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Teaching Engineering Ethics

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Abstract

Instruction in engineering ethics is an important aspect of professional development. For universities, it is an element of program assessment and is considered for accreditation. For engineering students, it addresses relationships in professional life and is a topic for professional licensure. A common instructional objective is for students to have an ability to continue developing their ethical knowledge and judgment. Topical content typically includes an introduction to principles of applied ethics with supporting examples of related engineering situations. This paper discusses the organization of the ethics component in a senior seminar course. Key topics are ethics principles in the context of the engineering profession, codes of ethics as developed by professional societies, and ethical judgment in case studies.

Keywords

Ethics, Profession, Case Study.

Introduction

The development of ethics knowledge and judgment is recognized as an essential part of engineering education. ABET student outcomes include "an understanding of professional and ethical responsibility" [1]. University engineering programs must address ethics education to prepare students for professional life and professional licensure. Undergraduate instruction in engineering ethics may take the form of stand-alone courses, topics within courses or seminars, and student life, e.g. expectations through honor codes and academic conduct. These experiences should facilitate career-long development of ethics knowledge and judgment.

Rich resources exist for teaching engineering ethics. Technical societies provide many of these resources especially as part of a defined course of professional study and as means to guide self-regulation of the profession. Many examples of codes of ethics have been developed to provide explicit statements of and guides for ethical conduct, cf. [2]. Some of the codes are lengthy while others are succinct statements such as those of the National Society of Professional Engineers (NSPE) [3] and Tau Beta Pi, the Engineering Honor Society [4], respectively. Other codes address specialty topics, e.g. software engineering ethics through collaboration of the IEEE Computer Society and Association for Computing Machinery (ACM) [5]. Engineering firms often have corporate codes of conduct for employees, cf. [6]. NSPE and IEEE have contests to encourage discussions in professional ethics [3,7]. Also, NSPE and the National Academy of Engineering (NAE) provide multiple resources including review cases with opinions and educational aids [3,8,9].

This paper describes the ethics instruction in a senior seminar course. The course components consist of a presentation on the principles of engineering ethics, an introduction for codes of engineering ethics, case study examples, and an analysis and discussion of an assigned case study. The presentation emphasizes the concept of a profession and the content of professional codes of ethics. The case study exercise provides the opportunity to define professional obligations in context of engineering situations. Guidelines for the development of effective case studies are proposed.

Background in Engineering Ethics

A. Teaching Engineering Ethics

The approach of the author is to present ethics in the context of engineering as a profession. In engineering work, ethical issues are commonplace and ethical conduct is habitual conduct. Issues can arise regarding safety, access to information, intellectual property, handling data, career credentials, work environment, etc. and the manner these issues are handled is central to ones reputation. Examples of common judgments that engineers make are:

- When does a product or procedure become "safe,"
- How should the technical work of others be credited, and
- What information must be disclosed?

The content of a one-hour presentation is described for teaching engineering ethics.

B. Engineering Ethics within the Profession

The behavior of engineers is guided by many types of rules – laws, government regulations, employer policies, professional consensus, peer expectations, cultural norms, religious standards, and consequences. Formal consensus within a profession typically takes the form of codes of ethics and these codes greatly influence accreditation standards for engineering programs of study and examination material for attaining a professional license.

The first portion of the presentation provides a background for discussing engineering ethics, i.e. applied ethics within the profession. A profession is defined as

> *An occupation that requires specialized knowledge and skills and that affects the public safety and welfare. Since the public cannot judge the quality of engineer work independently of practitioners, the profession cannot be governed solely by self-interest and who is paying the tab. Legal rules and professional standards define additional obligations.*

Many definitions for a profession include the characteristic that the members adopt forms of self-regulation and codes of behavior. The earliest professions included divinity, medicine, and law.

As a guide for members of a professional organization, a good ethics code must be both general and specific. As a general statement, it should relate principles and expectations that represent a broad consensus among the members and should accommodate honest viewpoint differences among its members while avoiding extraneous issues to the profession. As a specific statement,

it should be useful for supporting specific ethical behavior. Obligations beyond self-interest should be reflected and should include the interests of employers, customers, peers, and the public.

