Using Case Studies to Teach Engineering Ethics and Professionalism

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Introduction

Calvin College, a comprehensive Christian liberal arts college in Grand Rapids, Michigan, offers an accredited Bachelor of Science in Engineering degree. One of the desired learning outcomes for our graduates is that they “have an understanding of professional and ethical responsibility from a Christian, holistic perspective.” Individual faculty members within the engineering department have contributed informally to the achievement of this outcome in many different ways. In July of 2002, I had the opportunity to attend an Ethics Across the Curriculum (EAC) workshop at the Illinois Institute of Technology sponsored by the National Science Foundation. In response to that workshop, I have proposed the development of a formal plan for ethics instruction distributed throughout the engineering curriculum.

The goal of the plan is to guarantee that all engineering students become aware of the importance of ethics in the context of their technical work. This involves four objectives: 1) increasing students’ awareness of ethical dilemmas, so they recognize ethical dilemmas when they encounter them and take their responsibilities seriously, 2) increasing student knowledge of relevant standards so they know where to look as they establish what constitutes an ethical response in a given situation, 3) improving ethical judgment of students, so they have the critical thinking skills necessary for making an ethical choice, and 4) increasing students’ ethical willpower, so they have the courage and perseverance to follow through on their ethical judgments. Engineering students must experience this material as having direct relevance to their technical work. The plan would also allow later courses to build on ethics-related material that had been taught in earlier courses.
INTRODUCTION TO ENGINEERING DESIGN

The first course in which ethics is presented is ENGR 101 Introduction to Engineering Design. This course is typically taken by all engineering students during their first semester in the program. Enrollment in this course in the fall of 2003 was 134 students divided into 5 sections (115 students in the fall of 2002). The course is taught by a rotating roster of two to four faculty members each year. The lead instructor typically organizes a curriculum that is followed by all the sections.

There are four major objectives for this course: 1) students are introduced to the field of engineering and the concentrations offered at Calvin, 2) students learn computer tools useful for engineering work and presentations, including spreadsheets and presentation software, 3) students learn about some of the methods and issues that are important in engineering, namely: creativity and the design process, project planning, engineering economics, technical reporting and oral presentations, Christian perspectives on technology, teamwork, and ethics in engineering, and 4) students experience working in teams to solve open-ended design problems. The course topics are structured to support two student design projects. The first is a service-learning project in which groups of 4 or 5 students work together to design a fixture, device, or system to help the clients of a local non-profit organization which provides employment or rehabilitation opportunities for the mentally or physically handicapped. The second involves research into various electrical power generation alternatives in order to recommend the best option for a utility company. Within the department ethics plan, this course is where foundational principles are presented that can be extended in later courses.

ETHICS CONTENT

A conscious attempt was made starting in the fall of 2002 to integrate the ethics content with our goal of exposing students to engineering as a profession. The focus was on two case studies that were presented at the EAC workshop. Each of these case studies presents a dilemma experienced by an entry level engineer, someone with whom first-year engineering students can identify. The case studies serve to expose students to potential ethical questions. They also serve as the motivation for and demonstration of a structured ethical problem solving method and an introduction to a professional engineering code of ethics.
Catalyst B

About half way through the semester, students were presented in class with the “Catalyst B: Phase I” case study as a handout. The text of the handout is reprinted below.

Catalyst B: Phase I
Michael Pritchard, Western Michigan University

A recent graduate of Engineering Tech (ETU), you have been employed in the R & D Chemical Engineering Division of Larom, Inc. for the past several months. You were hired because of the promising research you did with catalysts as a student at ETU.

Alex Smith, the head of your unit, showed immediate interest in your research on catalyst B when you arrived at Larom, asking to see the results of the research you did at ETU. Although he said he found your work promising, your work assignments during the first several months at Larom have mainly been in other areas. You have had little time to pursue your research on catalyst B since your arrival at Larom.

Alex calls a meeting of engineers in your unit and announces that it must make a recommendation within the next two days on what catalyst Larom should use in processing a major product. The overwhelming consensus in the unit, based on many years of experience, is that catalyst A is best for the job. However, the research you have been conducting provides preliminary evidence that catalyst B may actually be better. So, you suggest that the recommendation be delayed another month to see if firmer evidence can be found. If B is the better catalyst, Larom will save a great deal of money if it opts for B over A.

Alex replies, “We don’t have a month. We have two days.” He then asks you to write up the report, leaving out the preliminary data you have gathered about catalyst B. He says, “It would be nice to do some more research on B, but we just don’t have the time. Besides, I doubt if anything would show up in the next month to change our minds. This is one of those times we have to be decisive – and we have to look decisive. They’re really getting impatient with us on this one. Anyway, we’ve had a lot of experience in this area.”
You like working for Larom and feel lucky to have landed such a good job right out of school. Although you would like to have more time to carry out your own research, you have enjoyed working on other projects in the division; and you have learned a lot from your colleagues in the few months you have been working with them. You are due for a significant pay raise soon if you play your cards right. It looks like you have a bright future with Larom, Inc.

What should you do?

Students were asked to imagine themselves in the position of an entry level chemical engineer and to decide on a morally correct response to this situation. Not all students were immediately aware that there was an ethical dilemma in this description. After some prodding by the professor and contributions from other students, the class began to understand the conflicting issues in the scenario. In the initial discussion, students wrestled with the problem, trying to pin down the specifics of the situation, and occasionally questioned whether it was realistic. This offered a perfect opportunity for the instructors to share their related professional experiences. At this point, I interrupted the discussion to recommend that a structured approach to solve this problem might get us to a better solution. I then handed out a Seven Step Guide to Ethical Problem Solving and pointed out the similarity of this approach to the engineering design process they had been using for their team project.

