Engineering Ethics: Teaching Moral Theories to Engineers

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Introduction

The Accreditation Board for Engineering and Technology (ABET) has long required that engineering programs address professional issues, including ethics, in their curricula. While engineering programs have approached this mandate from a variety of perspectives, adding code-based "ethics components" to existing courses in the curriculum seems to be the most common strategy.[1]

The Engineering Division at Lafayette College, a small, undergraduate institution, has chosen to address this requirement with a course called "Engineering Professionalism and Ethics." The course, which is required for all engineering students, has been taught by engineering faculty for the last thirteen years. It has been taught in more or less its present form since 1998.

The course uses a case study approach. However, the first section of the course, which was developed with significant interaction with the Philosophy Department, focuses on moral philosophy. Moral theories are then used as a basis for understanding and examining the engineering codes as well as the cases. This approach equips students with the tools to recognize arguments based on different types of moral theories. The students also learn the strengths and weaknesses of the theories. As a result, when a student needs to convince a colleague that a particular course of action is right, she or he is in a better position to make a rational case.

Although this paper is intended to be primarily a description of a particular course, a brief grounding in the existing literature should make the description more useful. According to Haws[2], at least 42 papers that addressed the teaching of engineering ethics were published in the American Society for Engineering Education (ASEE) conference proceedings between 1996 and 1999. In analyzing the papers, Haws looked at which students were required to take the courses and the content of the courses. He also considered the question of why we need courses in engineering ethics. Based on his analysis, he suggests that there are three primary objectives for engineering ethics instruction: improve students' ability to think divergently, improve students' ability to take the view of a non-engineer, and equip students with the vocabulary to articulate their ethical reasoning. He goes on to argue that of the six basic approaches to the subject he identified ("professional codes, humanist readings, theoretical grounding, ethical heuristics, case studies, and service learning" (p. 223)), none are sufficient in and of themselves, and that "theoretical grounding" (or the teaching of ethical theory) is critical.

This paper describes the origins of the professionalism and ethics course at Lafayette College, the current content of the course, the reasons for incorporating moral philosophy, and some possible future directions for the course. The course, as currently taught, does not meet Haws'

optimal ideas for an ethics course (it does not include service learning), but it does successfully incorporate the teaching of ethical theories to engineering students.

Course Origins

The Engineering Professionalism and Ethics course was developed at Lafayette College in the late 1980's and was first taught in the fall of 1989. The primary objective of the course was to expose engineering students to issues associated with science, technology, and society. The history of the course is described by Herkert[3], and its evolution to include the teaching of moral theories is discussed by Veshosky[4]. The course as it was originally designed is summarized briefly in the following paragraphs. It is interesting to note that although ABET requirements are commonly cited as a reason for teaching engineering ethics, Herkert makes no mention of that as a motivating factor for this particular course.

The course, to be taken during the sophomore year, was developed as a requirement for all engineering students. The four areas the course addressed included engineering and society, engineering economics, ethical aspects of engineering, and legal aspects of engineering. In addition to covering these general topics, the course required that the students participate in a panel discussion of a case study and write a short term paper.

The ethics portion of the course initially included discussion classes on topics such as safety and risk assessment, professionalism, codes of ethics, and the rights and responsibilities of engineers. Moral theories were only briefly introduced in an evening presentation called "Moral Thinking and Moral Theories," given by a guest lecturer from the philosophy department.

After the course became established, the instructors who taught the course met regularly to discuss how it could be improved. While case studies were used as a teaching tool from the start, the emphasis on case studies was increased significantly in 1994. At this time, the course was also modified to meet the requirements of a campus-wide curriculum change that required all students to take a Values and Science/Technology (VaST) seminar. To meet the VaST requirements, the students in the class were required to complete a minimum of 20 pages of process writing (writing that requires revision).

In January 1998, the faculty teaching the course participated in a seminar conducted by members of the philosophy department. This seminar was designed to help engineering faculty members incorporate moral theories into the Professionalism and Ethics course. The faculty members teaching the course were impressed with the potential of teaching moral theories in the engineering professionalism and ethics course and incorporated this change in the fall of 1998.

Current Course

Table 1 shows the course objectives and outcomes for the fall 2001 semester, and Table 2 shows the course schedule. The primary foci of the course are on understanding moral theories and applying them to the analysis of engineering cases, acquiring the skills to conduct a basic engineering economic analysis, and developing communication skills. Texts include a book on moral philosophy[5] and a more traditional engineering ethics book[6]. The philosophy book is used

Table 1. Course objectives and outcomes

Objectives	Expected Outcomes
To introduce students to common moral theories and to give them opportunities to apply these theories to societal and engineering problems.	Students will be able to define and discuss common moral theories and apply them to societal and engineering problems. Using two different case studies with significant ethical questions, they will complete one major paper and give one group presentation.
To introduce students to engineering case studies/issues where significant lessons were learned (e.g., the Bhopal disaster, the Challenger explosion, global warming).	Students will be familiar with a few of the major engineering case studies and/or issues where significant lessons were learned. They will have three short writing assignments on these cases/issues.
To introduce students to fundamentals of engineering economics involving the time-value of money and to give students opportunities to apply these economic concepts to engineering problems.	Students will understand the fundamentals of engineering economics with respect to the time-value of money and be able to apply these concepts to engineering problems. They will complete at least three engineering economics problem sets and one engineering economic case study.
To continue to develop students' presentation skills both in writing and in oral presentations. With respect to their writing skills, emphasis will be placed on improving organization and clarity of their writing.	Students will have greater confidence in their presentation skills and will be more aware of the weaknesses in their writing styles and of methods they can use to address these weaknesses.

to help students develop an understanding of moral theories and expand their vocabulary, and the engineering ethics book provides a connection to professional issues and cases.

