TEACHING ETHICS TO UNDERGRADUATE ENGINEERING STUDENTS: UNDERSTANDING PROFESSIONAL RESPONSIBILITY THROUGH EXAMPLES

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I . The context of engineering ethics in TCC 401-402

II. Why use case studies?

University of Virginia undergraduate engineering students study engineering ethics in their senior year as part of a required year-long course in the Division of Technology, Culture, and Communication. This course, TCC 401-402, helps prepare students for leadership roles in our increasingly more complex and highly technological society. The course emphasizes communication skills and develops a more comprehensive view of science and technology by learning to understand the power of myth in western technological society and defining engineering students' social roles and ethical responsibilities to society.

An important component of this broader understanding of science and technology is the senior thesis. All undergraduate students are required to write a senior thesis, usually on a topic in their field, under the supervision of a technical advisor and an advisor from the Division of Technology, Culture, and Communication. The research for the thesis can be done individually with the advisor, or as part of a group project. Even when working on a group project, each student is required to have his or her own part of the project and an individual thesis report. An exercise related to the thesis report is an "impact study" of each student's project. This is to make students think of possible consequences of their work beyond the obvious impact on themselves. If a particular thesis is part of a larger project, then students look at the impact the larger project has on themselves, the community and possibly society at large. This may even raise some ethical issues that a student needs to address in his or her paper.

The thesis project, in the form of a lengthy proposal, is started in TCC 401, "Western Technology and Culture." While students are deciding the topic of their research or design projects, they are introduced to the larger context of science and technology through readings and discussions in the course. They are required to consider that broader view when choosing the kind of project and specific topic on which they will focus their work. They learn to be more reflective about their chosen profession and senior project by asking questions about the

underlying assumption in our culture that all science and technology is progress in and of itself. The course encourages the students to view engineering from different perspectives, for example, from history, sociology, anthropology, psychology, comparative literature and philosophy. The concept of "progress" is examined in the context of western culture, sometimes by comparing it to other cultures.

When defining the essence and the boundaries of progress, students inevitably are confronted with the issue of human values: What are the human values that drive our view of progress and how does this relate to engineering work? What are the values associated with a particular senior thesis project or the kind of work that the project represents?

Such questions lead to discussions of individual responsibility in supporting our society's values. While the students frame and discuss these issues from a broader, philosophical perspective in the first semester of their senior year, in the second semester, in TCC 402, "The Engineer in Society," they take a much more personalized look at the issues of values and responsibility in the form of engineering ethics.

One half of the second semester is specifically devoted to the study of engineering ethics. The TCC professors use the textbook by Martin and Schinzinger, Ethics in Engineering[1], and a number of case studies from other sources (see accompanying paper by Gornan and Russell). The underlying message in the textbook is that anyone who works in science and technology, whether he or she is an engineer, manager or technician, is an active designer and participant in a large social experiment. This social experiment brings with it individual "social responsibility", even if the designer and participant is working as part of a team and has little decision making power.

Since most engineers work for corporations, the concept of individual social responsibility and how this fits in with corporate structure is important for engineering students to understand. This is where engineering ethics differs from medical ethics; for example, doctors are assumed to have autonomy over many life and death decisions. In the corporate structure, most of the crucial decisions are made by managers, not the individual engineers. This makes it easy to "pass the buck," and to take the position, "I am just a cog in the machine, and am only responsible for the technical expertise required of me and which is in my job description."

To teach the students that they are personally responsible not only for their work, but also for the impact of their work, is an important task. There are a number of approaches that can be used. One is the inductive method; the instructor starts off with a case study and discusses with the students the facts of the case and the implication of every action of every participant and then formulates the immediate and broader issues and questions that are raised by this particular example. This is usually a good way, a "hook," to get students personally involved in the study of engineering ethics. Ethics becomes more than an academic subject which is imposed on them. They realize from the start that they are being presented with dilemmas which might happen to them, and so they pay attention.