I continued the discussion by following the guide. The problem statement and fact-checking steps proceeded quickly, since many of these issues had been clarified in the earlier discussion. I then challenged students to come up with some relevant factors. They had very little to contribute that was specific to the situation. I followed up by talking about the responsibilities of a professional engineer. Here I stressed that professional engineers operate autonomously, with the implication that they are responsible for making ethical choices, not just following orders. I also stressed the common goal shared by those in engineering occupations of providing a service to society. The achievement of this goal implies the need for professional policing, or the provision of guidelines which all in that profession should be expected to follow. I handed out the Accreditation Board for Engineering and Technology (ABET) Code of Ethics of Engineers (including the guidelines) as a representative example of standards formulated by engineers to guide their conduct.
pointed out that these standards are not obvious, which means they need to be taught, and that they are specific to the field of engineering as opposed to other professions which see their ethical obligations differently. This was the first time we had focused directly on an engineering code of ethics as part of learning about the engineering profession and as guidance for ethical decision making.

I then challenged the students to identify parts of the ABET code that might apply to the case study. The most relevant passages were identified as Fundamental Principle II (serving with fidelity their employers), and Fundamental Canons 2 (perform services only in the area of their competence) and 3 (make public statements in an objective and truthful manner). In the Guidelines, 2a (when qualified by education or experience), 2c (not affix signatures to documents in which they lack competency), and 3b (truthful in all reports, include all relevant and pertinent information) are the standards that apply.

I then encouraged students to list possible responses, coming up with creative and detailed alternatives. These typically included: writing the report as ordered, refusing to write the report, writing two reports (one for your boss and one for management), writing the report as ordered but not signing it, writing the report and signing it but keeping a memo for your files explaining your disagreement, or going to your boss’s supervisor. We had only a little time to test the options before I concluded the lecture with a vote on the best choice. Typically two or three of the options were most popular while the others got few, if any, votes. The particular options chosen tended to differ by section, depending on the different emphases of the discussions. Although some students pushed for the right (i.e. professor’s) answer, most seemed to have moved beyond a simplistic black and white approach to the issue, recognizing the complexity of the situation.

At the beginning of the following class period, Phases II and III of the case study were handed out. In order to save class time, discussion was not used to consider these. Rather, students were required to write and submit a one-page response to either Phase II or III (their choice). The emphasis was on the consequences of the original response to Phase I. Students were told that good responses would refer to the code of ethics and other relevant factors to justify their decisions. Many students developed good response papers that demonstrated they had considered the problem carefully. I was somewhat disappointed in the lack of direct references to the code of ethics in their statements, but was generally satisfied with their first efforts.
Testing Water

Toward the end of the semester (following activities which included visits to the work sites of engineering mentors, a guest lecturer leading several case studies related to work-place ethics, and an introduction to Calvin’s engineering internship program), the “Testing Water … and Ethics” video was shown. In this case study, an entry-level civil engineer is faced with the problem of whether or not to report findings from a site water-quality test that are not required by law. Students watched the scenario on video. After the initial problem became clear, I distributed a worksheet with four alternative responses listed. Students were asked to identify the most ethically acceptable response, the least acceptable response, and the response they would recommend. I made reference once again to the ABET Code of Ethics for Engineers handed out earlier in the semester. Students spent 10 or 15 minutes filling in the sheets. After they were finished, the sheets were collected, and the remaining section of the video was shown. Students finished with a discussion, and the worksheets were graded with a simple ✓, +, or -. 

ASSESSMENT

A survey was completed by students on the last day of class indicating to what extent they thought the ethics instruction in the course was valuable. The student evaluations indicated that most students found the material useful. The following is data from the fall of 2002.

• 94% said the ethics component of the course increased their awareness of ethical issues likely to arise in their profession or job
• 74% said it changed their understanding of the importance of ethics
• 73% said it increased their ability to deal with ethical problems
• 70% said the right amount of time was spent on ethics (of the remaining 30%, twice as many indicated too much as opposed to too little time was spent)

The instructors felt the ethics material was very valuable. The case studies were an effective means of connecting ethical questions with the practice of engineering. We had a chance to introduce information about the nature of an engineering workplace and how employee/manager relations should be handled in a profession. Although students may not respond with enthusiasm to problems that are presented as purely moral/ethical issues (which they may perceive as philosophical and not
directly related to technical considerations) they are always interested in learning about the way things work in industry. We appreciated the opportunity to teach students about the special circumstances and standards that apply to engineering work using the engineering code of ethics, which they would otherwise have been unaware of.

CONCLUSIONS

We are concerned, as are all professional education programs, with how to encourage our graduates to “do the right thing” once they are out in practice. The pedagogical strategy of micro-insertion of ethics-related issues throughout the curriculum shows great promise. The “Catalyst B” and “Testing Water” case studies in ENGR 101 were much more valuable to the students than other case studies that had been used. Our previous efforts with failure case studies (a video interviewing Roger Boisjoly about his experiences with the Challenger, a skit about an antenna tower collapse, and video of the Dateline NBC/General Motors treatment of side-mounted truck gas tanks) were less successful. There was no direct connection between these issues and likely student job experience and too much time was spent assigning blame rather than constructing creative responses. The “Catalyst B” and “Testing Water” case studies were more directly relevant to our goals of helping students determine what it is like to be an engineer.

With both of these case studies, discussion was lively, but the required written assignments were also necessary. Students often disregard things that they aren’t held accountable for, and written assignments assure that this material is taken as seriously as other aspects of the course. In the future, we would like to develop greater student accountability for this material with quizzes or test questions.

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NOTES

1 Presented at the Thirteenth Annual Meeting of the Association for Practical & Professional Ethics, February 26-29, 2004, in Cincinnati, Ohio.