As Table 2 shows, the course begins with communications skills and the introduction of the core case studies. The core case studies are introduced early in the semester so we can refer back to them as we develop the moral theories in class. For example, Bhopal[7] illustrates some of the problems with cultural relativism, and the Citicorp case[8] provides relevant examples for egoism and cultural relativism. These connections make the theories less abstract for the students.

There has been extensive debate about the appropriateness of including engineering economics in the course. Although it is certainly important to an engineer's education and ability to function as a professional, it doesn't fit "neatly" with the rest of the course. In an attempt to integrate the course components better, the final "economics" case study requires the students to analyze the case from both an economic and moral perspective. For example, in the fall 2001 semester, the assignment asked to students to evaluate potential highway safety improvements on the basis of economic feasibility and moral correctness. We are continuing to assess how to

Table 2. Course Schedule, Fall 2001

Class	Topics
1	Introduction, What is Professionalism?, What is Ethics?
2-3	Communications – Oral Presentations and Technical Writing
4	Core Case Study: Citicorp Building
5	Core Case Study: Bhopal
6	Case study discussion
7	Moral Philosophy – Morality
8	Moral Philosophy – Cultural Relativism
9	Moral Philosophy – Subjectivism
10	Moral Philosophy – Religion
11	Moral Philosophy – Ethical Egoism
12-13	Moral Philosophy – Utilitarianism
14-15	Moral Philosophy – Kant – Rules and Respect for Persons
16	Codes of Ethics
17	Line Drawing
18	Moral theories summary exercise (in class)
19	Evening Guest Speaker: Dr. George Panichas, Professor of Philosophy
20-21	Case studies
22-23	**Student Presentations of Major Case Studies #1**
24-29	Engineering Economics
30-31	Responsible Engineers and Case Studies
32	Evening Presentation – Case Study
33-34	Honesty, Integrity, and Reliability and Case Studies
35-36	Risk, Safety, and Liability and Case Studies
37-38	International Engineering and Case Studies
39	Case studies
40-41	**Student Presentations of Major Case Studies #2**
42	Course Review

improve the integration of the economics component with the primary focus on engineering ethics.

Why Teach Philosophy to Engineers?

Lafayette is one of a handful of small liberal arts colleges with accredited engineering programs. As such, we emphasize connections between engineering, social sciences, and humanities throughout the curriculum. Ethics at its core is about morals, and moral philosophy has a rich and strong tradition, beginning at least as far back as the ancient Greeks. To teach ethics in a liberal education setting outside of the framework of moral philosophy is a little like trying to teach engineering without taking advantage of physics – it can't work! Moreover, moral philosophy and engineering share a rational, objective approach to their respective problems. Giving our students the framework of moral theories allows them to resolve ethical questions, such as "should the public be informed?" or "should I blow the whistle?" more rationally. As Haws[2] states, "the general idea [of teaching ethical theories] is to provide a more logical, systematic format for the resolution of ethical dilemmas" (p. 226).

While a case study approach seems appropriate for learning about engineering professionalism and ethics[2,9], students typically arrive in the class armed with no more than "it seems like the right thing to do" as a way to defend an individual's actions. From our experience, they also seem uncomfortable with the notion that an ethical judgment considers an action "right" or "wrong" – not "it depends." As a result, to develop a common framework for discussion, we spend three weeks of class examining strengths and weaknesses of moral theories (Classes 7-15 in Table 2).

As alluded to above, the first step in introducing this approach is to introduce students to the idea that we can make "true/false" statements about whether an action is ethical. The second step is to use case studies, discussion, and writing assignments to create an awareness of critical thinking and what it means to be "rational" – the idea that a rational being should examine the evidence and make a decision that is best supported by the evidence. A tension exists between what the students "believe" is right and examining evidence to be able to defend what is right. For example, the fall 2001 semester, when the students wrote the first of two significant papers in the course, they had not yet been introduced to moral theories. The assignment was to write about a current ethical issue of their choice. While many students clearly were passionate about their topics, most provided little connection between facts and morality. That is, the students seem to think that "it's obvious this is right so the reader should agree with me" rather than laying out facts and drawing conclusions. There seems to be a lack of connection between what we do in engineering – drawing conclusions using a logical framework in which we consider the relevant facts – and moral decision making. Developing the students' capacity for moral reasoning through understanding different philosophies helps to restore this connection.

