ENGINEERING ETHICS: WHAT? WHY? HOW? AND WHEN?

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ABSTRACT

Engineering ethics is professional ethics, as opposed to personal morality. It sets the standards for professional practice, and is only learned in a professional school or in professional practice. It is an essential part of professional education because it helps students deal with issues they will face in professional practice. The best way to teach engineering ethics is by using cases—not just the disaster cases that make the news, but the kinds of cases that an engineer is more likely to encounter. Many cases are available, and there are methods for analyzing them. Engineering ethics can be taught in a free-standing course, but there are strong arguments for introducing ethics in technical courses as well. Engineering is something that engineers do, and what they do has profound effects on others. If the subject of professional ethics is how members of a profession should, or should not, affect others in the course of practicing their profession, then engineering ethics is an essential aspect of engineering itself and education in professional responsibilities should be part of professional education in engineering, just as it is in law and medicine. Probably few engineering educators would disagree with these claims; their implementation in engineering education is another matter. We want to discuss the introduction of engineering ethics into engineering education in terms of four questions: What is engineering ethics? Why should it be emphasized in engineering education? How should it be taught? and When should it appear in the student’s education?

I. WHAT?

We begin with an obvious but important distinction, that between morality and professional ethics. Morality, as we shall use that term, refers to those standards of conduct that apply to everyone rather than only to members of a special group. Ideally, these standards are ones that every rational person wants every other to follow, even if everyone else’s following them would mean that he or she had to do the same. We were all quite young when we learned such basic moral rules as: don’t lie; don’t kill; don’t cheat; keep your promises; don’t steal; and so on. We were still quite young when we learned that these rules have exceptions (for example, “except in self-defense” for “don’t kill”). Now and then, we may change our view on how to interpret a particular rule or exception—for example, we may come to think that it is possible to lie without saying anything false (for example, by omitting some fact necessary for understanding what we do say). But, since we entered our teens, such changes have been few and relatively marginal. Our students are much like us. They arrive in class more or less morally mature. We have little to teach them about ordinary morality.

Not so with professional ethics. By “professional ethics” (henceforward in this paper, just “ethics”) we refer to those special morally permissible standards of conduct that, ideally, every member of a profession wants every other member to follow, even if that would mean having to do the same. Ethics applies to members of a group simply because they are members of that group. Medical ethics applies to people in medicine (and no one else); business ethics applies to people in business (and no one else); and engineering ethics applies to engineers (and no one else).1,2

The special standards that constitute engineering ethics are what are to be taught. They have been formulated in different codes of ethics, in formal interpretations of those codes, and in the less formal practices by which engineers pass on the special ways they do things to each new generation of engineers. So, except for those students lucky enough to have a mother or father who is an engineer, no one is likely to learn much about engineering ethics except at engineering school or while practicing engineering. Engineering ethics is as much a part of what engineers in particular know as factors of safety, testing procedures, or ways to design for reliability, durability, or economy. Engineering ethics is part of thinking like an engineer. Teaching engineering ethics is part of teaching engineering.

II. WHY?

Why teach engineering ethics? One possible answer is the long and familiar list of tragedies, disasters, and scandals in which engineers have been major players. Something should be done about all these bad things. This answer, what we can call the big news/bad news approach to ethics education, seems to miss the mark. Although these incidents should be a matter of concern to all of us, and especially to engineering students, who can learn from past mistakes, they are exceptional rather than ordinary occurrences in
Most engineers will never be involved in such news-worthy circumstances.

Big news for the media is usually bad news. This is why, when audiences are asked to think of media coverage of ethical issues in engineering, they come up with a familiar list of disasters: the collapse of the I-80 bridge in Kansas City, the Challenger disaster, the Bhopal disaster, DC-10 crashes, and so on and on. But an exclusive focus on big news/bad news events may encourage engineering students to think of ethics as primarily about others—those relatively few engineers who have the misfortune of being involved in something newsworthy. And they may take comfort in the knowledge that, despite some bad press for a few engineers, national surveys usually place engineers near the top of the list in regard to the public’s confidence in the ethics of the professions.

