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Educating Engineering Students about Ethics: Experiences at Brown University and Trinity College

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Abstract

Engineering students need to understand that their future profession is guided by principles of ethics – principles regarding both the practice of engineering itself, and the business environment in which that practice occurs. Since 2003 at Trinity College (Hartford), and since 2005 at Brown University, this need has been addressed in lectures presented by an ethics advocate, lawyer and member of the senior management team at a Fortune 50 corporation. These lectures draw heavily upon real-life examples of business situations in which the company's engineers faced ethical choices and decisions. The guest lecturer solicits student participation and discussion to illustrate the importance of ethics, the kinds of ethical decisions made in the business world, and the nature of ethical decision-making. Particular ethical challenges discussed during the lecture include conflicts of interest, gratuities and bribes, and the protection of proprietary information, among others. This paper will discuss the method and content of the lecture, and observations by the lecturer and the host engineering professors about the perceived level of ethical awareness among the students. The paper will describe the courses in which the lectures are presented at Trinity and Brown, and it will present and discuss the results of a survey completed by the engineering students. The survey, administered to current and past students at Trinity and Brown, asked them to evaluate the value and effectiveness of the ethics lectures. The survey questions asked students to recall the lecture, to consider the lecture's effect on their ability to make ethical choices, and to rate the value of the ethics lecture on their engineering education. Approximately 80% of those surveyed considered ethics to be a generally important topic to be covered in their college education, and 74% found this particular lecture to have been helpful for making ethical choices.

Making the Case for an Ethics Lecture

There is an apparent consensus among the business world, educators, accrediting authorities and agencies for scientific advancement [1] that colleges and universities should address ethics as part of undergraduate and graduate engineering curricula. The need for ethics in engineering education was framed by William A. Wulf in his 2002 editorial, which recognized the "enormous impact of engineers on individuals and society" and "deep moral and ethical responsibilities" in view of the rapid growth in nanotechnology, biotechnology, and information systems [2]. The "how" of teaching engineering ethics has been considered by many authors including Joseph Herkert, who described models for ethics instruction in the curriculum: stand-alone courses; course modules that study ethical issues by integrating ethics with engineering topics, often in capstone courses; shorter discussions, often in one lecture, that consider such topics as engineering failure, safety, and conflicting values [3] and via collaborative learning [4]. Further, Harris and his co-authors argued that the case study method is the most effective approach to teaching engineering ethics, allowing students to consider such issues as "drawing the line" and resolving conflicts that present ethical dilemmas [5]. Finally, Colby and Sullivan

suggest that codes of ethics serve well as frameworks for ethics discussions, and argue, in view of an engineering curriculum that is "full", that it may be advantageous to integrate ethics-related activities into the discussion of professionalism and the work of engineering professionals in technical and interpersonal realms. These authors also suggest the use of active pedagogies (guided practice, learning by doing), and integration of ethics issues in design courses, which inherently consider ethical tradeoffs presented by design problems [6].

The importance of instruction in ethics and professionalism has been recognized generally by the business and higher education communities. Consider, for example, Bryant University and Bentley University – two business-oriented universities that showcase a focus on "ethical reasoning" (an element of Bryant's First-Year Gateway core curriculum), and a "commitment to business ethics" where students learn about "management and moral behavior (highlighted themes of Bentley's general academic approach of integrating business studies with traditional liberal arts studies) [7,8]. Many, if not most, other colleges offering business programs likewise include an exposure to ethical problem-solving as a mandatory element of their curricula. They do this both in response to industry, where a well developed sense of ethics promotes and protects companies' reputations and bottom lines, and in response to the mandates of accrediting agencies that consider the study of marketing, accounting and business management to be incomplete without a discussion of how profits and losses are impacted by ethical decisions. [9].

The focus on ethics is also plainly evident in the field of undergraduate engineering education. Since 2001, the Accreditation Board for Engineering and Technology, Inc. (ABET) has required college engineering programs to address "an understanding of professional and ethical responsibility" as a student outcome. Our schools have embraced and met that requirement in an effort to provide well-rounded courses of study; and the companies that recruit and employ our engineering students view ethical awareness as a valuable asset – an important personal trait that makes a technically talented job candidate all the more attractive.