A variety of moral philosophies find application in engineering ethics. As shown in Table 2, we discuss everything from subjectivism and relativism to divine command, utilitarianism, and Kant's respect for persons. Just as some scientific theories fail the test of evidence and observation, many of these theories fail the tests of consistency, objectivity, and rationality, and we wind up with only a few that are helpful in resolving ethical questions and conflict. However, it greatly benefits our students to go through the process of learning a range of theories. They are able to identify and counter weak ethical arguments by recognizing their origins in weak theories, and hopefully to make their own decisions based on sound moral

theory. In the end, many students may still resort to their personal feelings and conscience; however, they should understand that there are other, sounder ways to make choices.

Challenges in Teaching the Course

Haws[2] notes one of the reasons engineering instructors don't like to teach ethics is that we feel that "the theoretical aspect of engineering ethics[,] is beyond our expertise" (p. 227). In addition to the challenge of teaching in an area that is not their expertise, the instructors teaching the course at Lafayette College have also identified challenges associated with teaching a discussion class and a writing class. The typical engineering professor is not trained in any of these areas.

Teaching a discussion class in a discipline that is still often lecture-based is difficult for both faculty members and students. Without a large number of alternative approaches to discussion, the class can become monotonous and students (and faculty!) lose interest. The faculty teaching this course use full class discussion, small group work, role-playing, guest speakers, videos, and brief in-class writing assignment to provide some variety.

The case study approach is common and has been well-documented in the literature. However, in spite of the wealth of material available in engineering ethics texts and on the world-wide web, challenges arise in several areas. Haws[2] and Harris et al.[9] raise concerns about contextualizing cases appropriately, providing a variety of cases, and ensuring cases have characters to whom the students can relate. We share these concerns, and we have tried to include more "mundane" cases (for example, whether to disobey your boss or what constitutes appropriate use of company resources) in addition to the major case studies. A further challenge has been to include cases from all engineering disciplines. Many of the more famous cases are tied to civil or mechanical engineering (for example, the Citicorp Building[8] or the Ford Pinto[9]), which frustrates our chemical and electrical engineers.

To deal with the issue of writing, the course is taught in conjunction with the college's writing program. Each section of the course is assigned a writing associate who serves as a peer evaluator of the student writing. This writing associate meets with each student for each writing assignment and reviews and suggests improvements to student drafts of papers. Writing associates who are also engineering majors are requested for the course when possible. In addition, the instructors spend time and effort to improve their methods of coaching student writing and evaluation of student writing.

Teaching out of an instructor's discipline requires time and study and presents the most challenge for the faculty. As Haws[2] states, "Learning, and then passing along technical skills and knowledge is relatively easy. Becoming morally grounded takes much more time" (p. 228). Faculty members teaching the course for the first time spend on average about twice the preparation time required for a typical engineering course. They also work with faculty members from the philosophy department to understand the moral theories and to learn to deal with typical student reactions to the applications of the theories to ethical dilemmas. For example, during the fall 2001 semester, two of the three faculty members teaching the course were new to the course. Early in the semester they met regularly with a member of the philosophy department to discuss the various moral theories, their application to engineering

problems, and the difficulties that could be anticipated in teaching these theories to college students. In January 2002, the philosophy department and the engineering division again sponsored a workshop for faculty members who teach Engineering Professionalism and Ethics. The focus on the workshop was on making connections between moral theories, professional codes, and cases. The support of and interaction with the philosophy department is an invaluable resource for the course.

Future Directions

Because the Engineering Professionalism and Ethics course is required for all engineering students and is now used to fulfill certain ABET objectives (e.g., ABET Engineering Criteria 2000, Criterion 3f), the engineering department heads and the head of the division of engineering must approve any changes to the course objectives and outcomes. This gives the faculty members teaching the course significantly less autonomy with the course than they would have with a course in their own department. However, at the end of each semester, the faculty members teaching the course meet to review and consider course modifications based on their own experiences and student assessments of the course.

At the end of the fall 2001 semester, the faculty members who were teaching the course recommended that more information concerning the history of the professional codes of ethics and their use in the professions be added, and that more time be spent discussing the relationship of the codes and the moral theories. Also, changes have been recommended to make the writing assignments more successful at helping students develop their critical thinking skills with respect to making moral decisions.

In addition, during fall 2001, the Engineering Professionalism and Ethics course underwent a complete review by a committee with representation from all engineering departments. Of the many changes that were considered in the course, the teaching of moral theories was again considered to be of significant benefit to the students, and the committee has recommended that this aspect of the course continue. The committee results will be presented to department heads and the head of the division of engineering in spring 2002, but no significant changes are expected to course content.

Conclusion

The Engineering Professionalism and Ethics course is required of all engineering students at Lafayette College. As a result, challenges and opportunities exist to engage the students across disciplines, to improve their critical thinking, moral reasoning, and writing skills, and to develop a basic understanding of moral philosophy. Students graduating with a Lafayette engineering degree should enter the workforce equipped to make sound ethical decisions based on evidence and to articulate the reasoning behind their decisions.

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