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Role of Engineering Ethics Case Studies and Student Learning

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Abstract

The engineering profession requires a high level of training and study at a college level due to its vital importance and impact on the public. However, engineers may not be particularly trained in psychology, sociology, economics, or in many areas relevant to assessing the social consequences of technology. This type of insight is crucial because engineers have an obligation to the public good, specifically the safety, health, and welfare of society. While engineering used to prioritize business and technological advancements, it often meant that morals took a backseat in projects. The profound shift of emphasis took place in the 1970s when the primary obligation of engineers shifted from clients to the public and abiding by engineering codes. These codes are formulated in terms of rules with prohibitive tones so they may easily be enforced. It is crucial for engineering students to familiarize themselves with these codes and to follow them when applicable. The responsibilities of engineers, however, are not limited to abiding by code prohibitions but to actively prevent potential harm to society from other engineers or technology developed. Keeping the obligation to the good of the public as the clear priority may also include the occasional disagreement with employers, clients, and other coworkers. Without previous exposure to different ethically compromising situations, it may be difficult for students to make moral choices in their future careers. There have been several case studies of engineering situations of the distant and near past that serve as clear and realistic instructional examples. Students can recognize ethical issues and test their moral decision-making by studying such cases. The study of ethics in engineering education may also aid in understanding that while the codes of ethics are handy; they may only sometimes provide clear-cut answers. Engineers are obligated to bring competence and integrity to their work but considering the public's welfare is equally important. This paper will discuss the classroom experience of an engineering technology student and how critical the case studies are.

Introduction

Engineering is a crucial profession that requires a level due to its vital impact on the quality of life for society. Engineers must perform under a high level of training and study at a college standard of professional behavior that requires adherence to the highest principles of ethical conduct. As engineering students earn their degrees and progress their way into the workforce, it is of upmost importance that these individuals conduct themselves honorably, responsibly, lawfully, and ethically. Engineering ethics is defined as the principles and guidelines engineers follow to ensure their decision-making is aligned with both their professional and moral obligations to the public, clients, and industry. The basis and knowledge for ethical behavior roots from an individual’s educational background. The study of ethics in engineering classrooms are recommended by the Accreditation Board for Engineering and Technology, or ABET, so that students may acquire an understanding of professional and ethical responsibilities. Through the study of professional ethical codes and the critique of case studies, students can gain

exposure to their future responsibilities to their company, clients, and their communities.

Code of Ethics

For the most part, teaching the subject of ethics in universities relied on the use of both hypothetical and "real" scenarios with open discussion framed by the code of ethics developed by the National Society of Professional Engineers, or NSPE. While engineering used to prioritize business and technological advancements, it often meant that morals took a backseat in projects. The profound shift of emphasis took place in the 1970s when the primary obligation of engineers shifted from clients to the public and abiding by engineering codes [1]. These codes are formulated in terms of rules with prohibitive tones so they may easily be enforced. It is crucial for engineering students to familiarize themselves with these codes and to follow them when applicable. The outlined standard of ethical behavior includes protecting public safety and welfare, performing services only in areas of competence, issuing only objective and truthful public statements, acting as faithful agents or trustees for each employer or client, avoiding deceptive acts, and conducting oneself lawfully and responsibly to enhance the honor and reputation of the profession.

Importance of Ethics

Whenever a piece of machinery fails or malfunctions, structure collapses, or other engineering related incident occurs, it likely makes headlines nearly immediately after. This is because trust is required between engineers and the public, thus why it is crucial for students to understand the importance of carrying professional duties out ethically.

Ethics may aid in improving public opinion about professions in engineering. However, to do so, engineers must be honest in public communications through truthful statements free of any private interests. Society is in an era where communication skills are only becoming increasingly valued, interacting ethically with the public may improve perceptions about the engineering industry. To add on, prioritizing ethical behavior in the workplace promotes safety and enhances quality of work. Public safety is the number one concern in an engineering project, so engineers are therefore expected to notify both employer and client when dangerous circumstance or non-standard conforming documents are overruled by judgement. In doing so, engineers can prevent harm to their community and maintain reliability standards. [2]

Adhering the ethical codes may also safeguard the interests of the company or firm. Engineers are discouraged from sharing or disclosing sensitive or confidential company information without explicit consent. Organizational leaders must also act to protect the intellectual property and confidential information, preventing theft and misuse of company's assets and protect investments [1]. Organizational leaders should also thrive to not only promote quality work but to also encourage others to maintain a high standard of ethical responsibility, as they often dictate the company's value and culture. From a business perspective, prioritizing ethical

behavior and safety not only protect the reputation of the company, but has also improves productivity and reduces accident and injury related costs. As an engineer, it is best for an individual to perform tasks that best align with their experience and educational background. By enabling specialists to do their highest-quality work in their field, the company and each of its individuals will be able to thrive and carry out quality tasks more efficiently.