Trinity College (Hartford) and Brown University are among the many colleges whose ABET-accredited engineering programs include ethics as an element of their curricula. At both of these institutions, an executive-level in-house lawyer and ethics advocate from United Technologies Corporation (UTC) has presented a guest lecture on "Business Ethics for Engineers", since 2003 at Trinity, and since 2005 at Brown. The idea for the lectures began at Trinity, which is located nearby the world headquarters of UTC and its Pratt & Whitney Division (a major jet engine manufacturer). The collaboration began when a senior Pratt & Whitney engineer who had graduated from Trinity recognized the common interest of the college and the company in promoting an understanding of business ethics, and encouraged a discussion between Trinity's faculty and Pratt & Whitney's senior management. When a resulting guest lecture was well received at Trinity, it came to the attention of a Professor and former Dean of Engineering at Brown – himself a Trinity graduate – and lectures began at Brown in the following year. (While some of the Trinity lectures also featured a second guest lecturer from another nearby company – Northeast Utilities – this paper focuses only on the lectures given by the UTC lecturer.)

At Trinity, the lecture is given in a first-year course, Introduction to Engineering Design: Mobile Robots (IED), which introduces prospective majors to the engineering field; exposes them to the conceptualization, analysis, synthesis, testing and documentation of engineering systems; and

engages them in team-based design of autonomous mobile robots for competition [10]. The course consists of twenty-six 75-minute lectures, half devoted to developing engineering skills related to robot design (e.g., programming, interfacing, sensing) and half devoted to developing professional awareness by discussing such topics as the nature and philosophy of design, the practice of design in industry, engineering ethics, and intellectual property. Offered in the spring semester, the course enrolls 24 students divided into eight teams whose membership is chosen to achieve a balanced set of student skills and interests. A team mentor, an undergraduate chosen from among former students, facilitates the team's project work and monitors interpersonal problems [11]. Assigned readings prepare the IED students for the ethics lecture [12-15].

At Brown, the lecture is part of a course in Electrical Circuits and Signals, which emphasizes the analysis and design of systems described by ordinary linear differential equations with a very strong emphasis on getting the students to think in the frequency domain. The class size for this course is typically about 80 students, and the class is made up mostly of sophomores from all seven of the accredited engineering programs. The course is considered a "core" course and is taken by nearly all engineering students just as they are set to declare their concentration – i.e., which engineering discipline they want to choose as their principal area. The Brown students are also tested on their understanding of the ethics topic in their final exams.

That the single lecture is a sufficient and effective way to introduce engineering students to the topic of ethics is supported by the results of a survey (discussed later in this paper) that was distributed to the students who have attended the lectures over the years. While opinions may vary on the need for a more comprehensive treatment of Ethics, the authors believe, and the surveyed Trinity and Brown students largely concur, that the dedication of one class period exclusively to the subject of ethics gives the students an introduction sufficient to encourage the integration of ethics into the overall thought process of engineering students as they pursue their chosen field.

Content of the Ethics Lecture

The overall nature of the lecture is interactive, calling for substantial student participation. The lecturer uses a series of PowerPoint slides to display important content, and supplements that information by writing on a chalk board certain responses and contributions provided by the students during the course of the lecture. The lecture begins by asking why we are talking to engineering students about ethics in the first place. By explaining that ethical questions arise frequently in the workplace, and that there are serious consequences for people and organizations that lose sight of ethical principles, the intent is to capture the attention of the class by letting the students know that exciting and negative consequences can and do result from ethical lapses, and that we will be discussing some practical, concrete, real-life situations illustrating the importance of ethical thinking. The students are told that careers can be ruined, fortunes can be lost and market values can be shrunk – sometimes to the point of complete liquidation in bankruptcy – when people ignore ethics. They are also told that we will not be discussing ethics in a highly theoretical or philosophical manner, both because time does not permit such a discussion in a single short lecture, and because the lecture's intent does not call for it. In addition, they are told that the lecture is not so much about *engineering ethics* as it is about *business ethics for engineers*. That is, the focus is not on technical engineering design or test decisions, but rather

on interpersonal behavior. While the former is a topic of enormous import, having potentially far-reaching consequences for the health and safety of society, the latter is the topic for the day.

