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Teaching of Professional Ethics in Engineering Design

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Abstract

Engineering has a direct impact on humanity and knowing the ethical aspects of engineering practice becomes essential. The study of ethics makes engineers more empathic and human, and also more aware of their responsibility as engineers. Despite progress in the industrial ethics program, there still remains a lot to be done in teaching ethics to students. This paper presents the integration of ethical, social and economic considerations in developing design solutions to meet human needs. The materials on ethics are integrated at each stage of the design development process. Students are introduced to codes of ethics developed by professional societies and also companies to assist engineers in answering questions which may arise in their profession. Case studies, specifically relevant in engineering design and product development situations are presented. Guidelines are used to separate known facts and assumptions while reaching solutions in ethics cases. The responsibility of engineers towards their employers and issues of their personal conscience are explained through examples.

Reasons we need to discuss ethics

Ethical and legal problems arise due to a number of reasons. In recent years, there has been a technological explosion, particularly as related to information handling. When you photocopy a page from your text (almost all books are copyrighted), are you breaking the law? Generally the question arises, what to do and what not to do under different circumstances. What is legal and what is ethical? In this paper, the role of professional ethics in teaching engineering design is discussed. The material presented here is part of topics which are taught in a two course sequence of Mechanical Systems Design at NJIT and is considered in detail in my forthcoming book [1] titled, ”Mechanical Design: Fundamentals to Capstone “ being published soon by NJIT.

Engineers are responsible to build things, make them perform better, create solutions to problems facing the society and also train other engineers. Engineers have created new electric vehicles, developed renewable energy sources, and have built a new global communications network that is connecting people worldwide. Engineers are held to high standards with their work, certainly higher than most other careers. But they should also be held to high ethical standards, to ensure all their work does not harm people. Engineers are now responsible for functioning of the whole world on a minute-to-minute level. They make the airplanes which fly all over, schedule our trains, make communications systems and build the computers and their software to run our schools, hospitals, businesses and governments. They build the security that keeps our data safe from hackers. The role of engineers is very important with profound impact on human society, one that should be approached with ethics in mind.

Ethics and the engineering curriculum

Despite progress in the industrial ethics program, there still remains a lot to be done in teaching ethics to engineering students [2,3,4,5]. Many of these authors believe that the study of engineering ethics is misguided as the focus is on individual acting alone avoiding wrong doing. They emphasize a more expansive and critical study of engineering, including its social/political dimensions. Some people believe that a person's outlook on ethics develops at a young age due to the influence of family, friends, church, elementary school teachers etc and cannot be changed significantly at the college age. This is well illustrated by the answers, the author received from his students for the following questions.

Some questions

1) Suppose you get access to your university computing system for a few minutes and you could change your grade with no one finding out. Will you change your grade ?
2) You are working in a group project and you know very well that your contribution to the group project was substantially lower than other partners. Are you comfortable receiving the same grade as other group members ?
3) You are an engineering major, but you have to take an art course; how bad is it to copy the homework for a class you think you will never use in your professional life?
4) You are personally against getting Covid vaccination. Would you lie to your college administration that you have been vaccinated?
5) Would you feel comfortable in buying merchandise which you know was made with child labor ?
6) Would you feel comfortable in working on a military related project, when you are personally against armaments ?

The answers to these questions are very varied demonstrating different view points on ethics, particularly in a diversified class. The students are taught that there are codes of ethics developed by professional societies, which guide engineers when faced with conflicting situations in professional practice. There are also codes of ethics developed by companies to assist engineers in answering questions which may arise in their profession.

ABET policy on ethics

The Accreditation Board for Engineering and Technology (ABET), which is the recognized organization for the accreditation of university programs in the United States states [6] the following per the curriculum requirements:

An understanding of the ethical, social economic and safety considerations in engineering practice is essential for a successful engineering career. Coursework may be provided for this purpose but as a minimum it should be responsibility of the engineering faculty to infuse professional concepts into engineering course work.

Because of this ABET requirement, universities that wish to maintain and improve their accreditation standing must include materials on ethics in their curriculum. This is generally done by integrating materials on ethics in lectures, assignments, and students design projects. Some institutions include ethics as a separate topic in an upper division course. ABET has developed guidelines for engineering institutions to integrate material on ethics and professionalism in the curriculum. In the student outcomes, ABET requires the following:

An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Importance of ethics in industry

Although people in the industry work on mutual respect and trust, but still there is a need for established standards of behavior. According to the Preamble of the NJ Society of Professional Engineers [7], "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. There are situations facing companies where a known defect in their product can lead to death of consumers. Should a risk/benefit analysis be used in situations where a defect in design or manufacturing could lead to death or seriously bodily harm ? In another situation, companies introduce a design feature shortening product life or decreasing capacity which increases revenue, while increasing customer cost, environmental damage or other harm to the customer or consumer. The students working on engineering design projects are expected to consider these ethical issues at different stages of the design process. What follows are two examples of ethical issues in design.

a) Should there be a price for human life ?
b) Good vs. profit challenge to you as a designer.

a) Should there be a price for human life ?