Realistic Scenarios in Case Studies

The American Society of Engineering Education, or ASEE, center their belief that ethic education in engineering should endeavor to equip students with the skills to confront ethical conflicts and practice exercising their ethical responsibilities as a future engineer. While it may be easier for educators to take the traditional approach by raising ethical issues in a lecture format, it is more useful for students to practice ethical problem solving, first-hand. ASEE suggest educators to employ a variety of problem-solving activities that may include role-playing, computer simulations, or the study of engineering cases that involve both unusual and everyday scenarios [3].

Without previous exposure to different ethically compromising situations, it may be difficult for students to make moral choices in their future careers. To introduce students to coping skills with ethical problems, educators must first help engineering students learn to recognize problems. Then only can students understand that the tasks and project they may work on, may affect the public for better or worse. Students must then strive to act as "moral agents" in the workplace and learn to anticipate the effects of what they work on or develop solutions if necessary. There have been several case studies of engineering situations of the distant and near past that serve as clear and realistic instructional examples [3]. Through the critique of several exemplary scenarios, students can practice recognizing realistic ethical issues and test their moral decision-making. Additionally, students will be able to take into consideration of the demands presently placed upon the profession. ASEE also strongly shares the view that for future engineers to survive in the work world of the 21st century whilst responsibly carrying out their roles as agents of technological change, the new engineering graduates must have substantial training in recognizing and solving real-world ethical problems.

Examples in Case Studies and Student Learning

To showcase the effects of studying engineering cases that involve both unusual and everyday scenarios, the following section will discuss the educational experience of engineering students in a SUNY Canton ethics course. The following case studies were taken from *Concepts and Cases, Engineering Ethics Sixth Edition* and given weekly to students to write their own opinions and course of action about, and an opportunity for open discussion for all case studies was given the following week.

One such case study dissected and discussed heavily by students is titled "Citicorp" [4]. In

this real-life scenario, William LeMessurier was responsible for the structural design of the 1977 Citicorp building in downtown Manhattan. He designed the building to go up and over the church by using columns and diagonal bracing to transfer and distribute the load. These columns were placed in the center of each side of the building as opposed to on the corners of the building. For this building, LeMessurier incorporated a 400-ton concrete block floating on oil bearings to cut down the wind sway on the building. The design took into consideration the effect of quartering winds instead of just the standard 90- degree winds. Additionally, the design of the columns in the centers instead of corners is better for quartering-winds. Students from a nearby university called stating their professor found an issue in the design however he was only taking into consideration the 90-degree winds. LeMessurier had decided his own students were to tackle the design issue since no one worked out calculations for quartering winds. However, when LeMessuier designed the building, he designed for welded joints for all the diagonal girders but when he called his home office to find the cost of welded joints of diagonal girders like the ones used in the Citicorp construction, he noticed one more crucial error. LeMessuier realized the specs for full-penetration welds weren't followed. Instead, the joints were all bolted together. The bolted connections meant that there would be a 40% increase in stress for certain areas of the structure and 160 percent stress increase on the building's joints. This meant is there was a "16-year storm" the building likely would fail and collapse due to these members and joints experiencing a larger load than they can withstand [4].

Overall, the design had still met the building codes that are in place in New York City, so LeMessurier was not concerned with the variance from his design. Additionally, LeMessurier realized if he were to report the findings the company could be at a large financial upset as well as his engineering reputation being put at risk. Thus, he acted quick and created a plan to fix the issue as well as creating estimates of what the adjustments would cost. He next informed the Citi Corp owners of his findings as soon as possible which made it easy for Citi Corp to act fast and decidedly. They decided to enact LeMessurier's new plan to correct the issue was immediately put into place and the work was immediately started. The public was not informed to the issue at hand. While the building's adjustments were being completed there was a hurricane projected to come up the east coast which added lots of pressure for the people involved. Correcting the problem cost the company millions, but all involved parties were able to act fast and decisive to solve the issues at hand. These millions proved to prevent future catastrophe that could cost much more and even have worst costs. After the design was\ changed the insurance rates for the company were lowered in result of the diligence of LeMessurier and the responsibility shown in his engineering work {4}.