Having assured the students that this is not a lecture steeped in the rhetoric of Aristotle or Plato, the lecturer next asks the students to help define "ethics". The students contribute a collection of words and phrases that commonly come to mind when one hears the word "ethics". The lecturer writes those words and phrases on the chalk board as the students call them out, and he then displays in PowerPoint both a dictionary definition of "ethics", and a second definition or explanation of the word, according to a modern author and motivational speaker. Invariably, the words and phrases provided by the students match up substantially with these definitions. Thus, very early in the lecture, the students have begun to invest their own thoughts into the topic, and those thoughts are immediately validated through the comparison of their own definitions with the reference definitions. To use a popular expression, the students establish some "ownership" in the lecture. That "ownership" grows over the course of the lecture, as the lecturer returns to the chalkboard throughout the class to emphasize some of the students' words and phrases while discussing examples of ethical decision-making.

As a second technique to stimulate student participation, the lecturer also asks the students to identify the "stakeholders" in a business environment for whom ethical behavior is important. Or, stated differently, who are the people to whom we owe a duty of ethical behavior? The students have always identified some, but not usually all, of the following constituencies: shareholders, fellow employees, customers, suppliers, competitors, and the communities in which a business operates. With those six stakeholders listed on the chalkboard, the lecturer has created a second source of student-provided information to draw upon throughout the remainder of the lecture. In effect, the students themselves have helped to establish a foundation and framework for discussing real-life examples of ethical questions as the lecture proceeds.

Before turning to those real-life examples, the students are shown the Code of Responsibility of the American Association of Professional Engineers, and the lecturer briefly reviews the six major principles of that Code. This segment of the lecture is intended to reinforce the point that ethics is not merely an ephemeral topic for academic and intellectual consideration – it is a concrete expectation of the engineering profession, just as it is in other professions such as law and medicine.

At this point, the lecture turns to a discussion of some ethical questions drawn from the real-life experience of the lecturer. The PowerPoint slide deck contains seven such questions, each presented as a set of facts and a question about the ethical implications of those facts. Without exception, the allotted time for the lecture has permitted a discussion of only three or four of these examples of ethical reasoning – a good indication that the students are engaged sufficiently to support a robust and lively discussion. Facilitated by the lecturer, the students usually express a range of reactions to the examples presented. There are often conflicting viewpoints among the students – disagreements over what constitutes ethical behavior in a given set of circumstances. The discussion becomes highly interactive, both between the lecturer and the students, and among the students themselves. Spin-off questions arise, permitting the lecturer to guide the conversation in a way that refers back to the fundamental framework

established earlier in the lecturer, and to illustrate and encourage a thought process in which ethics plays an important role.

The first set of facts presented for discussion explores the interplay between what is "legal" and what is "ethical". The students are told that a large, high-tech company enters into a written and legally binding one-year contract with a consulting engineer to assist the company with a large new product development program. The contract obligates the consultant to be available for the company engineers to call upon at any time during the year, describes the daily rate of compensation to be paid ($800 per day), and guarantees that, in any event, the consultant will be paid a yearly minimum amount of $24,000 – the equivalent of 30 days of consulting work – regardless of whether the company actually calls upon the consultant to work at least that minimum number of days during the year. (This is explained as a somewhat common structure for consultants who have agreed to make themselves available to the company for a long period of time, e.g. a year, and who might well decline other employment or engagements in order to honor that availability promise. The "guaranteed minimum" compensates the consultant for the lost opportunity to do other paid work). The students are also told that the contract contains a clause concerning invoicing, which states that the company is under no obligation to pay the consultant unless and until the consultant submits a detailed written invoice, and that all invoices must be submitted no later than 30 days after the one-year term of the contract. After entering into the contract, the company used the consultant's services only 20 days during the ensuing year, and so the consultant has submitted invoices for, and has been paid a total of $16,000. However, several months after end of the one-year contract period, the consultant has not invoiced the company for $8,000 -- the amount that would bring his total compensation up to the guaranteed minimum amount. The engineering department is working on its budget for the current year, and has assumed that because the consultant has not met his legal obligation of submitting a timely invoice, the company is not obligated to pay the difference between the "guaranteed minimum" and the amount paid for actual consulting work. The engineering manager having responsibility for the current year engineering budget therefore assumes that she may consider that difference of $8,000 to be available for next year's expenditures, free from any legitimate claim of the consultant, and she has asked the company's lawyer whether that analysis is correct. The question for discussion is whether the students see an ethical question here, and how they think the company engineer should be answered.