The deductive method is effective as well. Students are led from the broader perspective to the specific cases. If the instructor approaches the subject of ethics from the perspective that everyone in the class has a well-developed sense of right and wrong, but that there are different, philosophical approaches to framing problems, students take at least an academic interest, They willingly learn about the underlying assumptions of philosophical systems such as "utilitarianism, duty and rights ethics," for example, and learn theories of how to achieve "moral autonomy" and how to frame a problem. This can only be a smaller part of the introduction to engineering ethics; the next step has to be studying particular cases and then apply some of the general principles just learned.

Again, the case studies are absolutely necessary to convince the students that the study of engineering ethics is relevant, important and helps prepare them for their professional lives. We have found it most effective to present them with many different types of dilemmas that engineers confront and to go back and forth between the specific case studies and the general principles they demonstrate. We often ask groups of students to role play a particular scenario and then ask all of the students to comment and analyze. Their perspective changes when the situations are so personalized and graphically demonstrated. They learn to see problems from different perspectives in a larger context.

To develop the ability to understand individual behavior in the context of the society at large requires a certain amount of practice. For three years these students have been trained in convergent thinking. They have learned to frame specific problems in their engineering courses and solve them step by step. While the study of engineering ethics problems uses these same skills, it also requires divergent thinking. Students learn to see connections between the specific and the general, and they are asked to jump back and forth between the two without losing the connection. Sometimes several general principles need to be explored to understand the specific problems. Students learn that actions, and decisions to act, can have consequences that are not immediately apparent, but, nevertheless, have profound impact on the society and back on the individual. This may seem like teaching common sense, but it is really learning to develop habits of thinking before acting. It is learning to think on several levels at the same time and always considering that there are consequences to every action. Every action contains the past, the present and the future.

When students learn the importance of their actions, especially in the context of science and technology which often has immediate and widespread effect on society, they also get a much different sense of what it means to be a "professional engineer." Studying engineering ethics inevitably brings up the question of what it means to be a "professional." All engineering professions have ethics statements, which are generally prominently displayed in the various academic departments at the university. Even so, they tend to be unread by the students. Some students are surprised to learn that part of being a professional engineer is subscribing to a stated general and a specific code of ethics, one the code of ethics for all engineers and the other specific to various engineering disciplines. Studying these formal codes of ethics for engineers along with case studies also helps students understand the complexity of the profession they have

chosen. There is a formal structure in place that helps engineers make difficult decisions; they are professionals who are expected to uphold high professional standards.

The case studies give the students many specific examples of how their "professionalism", their ethics in general, might be challenged on the job. One could call the use of all these examples of ethical dilemmas "rehearsals" for the real dilemmas that these students will inevitably face when they are practicing engineers.

The Division of Technology, Culture, and Communication also brings in guest speakers to address the issues of engineering ethics and to tell about their own personal experiences. One such speaker was Roger Boisjoly of the Challenger Disaster, who was a case study unto himself. Up until now, all of the students remember the Challenger Disaster and have seen footage of the explosion of the space shuttle. Roger Boisjoly's talk made the event and the ethical questions it posed on a general and specific level most relevant to the students. Other speakers have been former students who tell of their own experiences while working in industry and the decisions they have had to make in the face of possible improprieties.

By the time the students finish the second term, TCC 402, they have a keen sense of the nature and complexity of engineering ethics, and of the problems they might face as professionals. They also have a much better sense of their own personal belief system. This is achieved by the students through reading various materials, including case studies, writing about these issues and leading and participating in spirited discussions of issues in engineering ethics. Students show a new respect for making decisions about what is right and wrong on the job; their thinking is no longer simplistic or one-dimensional. Studying the general principles of ethics in the context of the culture at large has forced them to examine their own beliefs, as well as the values inherent in our society. Analyzing the engineering case studies has personalized the study of ethics for them. They are much better prepared to face the challenges of the work place because they know how to recognize, frame and think about ethical problems; they are ready to take their place in our technological society.

Reference

[1] Ethics in Engineering, Second Edition, Mike W. Martin and Roland Schinzinger, McGraw-Hill.

Biographic Information

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