethics as the “joint-venture” approach from the year before, while also allowing for the possibility of easier scaling of the model. In order to determine the effectiveness of the blended online method, classes were divided into two experimental groups. One group received guest lectures from philosophy faculty while the other group participated in the online “blended” method.

The experiment for the online blended approach included a series of paired classes from different engineering departments (and so expanded from the sole use of biomedical engineering courses in previous years). Each of these paired courses had roughly the same number of students. One of the paired courses used a joint-venture model in the same way as the previous year’s study; a philosophy professor led the discussion/lecture, while the other class in the pair watched the videos created by the team online, read the case study, and then participated in a discussion led by the engineering professor. The online lecture results were then compared

against the in-class lecture results. For this experiment, all of the classes received a case study prior to having an in-class discussion. Both groups answered questions related to the case study they received in order to compare the learning comprehension of the students.

Before the classes received the case studies, students of each group received a pre-survey, asking how much exposure to ethics education the students had prior to the class, how much they valued ethics education, and how they felt about ethics being discussed in engineering classes. The three groups also received a post-surveys that gauged their overall experience with the modules. In all, 6 different engineering courses were used in the experiment, with a total of about 450 students involved in the experiment.

Results and Discussion

In the latest iteration of the project, over 170 students from four “joint-venture” classes and over 180 students from two blended classes were surveyed. 14% of students had taken a full ethics course previously and 78% reported having encountered some ethical content in courses prior to our module. 60.5% of joint venture participants reported increased confidence in handling ethical dilemmas, while 78.9% reported the same for the online method. After participating, 91.7% of joint-venture students reported that they could identify, analyze, and handle an ethical situation in the workplace, with 93.3% for online students, a less than 2% difference. If ethics content was incorporated into other courses, 67% of participants in the joint-venture experiment would be interested in having ethics delivered this way, whereas 85% of the students in the online ethics experiment were interested in having ethics incorporated into other engineering classes (see Table 1).

In the pre-survey, students were given nine statements about ethical knowledge and competence and asked how much they agreed with the statements on a likert-scale (strongly disagree, disagree, neither agree or disagree, agree, or strongly agree). We should note here that these nine questions are part of the pre-survey whereas the six questions in Table One below are the post-survey. The responses from all nine questions were binned together. Upon analysis, the data were too fine-grained to make any conclusions, whereas in aggregate the responses provided a good self-assessment of overall confidence in making decisions ethically. Overall, 74.1% of students either agreed or strongly agreed with the 9 statements (a-i below), while only 5.1% of students either disagreed or strongly disagreed.

Those statements were:

- a) I can analyze a long-term problem to find an ethical solution.
- b) I can represent my work ethically to management.
- c) I can make suggestions to management for resolving an ethical problem.
- d) I can write a proposal to resolve an ethical problem.
- e) I can remain calm when facing ethical difficulties.
- f) I know how to deal with unforeseen ethical dilemmas.
- g) If someone opposes me, I can find ethical means to get what I want.
- h) I can usually handle whatever ethical situation I find myself in.
- i) It is easy for me to stick to my aims and accomplish my goals while maintaining ethical standards

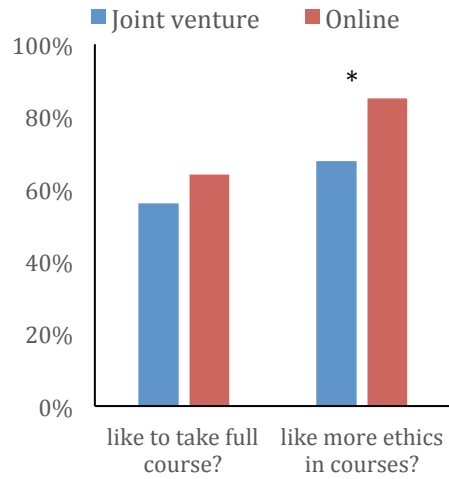
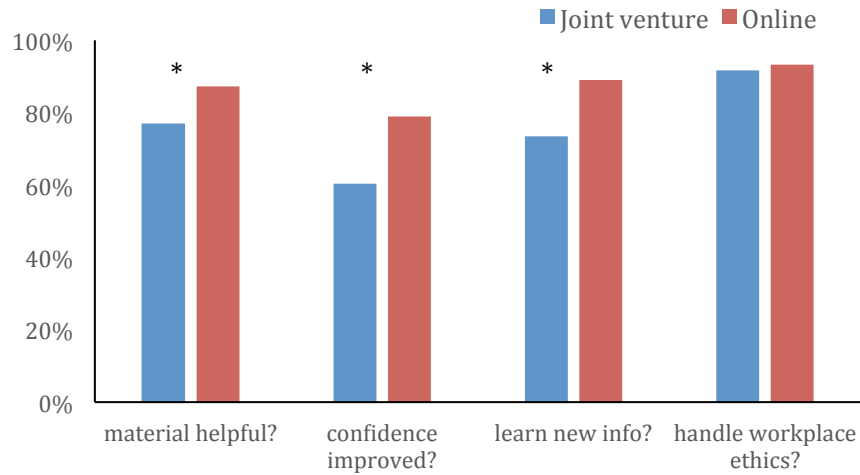


Figure 1: a) Percentage of students who answered “yes” to each of the four questions in the post-experience evaluation regarding efficacy of the teaching materials and learning. B) Percentage of students who answered “yes” to the two questions in the post-experience evaluation regarding interest in learning more about ethics. * indicates $p < 0.05$. Full text of questions and statistical significance is provided in Table 1.