This first discussion example often elicits a range of responses that span the entire spectrum from

> "It is perfectly legal for the company to refuse to pay, so the company should avail itself of its legal rights, and refuse to pay"; to
>
> "It is not enough for the company to ask whether its actions are legal. It should also consider whether it is doing the *right thing,* and the right thing is to pay the minimum."

The discussion of this example requires the students to think about some of the stakeholders they identified earlier in the lecture session – most notably the company's shareholders (who care about preserving capital and whose interests include an aversion to the spending of company funds that need not be spent), and the company's suppliers (such as this consultant, who is a supplier of technical services, and whose interests include fair treatment). The example also

calls upon the students to consider both the short-term and long-term implications of the company's actions. That is, while it may serve the short term interests of the company and its shareholders to conserve cash in the current financial reporting period, it may harm the long term interests of the company to damage both a relationship with a valuable consulting resource, and the company's reputation among similarly situated consultants. And, of course, the example requires the students to weigh that which is ethically right against that which is technically legal.

Another fact pattern, chosen to explore the topics of bribery, and the giving and accepting of business gifts and gratuities, is as follows: A large manufacturing company sends a team of several people to Turkey, to visit several Turkish companies that are potential suppliers of low-cost, high quality parts. The team consists of a financial analyst, a purchasing specialist, and a manufacturing engineer, so that the relative merits of each potential supplier can be evaluated from the perspective of each of these professionals. After visiting the last of the Turkish companies, and on the planned day of departure for the U.S., a huge snow storm arrives on the scene, shutting down all area airports, and filling up all hotels in the area with stranded travelers. The company team calls many hotels looking for rooms, but finds none available. The president of the last-visited Turkish company, recognizing the predicament of the U.S. travelers, offers to use his "connections" to find the team some rooms in a luxury hotel and, miraculously, he does so. Two days later, when the weather has cleared and flights have resumed, the U.S. team goes to the front desk of the hotel to check out and pay their bills, but is told by the hotel clerk that all of their expenses (room charges, meals, in-room movies, laundry service, bar bills, etc.) have been covered by the Turkish company that arranged the rooms, and therefore nothing is due. The students are asked to discuss whether there are ethical questions to consider in these circumstances.

The discussion of this example allows for an exploration of the difference between an acceptable business gift or gratuity on the one hand, and an unacceptable bribe on the other hand. The students learn that many ethical questions do not have "black and white" answers -- there are "shades of grey". This example is also a good context in which to discuss the importance of cultural awareness – i.e. behavior considered improper in one part of the world can be considered quite normal, even expected, in another part of the world.

In order to touch upon the topic of protecting proprietary information, the lecturer presents another example for the students: Two rival aircraft engine companies are both working with an aircraft manufacturer in the design and development phase of a highly competitive aircraft procurement program. The aircraft manufacturing company has signed nondisclosure agreements with both engine companies, requiring the aircraft manufacturing company to strictly protect each company's technical information against disclosure to others. Nonetheless, through an error, the aircraft company sends to the engineering manager of one of the engine companies a computer disc that contains the other engine company's highly sensitive and competitively valuable technical data. The students are asked to assume that neither the aircraft company nor the engine company whose data has been mistakenly disclosed is aware of the disclosure. The question, then, is whether the engineering manager on the receiving end of this error – having done nothing to cause the transmittal of the data – is on ethically sound footing to keep and use the data for the benefit of the receiving company.

Some students believe that this is a simple matter of "finders, keepers", and that as long as the event is not tainted by some kind of trickery on the part of the receiving company or its engineering manager, that manager and the receiving company may keep and use the disclosed data. Some even say that the receiving company *must* keep and use the data, because it has a duty to its shareholders to use every bit of knowledge at hand to vigorously compete for new business. Other students are uncomfortable with that approach, reasoning that if the shoe were on the other foot, the students advocating "finders, keepers" would feel quite differently. The discussion, aided again by the definitional and foundational information elicited from the students at the outset of the lecture, provides a rich opportunity to explore the concept of a "golden rule" approach to ethical questions. That is, shouldn't we treat others in the same manner that we would wish to be treated by them?