This case involves the explosion of Ford Pinto cars [8] due to a defective fuel system design. There is a debate on the issue of the use by Ford of a cost-benefit analysis and the ethics surrounding its decision not to upgrade the fuel system. Should a risk/benefit analysis be used in situations where a defect in design or manufacturing could lead to death or seriously bodily harm? There are arguments both for and against such an analysis. It is an economically efficient method which has been accepted by courts for numerous years, however, juries may not always agree, so companies should take the moral issues into consideration. Although Ford had access to a new design which would decrease the possibility of the Ford Pinto from exploding, the company chose not to recall which would

have cost $11 per car, even though it had done an analysis showing that the new design would result in 180 less deaths. Based on the numbers Ford used, the cost would have been $137 million versus the $49.5 million price tag put on the deaths, injuries, and car damages. Based on their analysis, Ford legally chose not to make the design changes which would have made the Pinto safer. However, just because it was legal doesn't necessarily mean that it was ethical. It is difficult to understand how a price can be put on saving a human life. There are several reasons why such a strictly economic theory should not be used. First, it seems unethical to determine that people should be allowed to die or be seriously injured because it would cost too much to prevent it. Second, the analysis does not consider the consequences, such as the negative publicity that Ford received and the judgments and settlements resulting from the lawsuits. Also, some things just can't be measured in terms of dollars, and that includes human life.

b) Good vs. profit challenge to you as a designer

This situation happens when a design feature increases the revenue by shortening the product life or decreasing capacity, while increasing cost, environmental damage or other harm to the customer or consumer. This is a constant issue for most engineers because profitability often depends on more frequent purchases, such that engineered obsolescence is a powerful tool, yet one that is costly for the consumer and very damaging to the environment. There are several different ways companies introduce planned obsolescence in their products [9]. They may use inferior materials in key components causing pre-mature failure of the design. Sometimes they seal some parts, so maintenance is difficult or reaching defective parts is impossible. Certain devices like cell phones are designed with software, which slows down the performance after some time. Here are the most common types of planned obsolescence in our culture today.

Examples of planned obsolescence :

Limiting the life of a light bulb.
Coming out with a new model for a car every year with minor changes.
Short-lasting nylon stockings.
Products with irreplaceable batteries.
Cartridge in a printer.
Slowed down cell phones.
Marginally modified textbooks.
Fast fashion, low-quality clothes.
Limiting the software upgrades on the device.

Questions you ask yourself: Students work on several engineering problems and design projects. Students are asked to consider the following questions:

Did you try to develop a best solution and did you do research for your design?
Does your project/problem solving create something useful?
Did you ensure that your analysis and calculations are correct and the results are consistent?
Did you consult with other engineers and professionals for your project?

Do you inform the people involved, about the potential issues and problems in the current project ?
Did you make sure that your design has no adverse effects on others and the environment?

Codes of Ethics

The students are taught that there are codes of ethics developed by professional societies, which guide engineers when faced with conflicting situations in professional practice. For example, the ASME policy on ethics is described below.

The ASME requires ethical practice by each of its members and has adopted the following code of ethics of engineers as referenced in the ASME Constitution, article C2.1.1 [10]. ASME Code of Ethics for Engineers constitutes two parts, the fundamental principles and the fundamental canons.

The Fundamental Principles

Engineers uphold and advance the integrity, honor, and dignity of the engineering profession by:

I. Using their knowledge and skill for the advancement of human welfare.
II. Being honest and impartial, and serving with fidelity the public, their employers and clients, and
III. Striving to increase the competence and prestige of the engineering profession.

The Fundamental Canons

1. The engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties
2. Engineers shall perform services only in the areas of their competence.
3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees and shall avoid conflict of interest.
5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
6. Engineers shall associate only with reputable persons or organizations.
7. Engineers shall issue public statement only in an objective and truthful manner.
8. Engineers shall consider environmental impact and sustainable development in the performance of their professional duties.
9. Engineers shall not seek ethical sanction against another engineer unless there is good reason to do so under the relevant codes, policies and procedures governing that engineer's ethical conduct.

Approach to ethics case analysis

For engineering students case studies are useful means to learn about ethics. Case studies capture a range of views and illustrate the resources available to engineers in resolving ethical issues in their profession. Prof. Watkins of Missouri University [3] has suggested an approach shown in the Table 1 below which encourages the separation of known facts and assumptions while reaching conclusions as to ethically preferred responses. The approach encourages the recognition that that some actions may not be wise, may show poor judgment, or may be a mistake without being an ethical error.