Example Resources

A. Understanding the Tau Beta Pi Code of Ethics of Engineers

The second portion of the presentation examines two codes – the Code of Ethics for the National Society of Professional Engineers (NSPE) and the Code of Ethics of Engineers for Tau Beta Pi, the Engineering Honor Society. Since the NSPE code is lengthy, the separate NSPE Engineers' Creed and selections from the NSPE code are given to illustrate typical statements of principles and a listing of the fundamental canons. This content is repeated in Appendix A. The Tau Beta Pi Code of Ethics of Engineers is a single page and is given in its entirety. It also has a statement of principles and a listing of fundamental cannons.

The statements of principles contain common themes. Engineering is a profession. Engineers have associated obligations to the profession and society. Engineering provides for the public welfare. Engineers must act according to the highest standards of integrity and ethics.

The listing of fundamental cannons provides specifics. General categories are:

- Performance as engineers,
- Role in society,
- Personal obligations, and
- Interaction with others, especially with other engineers.

Table 1 presents the Tau Beta Pi Code of Ethics for Engineers [4] and shows how the items fit into categories. Note that even though this code is one page, the desired behavior is clearly described, e.g. "engineers shall issue public statements only in an objective and truthful manner" and "engineers shall avoid conflicts of interest." The longer codes add more detail. For instance, the NSPE code also states "engineers shall issue public statements only in an objective and truthful manner" and add related expectations, e.g. II. Rules of Practice, 3. a) "Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current."

The advantages of having formal engineering codes of ethics are obvious. Expectations for the workplace and the consensus of the professional community are explicit. An engineer objecting to unethical behavior can point to the professional code (even if the behavior is not illegal).

Similar themes are present in codes of conduct for businesses. The employee Code of Conduct for the Boeing Company is given as an example in Appendix A, Figure 1. Although, it is general for their employees, including non-engineers, the code includes a statement on avoiding conflicts of interest. Companies often have other ethics resources such as ethics advisors, ethics call-in lines, and company-specific case studies.

Other resources for formal or personal instruction are provided by the National Academy of Engineering [8,9]. Student ethics competitions are available such as the IEEE Student Ethics Competition [7]. Students can be encouraged to participate as professional development.

Table 1. Examination of the Code of Ethics of Engineers from Tau Beta Pi.

Code of Ethics of Engineers **Tau Beta Pi, The Engineering Honor Society**	
	The Fundamental Principles
Statement of Principles Identification as a Profession	Engineers uphold and advance the integrity, honor, and dignity of the engineering profession by: Using their knowledge and skill for the enhancement of human welfare; being honest and impartial, and serving with fidelity the public, their employers and clients; striving to increase the competence and prestige of the engineering profession; and supporting the professional and technical societies of their disciplines.
	The Fundamental Canons
Performance as Engineers & Role In Society	1. Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties.
Personal Obligations	2. Engineers shall perform services only in the areas of their competence.
Performance as Engineers	3. Engineers shall issue public statements only in an objective and truthful manner.
Performance as Engineers	4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
Personal Obligations & Interaction with Others	5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
Role in Society	6. Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the profession.
Personal Obligations & Interaction with Others	7. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

B. Case Studies in Engineering Ethics

The third portion of the presentation is two case studies. The first case involves Intel's Pentium chip as described in the literature [10] and the second involves a hypothetical situation inspired by advice column called "Ask Dr. Job" in the *Graduating Engineer & Computer Careers* magazine. For each case, the details are described and then a formal analysis is shown. (The analysis procedure used is a model for that to be used in a later case study assignment.)

The Pentium chip case study is summarized below [10].

Situation: In 1994, Intel produced a defective processor chip. It misrepresented the defect and and mishandled customer complaints.

Ethical Points: The defect was not disclosed appropriately, the defect significance was grossly misrepresented, and interests of customers were disregarded.

Consequences: The company suffered tangible losses (financial) and intangible losses (loss of customer confidence).

The public statements by Intel during the event include a claim that the error due to the chip defect was unlikely to occur and that the typical spreadsheet user would have an error on average of "once every 27,000 years of use."

The discussion highlights several key points. The chip defect itself was not due to negligence, i.e. a bad result or mistake does not imply negligence necessarily. The case shows the overlapping interests of the company, the shareholders, customers, and the public. The students can consider if Intel's statement of an error "once every 27,000 years of use" could possibly be an honest engineering mistake when IBM's engineers determined the likelihood of an error was about every 24 days. The consequences to Intel were dramatic.