Another example used in the lecture addresses "conflicts of interests": A highly respected and influential company engineer owns a small family business "on the side". He runs that business strictly on his own time – at night and on weekends -- using no company resources, equipment, data, etc. His family business responds to a request for bids published by the company where works. Are there ethical issues lurking here?

This example requires the students to explore the notion that an individual's personal interests might be at odds with the company's interests, or might at least appear to be. Thus, the discussion typically touches on the importance of "appearances", and on strategies that can be used to mitigate conflicts, or potential conflicts, of interests, beginning usually with the "sunshine" strategy – i.e. bringing the conflict or potential conflict to the attention of the company (placing it in the "sunshine") so that further mitigation efforts can be taken. Recusal – the removing of oneself from a decision-making role in which the conflict or potential conflict could play a role -- is also discussed. Finally, the discussion of this example often allows the lecturer to introduce concepts such as the "New York Times" test for identifying ethical issues: if the action you are contemplating is one you would not wish to read about on the front page of the New York Times, then thoughtful ethical analysis is recommended. Similarly, under the "sweaty palms" test, if a given action, behavior or decision makes you intuitively uncomfortable – gives you sweaty palms – you should consider that unease as a symptom calling for the application of ethical thought.

There are three additional examples in the lecturer's deck of slides. These involve (a) the receipt of information from a marketing consultant under "shady" circumstances, (b) an invitation from a supplier to attend a nationally followed car racing event, in a lavish "sky box", on the eve of that supplier's critical design review with your company, and (c) a planned men-only golf outing for customers, featuring bikini-clad beverage hostesses who would both serve drinks on the golf course and provide dancing entertainment afterward. As mentioned above, there is rarely time in the assigned class period to discuss all seven of the examples available in the lecturer's slide deck. The important concepts to be addressed during the lecture are usually covered in the discussion of three or four of those examples.

The summation of the lecture is very basic: engineers, as well as others, should behave with honesty and integrity. They should not lie, cheat, or steal; they should not encourage that behavior by others, or sit by quietly if and when they observe it; and, because ethics questions

are often presented in shades of grey, they are well advised to address such questions collaboratively with others, rather than trying to make difficult decisions on their own.

Classroom Observations

The authors observe that the lecture topic and its interactive format combine to produce a generally attentive and engaged classroom. While some students are more willing than others to participate in discussions, no students have appeared to be bored or tuned-out. To the contrary, it is typical for students to become somewhat excited about asserting and defending their viewpoints during the lecture, and it is not uncommon for students to continue conversations with the lecturer after the lecture is concluded.

The vast majority of classes appear to reflect a spectrum of moral/ethical sophistication among the students – ranging from those who have clearly given considerable thought to the general topic of ethics, to those for whom the subject of ethics is relatively undeveloped. Such a diversity of familiarity with ethics may be somewhat reflective of ethical awareness among the population at large. There was only one instance of a lecture in which the vast majority of students in the class, as reflected in their discussion comments, clearly exhibited a striking lack of understanding of and concern for ethical considerations, and a seeming willingness to ignore or dismiss the importance of ethics. That was surprising, and frankly disappointing. However, such an observation only underscores the need to present the lecture and discuss its content, so that the subject is addressed for all students – perhaps especially for those who may enter the lecture unaware of their responsibility to think about "doing the right thing".

The Survey

With ten years of lectures having been presented at Trinity, and eight years at Brown, it seemed appropriate in the spring of 2012 to ask the students themselves about the value and impact of the lecture. So, a simple one-page, eight-question survey was devised and distributed to all of the students who had attended the lecture over the years at both colleges (see the Appendix). Students currently enrolled in the classes at both colleges completed the survey in hard copy, while students from earlier years' classes were solicited to respond using the on-line survey tool, Survey Monkey [16].

The intent of the survey was to generally gage the success of the lecture by asking (a) whether the students even remembered the lecture, (b) whether the principles or concepts presented in the lecture have subsequently been helpful to the students when dealing with ethical questions, and (c) whether the students found the lecture to have been a valuable or important part of their studies. Students were also asked to contribute any comments they wished to offer concerning the value of a lecture on Ethics as part of their engineering studies.