However, rather than relying on media coverage of disasters or public surveys for an answer to the question, “Why teach engineering ethics?” we suggest looking elsewhere. Some years ago the Hastings Center, an ethics think tank in New York, brought together educators from a broad range of disciplines to talk about what should be the common goals of ethics education in colleges and universities. One goal they identified was to stimulate the ethical imagination of students. Too often, the educators agreed, young professionals get caught by surprise when faced with an ethical problem in their professional practice. Never having seriously thought about such a problem, they may not handle it well.

A related goal is to help students recognize ethical issues. Although a conflict of interest may be lurking around the corner, it may not announce itself to the involved parties until matters have gone too far. For example, what counts as a conflict of interest in engineering practice—as well as precisely why it is an ethical problem—may not be obvious to the uninitiated. So, a third goal is to help students analyze key ethical concepts and principles that are relevant to the particular profession or practice. Other concepts come to mind—public health and safety, quality, usefulness, efficiency, cost/risk/benefit analysis, environmental harm, truthfulness, trustworthiness, loyalty.

Many of these concepts are “messy.” They resist the sort of precise definition engineering students might want. Even if there are paradigms for, say, “safe” or “unsafe,” there are areas of vagueness and uncertainty. Algorithms that do justice to the ethical issues are hard to come by. So, yet another goal is to help students analyze key ethical concepts and principles that are relevant to the particular profession or practice. Other concepts come to mind—public health and safety, quality, usefulness, efficiency, cost/risk/benefit analysis, environmental harm, truthfulness, trustworthiness, loyalty.

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Finally, teaching engineering ethics can increase a student’s ethical will-power. One might say, “Surely the classroom and laboratory are not the place for that.” Think again. Isn’t an engineer who knows that he shares a particular standard of conduct with other engineers more likely to follow it than one who believes himself alone? One benefit of discussing ethics in the classroom is that it shows students how much consensus there is (among engineers) on most standards of engineering ethics. There is power in numbers. That is one source of will-power.

III. How?

There is widespread agreement that the best way to teach professional ethics is by using cases. There are several modes of ethical analysis that can be useful in teaching problems. We shall discuss two of them. (For fuller accounts, see reference 5) Both methods are based on concepts and even expressions that we use in everyday experience when we talk about moral problems.

One of these expressions is “drawing the line.” We often ask where we should draw the line between acceptable and unacceptable actions. Let us consider a case that illustrates this first mode of ethical analysis, which we shall refer to as resolving a line-drawing problem.

Engineers often face the problem of accepting gifts from vendors. On the one hand, most engineers probably believe that accepting a cheap plastic pen from a vendor is permissible. On the other hand, all engineers believe it is not permissible to accept a $10,000 check from a vendor to specify a product that is both infra-

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rrior and more expensive. But where do we draw the line between these two extremes? Suppose a vendor offers to take us to the local country club for golf, or to sponsor us for membership in the country club. Suppose he invites us to a seminar in Hawaii, where his company and ours split the expenses. Suppose he invites us to a seminar in Hawaii, all expenses paid. Where do we draw the line?

In the line-drawing method, we compare the controversial case to noncontroversial cases, i.e. to the cases where there would be little doubt that the action is right (accepting the plastic pen) or wrong (accepting the $10,000 bribe). By isolating the similarities and differences between the controversial case and the noncontroversial cases, we are usually able to decide whether a controversial action is morally acceptable.

Now let us turn to the second mode of ethical analysis. A nother term that we often use in referring to moral problems is “conflict.” We say that we are in a conflict over an issue, meaning that we feel pulled in two different directions by competing considerations. Here we must engage in resolving a conflict problem.

The popular videotape “Gilbane Gold,” produced by the National Society of Professional Engineers, presents a classic conflict problem. In the story, a young engineer, David Jackson, the environmental engineer at ZC0RP, faces a problem. His job requires him to sign documents certifying that the plant discharge into the local sewer meets city regulations, when he suspects that it does not. To make matters worse, the contaminants in the plant’s discharge are arsenic and lead, and the sludge from the water treatment plant is made into a fertilizer (Gilbane Gold) which is used by local farmers. Plant management does not want to spend any more money to treat the discharge, and David believes that he could lose his job if he presses the issue too far.

David’s situation can best be described as a conflict problem. His major conflict is between his obligation to be a loyal employee and his obligation to protect the health of the public. Both obligations are legitimate. What should he do?