The "Ask Dr. Job" case study was inspired by a career advice column from the December 2001 issue. A student asked if he should renege on a previously accepted job offer after receiving a better one. The answer given by the magazine was to take the better offer. After many letters of criticism (many of which were published showing reader perspectives), the magazine justified its earlier advice in the Spring 2002 issue with "It's nice to be ethical, but it's not always realistic." The case provides many discussion points in a situation that the graduating students could easily face. The magazine published many of critical letters including one from a career advisor at the University of Missouri-Rolla (now Missouri S&T) that read,

> "… (The student's) word should mean something. … (Otherwise) his/her word may be questioned in the future. … (The students would) leave the company in a poor position. … We tell students to quit interviewing when they have accepted a job. It is like continuing to date after you are married."

Students frequently ask about professional expectations.

> *At what point am I committed to take a job – after a verbal acceptance or after papers are signed? What if the company will not wait longer for an answer to a job offer?*
>
> *How long should one work at a company before looking for other employment?*

The students are asked to consider if they would want to work for an employer or a supervisor

that had the attitude of “It’s nice to be ethical, but it’s not always realistic.”

To focus the discussion on the ethical issues and prepare the students for a formal assignment, a hypothetical case based on the "Ask Dr. Job" situation is posed.

Situation: A student formally accepted a position in which all significant terms of employment were specified. The student backed out of this agreement to accept a second, more desirable offer.

Ethical Points: Is the student ethically bound to honor the signed letter of acceptance with the first company? Have other job seekers been harmed by the student's action. Has the first company been harmed by the student's action?

Consequences: What consequences might the student face in the future when seeking jobs later in his career? If they know about the situation, what attitude might the student's references have?

References to the Codes: Is the student's action consistent with the NSPE Preamble "As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity …" and with the Tau Beta Pi canon six "Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the profession."

Other Discussion Questions: What difficulties would the student face if the situation were reversed, i.e. the company backs out on a job offer? What could result if similar justifications were applied to product development situations?

The author is able to relate a similar situation from his personal job search in which an employer would not wait on an answer and the job offer was rejected.

Case Study Selection and Development

Case studies in ethics related to actual situations are valuable, especially for relating the consequences of ethical failures. Sometimes it is difficult to obtain sufficient details for the case description or the case analysis may require specialized knowledge. Cases that are well known may have an obvious analysis. Hypothetical cases, typically inspired by events, provide flexibility to tailor an assignment for a particular group and to target specific ethical issues. Some recommendations for developing hypothetical cases are given below.

A case with multiple facets can be more challenging to analyze than one with a single issue.
Students should be able to identify all of the ethical questions in a situation.

A case should not have an anticipated analysis with all of the results being positive or negative.
Students should be able to discriminate among actions that have no ethical error, minor ethical errors, or major ethical errors. An action can be unwise or a mistake without being unethical.

A case can used to promote understanding of specific ethical concepts.
Such concepts as conflicts of interest, safety, data selection, and responsibility can be related to the workplace. Also, new ethical concepts can be introduced in the context of a case study.

A case assignment can be tailored by providing none or part of the analysis procedural steps.
The analysis procedure often requires a restatement of the relevant facts, an explicit listing of ethical questions, analysis assumptions (if any), and references back to a specific code. Selected ethical questions could be included or a discussion of recommended corrective actions requested.

Discussion and Application

The senior seminar course for electrical and computer engineering students at Missouri University of Science and Technology includes two sessions on professional ethics. The first session is a formal overview of ethics as related to engineering work and it is focused on applied ethics as part of a profession. Example case studies related to electrical and computer engineering and general profession life are included. Selected slides from the introduction and summary of the "Engineering Ethics" presentation is given in Appendix B in Figure 2. The second session is a presentation of case studies for teams of students to analyze. This assignment is tracked as part the department's ABET assessment plan that is related to student outcome (f) "an understanding of professional and ethical responsibility [1]."

The objectives of the ethics seminar presentation, i.e. the first session, are:

- To define engineering as a profession,
- To convey the range of ethical issues in an engineering career,
- To introduce important codes of ethics as developed by engineering organizations,
- To provide case study examples in engineering ethics, and
- To promote awareness of career resources related to engineering ethics.