Table 1 - Approach to ethical case analysis

Analysis Steps	**Questions to Answer**
Situation	What are the known facts?
Ethical Points	What are the ethical questions?
Consequences	What are the possible consequences for all concerned parties?
Code References	What guidance is given by the relevant code of ethics?
Recommendations	What are possible ethical responses for the concerned parties? What is the best ethical response and why?
Other Discussion	What assumptions are needed to reach an analysis? Would the analysis change if other facts were known? Are any of the described actions a result of mistakes, poor judgment, etc. rather than ethical lapses? Could the analysis be applied to other situations ?

Case Studies: Two case studies are presented which deal with Ethics situations for engineers. First is about a company trying to sell used cars as new and the second is a situation faced by an engineer who faces a tough choice of confronting his employer and protecting the safety, health, property, and welfare of the public. This study demonstrates how the Code of Ethics can help the engineer.

1) Case Study - Driven cars sold as new

Some years back, Chrysler Company was charged with selling cars that had been driven with odometers disconnected and also selling damaged cars as new after repairs [11]. Car companies often let their engineering executives drive new cars for testing out the new models in a more realistic environment. Although Chrysler Corporation agreed to the policy, several consumers thought that they had been shortchanged and Chrysler Corporation had been unethical in its dealings. More than half of these cars had been in accidents and had been repaired and sold as new.
Question ?
Did Chrysler Corporation break the law?
Was their action ethical or not?

The Justice department considered that the law was broken and the customers considered company actions to be unethical. Chrysler offered to either replace the cars or extend their warranties. This was accepted and charges were dropped.

2) **Case Study - Whistleblowing - Do engineers have a right to protest shoddy work and cost overruns?** (Adapted from NSPE Case No. 82-5)

Description: This is an open-ended scenario for discussion based on a case from the NSPE Board of Ethical Review [12]. It describes a situation in which an engineer employed by a government contractor objects to a subcontractor's poor performance and is ignored and silenced by the management.

Jim is an engineer who works for a large defense contractor. Part of Jim's job requires reviewing the work of subcontractors the company employs. Jim discovers that certain subcontractors have made submissions with excessive costs, time delays, or substandard work. He advises management to reject these jobs and require the subcontractors to correct the problems. After an extended period of disagreement with Jim over the issues, management places a warning in Jim's personnel file and places Jim on three months' probation, with a warning about possible future termination. Jim believes that his company has an obligation 1) to ensure that subcontractors produce acceptable work, and 2) cut unnecessary costs to the government. Finally, Jim requests an opinion on the matter from the NSPE Board of Ethical Review.

Questions ?
Does Jim have a right to protest shoddy work and cost overruns? Does Jim have an obligation to do so?
Is it appropriate for Jim to approach the NSPE Board of Ethical Review for an opinion?

References
Code of Ethics - Section II.1.a - "Engineers shall at all times recognize that their primary obligation is to protect the safety, health, property, and welfare of the public. If their professional judgment is overruled under circumstances where the safety, health, property, or welfare of the public are endangered, they shall notify their employer or client and such other authority as may be appropriate."
Section III.2.b. - "Engineers shall not complete, sign, or seal plans and/or specifications that are not of a design safe to the public health and welfare and in conformity with accepted engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project."

Discussion: This is what the NSPE Board thinks about the merits of this case.
The situation presented here has become well known in recent years as "whistleblowing", and there have been several cases evoking national interest in the defense field. We recognize that if an engineer feels strongly that an employer's course of conduct is improper when related to public concerns, and if the engineer feels compelled to blow the whistle to expose the facts as he sees them, he may well have to pay the price of loss of employment. In some of the more notorious cases of recent years, engineers have gone through such

experiences and even if they have ultimately prevailed on legal or political grounds, the experience is not one to be undertaken lightly. In this type of situation, it is felt that the ethical duty or right of the engineer becomes a matter of personal conscience, but we are not willing to make a blanket statement that there is an ethical duty in these kinds of situations for the engineer to continue his campaign within the company, and make the issue one for public discussion. The Code only requires that the engineer withdraw from a project and report to proper authorities when the circumstances involve endangerment of the public health, safety, and welfare.

Conclusion: Engineer Jim does not have an ethical obligation to continue his effort to secure a change in the policy of his employer under these circumstances, or to report his concerns to proper authority, but has an ethical right to do so as a matter of personal conscience.

Conclusions

This paper presents the integration of ethical, social and economic considerations for engineers working on design problems. The materials on ethics is integrated at each stage of the design development process. Students are introduced to codes of ethics which companies have developed to assist engineers in answering questions which may arise in their profession. Case studies, specifically relevant in engineering design and product development situations are presented. Guidelines are used to separate known facts and assumptions while reaching solutions in ethics cases. The responsibility of engineers towards their employers and issues of their personal conscience are explained through examples.

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