David needs to do some brainstorming. In fact, the importance of imagination in resolving ethical problems cannot be overemphasized, whether they are line-drawing or conflict problems. David should first think of what we call creative middle ways, i.e. actions that will enable him to meet all of his apparently conflicting obligations. For example, David might try to find a technical solution to the problem. This would enable him both to protect the citizens’ health and to protect ZC0RP. Failing this, he might suggest to his manager, Diane, that she, along with other managers of high-tech plants in the area, approach the city with the problem in a non-confrontational way. He might encourage her to argue that the plants and the city have a mutually beneficial relationship that should be preserved and that the problem can be solved if they work together.

Unfortunately, creative-middle-way solutions are not always possible. Then more difficult choices must be made, in which some obligations must be given priority over others. David might have to tell his superiors that he will not conceal anything from city authorities. He might even have to refuse to sign any more documents that certify that ZC0RP’s discharges are within city regulations. As a last resort, he might have to resign and go public, if he believes the situation is serious enough.

There is now a considerable body of cases in engineering ethics for case analysis. The Ethics and Values in Society (EVS) Program at the National Science Foundation, under the direction of Dr. Rachelle Hollander, has funded several projects designed to create cases. One, at Western Michigan University, developed a set of 33 cases, each focused on a single issue. The cases come from the experiences of practicing and retired engineering managers and focus on the kinds of situations a practicing engineer is likely to encounter. Each case is followed by discussion by a board of commentators. Another project, at Texas A&M University, developed a set of 11 cases taken mostly from real-world situations. The cases are presented with student handouts, instructor’s guides and recommendations for classroom use. Each case is specifically aimed at a particular required course (or courses) in the engineering undergraduate curriculum.

The National Society of Professional Engineers has case material available under the title, “Professional Engineers in Education (NSPE-PEE).” An electronic disc containing eight cases with guidelines is available from the Murdock Center for Engineering Professionalism and Ethics at Texas Tech University, directed by Dr. Jimmie Smith. Dr. Pennington Vann, also at the Murdock Center, has developed a bibliography on engineering ethics, including a listing of video tapes, such as “The Truesteel Affair” and “To Engineer Is Human.”

We believe students should be introduced to ethics in as many times and places inside and outside the curriculum as possible. Guest lectures, presentations to student chapters of professional societies and many other possibilities present themselves.

A nother possibility is to have a single, free-standing, non-technical elective course. At some schools, engineering departments offer seminar courses on engineering ethics. Elsewhere, such free-standing, non-technical electives are offered by philosophy departments. At Texas A&M, the course is taught by both an engineer and a philosopher. The course consists of one-hour lectures on Monday and Wednesday and a two-hour recitation section on Friday, which is devoted to case analysis. The usual format for the Friday session is to have a student act as a scribe to summarize the results of the class discussion on the blackboard. The instructor is then free to move around the room and encourage student discussion, in accordance with the line-drawing, conflict-resolution and other methods of case analysis.

Another approach is to introduce engineering ethics into required engineering courses. This approach has the advantage of teaching engineering ethics in a way that brings home how integral engineering ethics is to engineering practice. One way is to use videotapes or cases, such as the ones mentioned in the previous section.

Still another way is simply to enhance student awareness of ethical issues. (See reference 13.) For example, in a course on electrical circuits, an instructor might take a moment now and then to point out the practical effect of getting a problem wrong: “These circuits are typically used in aircraft navigation systems; a small error here, combined with two common errors of pilots, could cause a crash. In practice, your calculations will be checked many times, but some errors slip through. The easiest way to prevent disaster is to get the problem right the first time. Next problem.” Even a few such comments in the course of a semester can help engineering students see the practical context of highly abstract calculations: both the rela-
tion of those calculations to such ethical concerns as safety and the relation of their education to what they want to do after graduation.

Another easy way to provide information about ethics is to pass out a code of ethics at the beginning of the term and refer to it often enough during the term so that students get the idea it would be good to read it. A n instructor can mention that such-and-such a provision makes engineers responsible for the safety of what they help to make. It is surprising how many engineering faculty have not read a code of engineering ethics. Needless to say, their students are even less likely to have read a code. Just exposing students to a code is therefore a significant contribution to their ethics education.

V. CONCLUSION

Engineering ethics appears to be emerging as a distinct discipline, taking its place with medical, legal and business ethics. We believe the time is approaching when most if not all engineering schools will have some program for introducing students to engineering professionalism and ethics. The time for thinking about implementing such programs has arrived.

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