Then, the second session provides an exercise in application of the ethical concepts. The perspective given in the presentation is that ethical conduct is more about establishing wise habits, meeting professional obligations, and building a favorable reputation than it is about handling problem situations. Often, career difficulties are avoided through appropriate habits and self-awareness. The word ethics is derived from the ancient Greek word "ethikos" meaning the study of morals; the ancient Greek root word is "ethos" meaning character or habit.

For the author, key points in teaching engineering ethics are encouraging students to be intentional, developing student awareness of professional expectations, and promoting clear thinking about ethical behavior. Students are building their ethical habits while in school and should view their choices with a long-term perspective. Academic honesty during assignments and frank communication of credentials and background (such as on a resume) are examples. Professional codes represent a consensus of the professional community and provide explicit guidelines for workplace expectations. The case studies provide opportunities to illustrate critical analysis. For instance, the phrase "ethical dilemma" is sometimes misapplied. Ethical dilemmas occur when a complex situation has an inherent conflict among right courses of action. The Dr. Job case study illustrates a situation in which the conflict is not between right courses of action, but between a right course of action and an expedient course of action.

Case studies in ethics are common tools for assignments and they are used in this seminar to provide an active mode of learning. Hypothetical situations provide the most flexibility and can be adjusted for different audiences and semesters. Discussion is promoted if a given case study has several facets with differing levels of unethical content. The analysis should include a restatement of the facts in the situation, an explicit statement of the ethical points, and references back to noted sections in the professional code in use.

Appendix A: Ethics Statements for Teaching Engineering Ethics

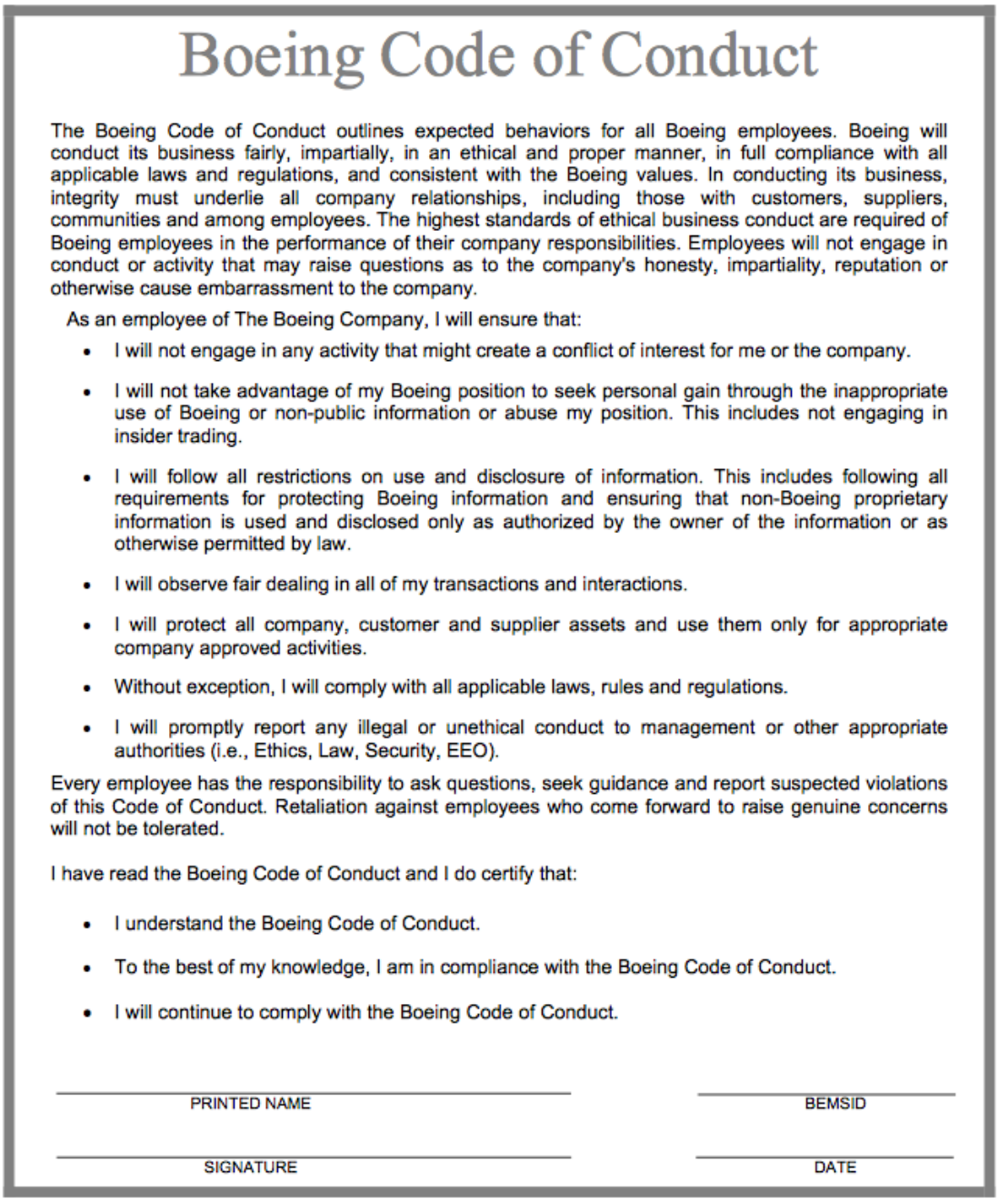
Ethics statements from the National Society for Professional Engineers (NSPE) and the Boeing Company are shown in Table 2 and 3 and in Figure 1, respectively.