Table 1: Full text of post-survey question with statistical results (t-test, comparison of Joint-Venture and Online approaches)

Post-survey questions	p-value
Was the material helpful with the assigned case?	<0.05
Are you more confident in answering ethical dilemmas than previously?	<0.05
Did you learn anything new regarding ethical situations?	<0.05
If encountered with an ethical situation in the workplace, could you identify, analyze, and handle it?	n.s.
Would you be willing to take a 1/3 unit (full) course in ethics related to your major?	n.s.
Would you like other courses in your major to incorporate similar ethical modules in the future?	<0.05

It is clear that some of the methods piloted here have been effective. As the data show, in all cases, the better result came from the online version. We think that in part, this is due to the fact that the amount of time students spent watching the videos and then having discussion in class was actually more than the amount of time spent on ethical theories and the case study in the joint venture model. So this allowed students to gain more knowledge overall and to bring that knowledge to bear in the discussion. Nevertheless, both methods have proven to work in helping students see the importance of ethics and ethical thinking in their future careers.

One limitation of the studies as we have conducted them thus far is that the modules and their content remain somewhat isolated interventions into the courses. This is because the content of the case studies used is not weaved throughout the course itself but rather discussed only during the duration of the module itself. This limitation is somewhat structural insofar as it is the case that these studies are themselves pilot studies. Due to the limited time devoted to ethics in any one course in this study (generally one lecture or less and one assignment), we did not expect instructors to observe objectively increased ethical behavior or thinking in each course. In future implementations, we will encourage instructors to ask questions about ethical practice in later assignments in the courses. Further, if engineering programs at our university were to adopt these methods in a more programmatic way, we would like to see the themes in the cases studies returned to at different points in the classes.

Not only have these methods been effective at getting students to think, and be excited about ethical issues in their chosen disciplines, but they have provided us, the faculty involved in the project, with a multi-year opportunity to discuss, think about, and reflect upon the respective views that each of us has about the goals of the project, what topics in engineering ethics are important, and the role of ethics in engineering more generally. We think that this reflection is critical for determining how to teach ethics across our curriculum.

We think that case studies are good ways to teach ethics in technical courses and they have proven effective in some studies (Yadav, Shaver & Meckl, 2010). However, we also agree with the literature that argues that using case studies that do not connect more closely to student experience, the content of a given course, and the kinds of everyday ethical questions students will face in their careers are not as effective at helping students integrate ethics education into their understanding of the scope of their education and future work (Lynch and Kline, 2000; Newberry 2004).

Further, though it is often the case that students are referred to ethical codes as examples of the importance of ethics in engineering, we feel that this is not enough and can actually have the effect of dampening student thought regarding ethics in their everyday practices. While it is true that codes of ethics do provide a useful overview of what a particular discipline or profession sees as right behavior, such ready-made sets of rules do not allow students to think reflectively and critically about their ethical perspectives and the intersection between those perspectives and the work that they do (Durbin, 2008; Bassart and Serra, 2013). We also contend, and our data show, that any education around engineering ethics, including that which uses case studies, should be paired with some education of philosophical ethical theories in order

to provide both context for ethical decision making and also to help students understand how to ground decisions relating to ethical conduct.

I (first author) was initially circumspect about the effectiveness of case studies as a method for teaching ethics. Given my training as a philosopher in ethical theories, and my teaching of ethics in standard, full length philosophy courses I tended to think that case studies as examples of ethical situations were too isolating in content and made it seem as though ethical reasoning was confined to only parts of a person's professional life whereas I tend to think of ethical reasoning as a foundational activity which permeates an individual's existence and is at the foundation of many decisions about who one is, who one wants to be, and more generally one's outlook on life. Throughout this project though, I have come to see the ways in which case studies can be effective tools for thinking through one's ethical outlook and how they can, if properly connected to the larger context of a given subject of study, actually help students see the ways in which ethical reasoning is foundational in just the ways that I thought they could not.

A second way in which my views of this as a faculty member have been changed in the course of this project is in relation to how effective I think that the insertion of short modules into technical courses can be. My initial view was that there could not be much we could teach students about ethical reasoning in a one hour session but I have seen the ways in which these act as instigators for students to think more deeply about their own ethical positions and the relation between those and the work that they will eventually do. These modules act as ways to peak student interest and, as our data shows, can lead to further investigation of ethical questions. As one of the participating faculty in the joint venture model, I have had students who have been a part of one of my module lectures, end up in one of my full-length ethics courses as a result.

Over the course of the successive projects, my (second author) perspective on ethics education has changed dramatically. As an engineering professor, I still believe it is critical that the students be exposed to ethical situations in the context of solving engineering problems so that they understand that even everyday decisions require ethical choices. However, I now recognize the need for a deeper understanding of the variety of ethical theories. It is not enough for students to read a case study, discuss their personal views on the matter, then debate with peers to see if they can change each other's minds (although this is a good exercise). In depth study and comparison of the key ethical theories (e.g., Kantianism vs. Utilitarianism) provides a common vocabulary for these discussions. More importantly, an understanding of these theories has the potential to enlighten students to the reality that there are multiple equally valid (theoretically at least) ways of navigating an ethical dilemma which may yield very different decisions. It is critically important that the engineers be trained to become self-aware of the basis for their ethical decisions and to respect their coworkers' points of view, even if they disagree. Examining the problem through the lens of multiple ethical theories may change their decisions, or aid them in convincing others to do so.

Conclusion

In summary, we found that when pairing case studies that relate closely to course content with lectures/discussions led by professors with expertise in ethical theory students found the material stimulating and reported learning gains. This result did not change when using videos as a way to scale up such joint venture type ethics modules and solve the problems associated with such methods.

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