A total of 169 students responded to the survey. As a threshold matter, it was an encouraging relief to the lecturer and professors alike that 90% of the students recalled the lecture. Given that these students attend hundreds of classes as they matriculate, it is understandable that some of the students may have simply missed class on the day of the lecture, and others may have just relegated the lecture to the trash-heap of forgotten classroom experiences. We therefore consider

the broad recollection of the lecture to be a moral victory – an affirmation that we have, to a very great extent, at least caught the attention of the students in a way that transcends the immediate classroom session, and indeed survives for several years thereafter. So far, so good.

The survey data yields another encouraging observation: 96% of the students answered that, when they make decisions, they consciously consider the ethical aspects of those decisions. That data should give us comfort that our students are getting the message about the importance of ethical thinking and analysis. With such a dramatically high percentage of students reporting deliberate thoughtfulness about ethics, it cannot be said that, generally speaking, our students go about their lives with an ethical blind spot (notwithstanding the single lecture session mentioned above, which left both the lecturer and professor dejected and worried about the existence of such a blind spot!).

Indeed, the survey data suggests not only that students widely practice ethical thinking and decision-making, but that a considerable number of them came to the lecture with a pre-disposition to do so: Sixty four percent of the survey respondents answered that the concepts presented in the lecture have been helpful tools for their ethical decision-making. This could be interpreted to mean that the remaining 36% of the students felt that they already had the ethical decision-making tools they need, and thus could have done without the lecture.

Notwithstanding that insight, 74% of the students answered "yes" when asked whether the lecture on the subject of Ethics was an important or valuable part of their studies. Similarly, 80% of the written comments submitted on the surveys attached positive value to having this topic covered as part of engineering studies. Among those few comments to the contrary, one expressed a somewhat "purist" view on course content, suggesting that a lecture on ethics was an inappropriate interference with the principle technical subject matter of the course, and that ethical awareness ought to come from other sources outside of an engineering class. Other comments (not really negative as to the importance of teaching ethics, per se) were to the effect that (1) the subject of ethics should be more widely incorporated into all of the college's courses – not just in the engineering major, and (2) a lecture on ethics would be welcome once each semester, instead of once each year.

Conclusion

The importance of teaching ethics is manifest in (1) the desire of the business world to employ ethically sensitive employees, (2) the increasingly common integration of ethics into college curricula**,** (3) the expectation of accrediting agencies that students should receive an understanding of ethics as a necessary outcome of their studies, and (4) the opinions of students themselves as expressed in survey responses. While there is no single, universal formula for delivering course content on ethics to our students, the Engineering Department at Trinity College and the Brown University School of Engineering have adopted the approach of devoting a full class period in an introductory or lower-level course to the discussion of ethics, during which a guest lecturer from industry conducts an interactive presentation drawn from real-life experiences and focused entirely on this subject. Classroom observations, anecdotal student comments, and student survey results appear to confirm that these lectures have been an effective

way to fulfill the common mandate of industry, academia and accrediting agencies for ethical awareness.

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Appendix: Survey Form (Trinity version)

Question 1: Your class year? _____

Question 2: Do you remember that in the spring semester of your first-year Engineering class, ENGR 120, there was a presentation by a guest lecturer(s) on the subject of Ethics? (yes/no). Comments?

Question 3: Since you took that class, have you encountered circumstances in which you had to make an ethical choice or decision? (yes/no) Comments?

Question 4: If you answered "Yes" to the last question, how many ethical decisions do you recall making? (circle one: 1, 2-4, 5-7, more than 7, N/A) Comments?

Question 5: Were the principles or concepts presented in the ENGR 120 session on Ethics helpful to you when making ethical decisions? (yes/no). Comments?

Question 6. Generally, when making decisions, do you consciously consider the ethical aspects of those decisions? (yes/no). Comments?

Question 7. Looking back on your studies at Trinity, do you think a lecture on the subject of Ethics was an important or valuable part of your studies? (yes/no). Comments?

Question 8: Please provide any comments you have concerning the value of a lecture on the subject of Ethics as part of your engineering studies.