Table 2. Engineers' Creed for the National Society for Professional Engineers (NSPE) [3].

Engineers' Creed (NSPE) ***Adopted by the National Society for Professional Engineers, June 1954***
As a Professional Engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare. I pledge: • To give the utmost of performance; • To participate in none but honest enterprise; • To live and work according to the laws of man and the highest standards of professional conduct; • To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations. In humility and with need for Divine Guidance, I make this pledge.

Table 3. Preamble and Fundamental Canons from the Code of Ethics for NSPE [3].

Selections from Code of Ethics (NSPE) ***Last Revised by the National Society for Professional Engineers, July 2007***
Preamble Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct. **I. Fundamental Canons** Engineers, in the fulfillment of their professional duties, shall: 1. Hold paramount the safety, health, and welfare of the public. 2. Perform services only in areas of their competence. 3. Issue public statements only in an objective and truthful manner. 4. Act for each employer or client as faithful agents or trustees. 5. Avoid deceptive acts. 6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.



Boeing Code of Conduct

The Boeing Code of Conduct outlines expected behaviors for all Boeing employees. Boeing will conduct its business fairly, impartially, in an ethical and proper manner, in full compliance with all applicable laws and regulations, and consistent with the Boeing values. In conducting its business, integrity must underlie all company relationships, including those with customers, suppliers, communities and among employees. The highest standards of ethical business conduct are required of Boeing employees in the performance of their company responsibilities. Employees will not engage in conduct or activity that may raise questions as to the company's honesty, impartiality, reputation or otherwise cause embarrassment to the company.

As an employee of The Boeing Company, I will ensure that:

- I will not engage in any activity that might create a conflict of interest for me or the company.
- I will not take advantage of my Boeing position to seek personal gain through the inappropriate use of Boeing or non-public information or abuse my position. This includes not engaging in insider trading.
- I will follow all restrictions on use and disclosure of information. This includes following all requirements for protecting Boeing information and ensuring that non-Boeing proprietary information is used and disclosed only as authorized by the owner of the information or as otherwise permitted by law.
- I will observe fair dealing in all of my transactions and interactions.
- I will protect all company, customer and supplier assets and use them only for appropriate company approved activities.
- Without exception, I will comply with all applicable laws, rules and regulations.
- I will promptly report any illegal or unethical conduct to management or other appropriate authorities (i.e., Ethics, Law, Security, EEO).

Every employee has the responsibility to ask questions, seek guidance and report suspected violations of this Code of Conduct. Retaliation against employees who come forward to raise genuine concerns will not be tolerated.

I have read the Boeing Code of Conduct and I do certify that:

- I understand the Boeing Code of Conduct.
- To the best of my knowledge, I am in compliance with the Boeing Code of Conduct.
- I will continue to comply with the Boeing Code of Conduct.

PRINTED NAME _____ BEMSID _____

SIGNATURE _____ DATE _____

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Fig. 1. Boeing Code of Conduct [6].

Appendix B: Introduction and Summary Slides from "Engineering Ethics"

Fig 2. Introduction and Summary Slides from "Engineering Ethics" presentation.

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