This example showcases the cause-and-effects of the decision making of one single engineer. When discussed in a SUNY Canton classroom setting there were many varying opinions. Some believed that he worked he was right in working fast before any true devastation took place and he was innocent in the calculation phase for quartering winds, therefore following the no harm,

no foul ideology. While others argued that though no harm was done, he was an experienced engineer that knew better than to risk the potential outcome of a structure failing due to his chosen design process. However, students came to a mutual consensus in the end agreeing that engineers should think back to things like this that happen that differ from the plan and see if there is any significant impact on the final product. The problem could affect the well-being of the people so taking into aspect every change from the plan is important for success. Students also were able to discuss how if the building design and construction was done right and up to code initially, it would have also saved a lot of time, money, and effort for the company as well

Another ethical case study discussed by students was titled “Gilbane Gold” [4]. Gilbane Gold is a fictional case study presented in a popular video tape. This case focuses on a young engineer, David Jackson, who works in the environmental affairs department of ZCORP, a manufacturing firm based in Gilbane. The company manufactures computer parts and discharges its lead and arsenic into the sanity sewers of the city. The city however, had created a good business of taking the sludge and making it into fertilizer for farmers in the surrounding area. To protect the Gilbane Gold from being contaminated with the toxic chemicals in the water from the manufacturing plants the city imposed strong regulations on the amount of lead and arsenic in the water. Jackson faces a conflicting situation because he believes that recent tests may show that ZCORP might be violating standards by putting greater amounts of waste than they are supposed to into the river. Jackson feels conflicted due to the convergence of four moral claims. The first is the obligation that comes from being a good employee seeking to promote the interest of their company. David Jackson believes that more pollution-control equipment should be bought or just the idea be brought forward thought about. However, the management of the company thinks it would be prohibitive on their production. If the production is lowered then the company will lose money in the long run, potentially a lot. David wants to be a good employee to his company and stay loyal and act with their best interest, he also must worry about his personal integrity he needs to make a choice that stays true with his personal values, and he wants to worry about his professional engineering integrity especially his special role as an environmental engineer.

However, the second moral claim Jackson must consider is his own obligation to personal and professional integrity. Ethically speaking, guilt and conscience play a large role in personal and professional integrity. Once Jackson uncovers the truth about the violated standards, it may be difficult for him to stay quiet, depending on how strong his own morals and values are. Again, it is also important to consider his own career and reputation. The third conflicting claim Jackson must consider refers to his obligation as an engineer to protect the health of the public. When working as an engineer, or even studying to become an engineer, a common fact that is often repeated refers to how you will be responsible for the safety and general health of the public. Whether it is structural, or machinery based, engineers overlook and measure out a great deal of factors, keeping the safety of the public in mind when working. The last claim is Jackson’s right

to protect and promote his own career. Personally, I can understand this claim as an individual that will be going into the engineering field as a career. Employees must think about the company's interest and their own career as an obligation they have accepted once they were hired. If the company were to thrive or fail, the career of each individual working for the company would be affected.

This case study was a clear-cut example of the many different "moral obligations" and paths an individual may choose to take. As student begin to make their career paths in the field, it is crucial for them to reflect on which moral obligations matter most to them. Through the opportunity of open discussion in a SUNY Canton ethics class with widely diverse individuals, students can hear the thoughts of future potential coworkers whilst understanding the effects of whichever moral obligation they may choose to answer to. Though different individuals may have varying attitudes towards this issue, depending on company role or position, every engineer has the responsibility and right to "blow the whistle". From an ethical standpoint, one's main concern should be how their company affects the safety of the people and the environment around it.

Lastly, one engineering case study that allowed for students to see the potential consequence of decision making is named "The Big Dig" [4]. The Big Dig is a tunnel system that is in Boston, and it carries interstate 93 beneath downtown Boston and extends the Massachusetts turnpike to logan airport. On July 10, 2006, a connector tunnel in the Big Dig system collapsed and a woman was killed, as well as her husband was injured. Subpoenas were issued to all involved in the situations such as the contractors, the sub-contractors, and the material suppliers. A Federal investigation came shortly after the issuing of the subpoenas. The National Transportation Safety Board (NTSB) released its findings about the incident a year later in an article. The focus of the article was the epoxy used to hold the concrete slabs to the ceiling of the tunnel as well as the hardware used. The product was from Powers Fasteners Inc. which is a company that specializes in making and selling products both that are anchoring and fastening materials for concrete, masonry, and steel. Powers distributes two types of epoxies, one that is a standard set-time and another that is a fast-set time. The one used in the tunnel was the Fast Set which was very susceptible to "creep" in which the epoxy deforms, and the epoxy material will fail. This was found to be the cause of the ceiling tile collapse on July 10, 2006.

According to the report by NTSB Powers was aware of the creep that the epoxy may have and that its only good for short term load bearing applications. Powers did not make the difference to be clear with the marketing of their epoxies in any way at all. The epoxy that was intended to be used could hold a long-term tensile load which the quick-set epoxy is not best for. From the report Powers was indicted with involuntary manslaughter by the Massachusetts attorney general's office. The indictment stated that Powers had the knowledge of the creep in an application such as this, however they had failed to state any warnings or information about the

issue. The company had the knowledge to prevent the incident altogether but failed to do so. In the end the construction companies involved in building the tunnels were found to have not taken the creep into consideration at all especially under the required long-term conditions. The report stated that the companies should have had load and tensile testing done of the material before it was put in use on the Massachusetts turnpike. If such tests were taken, then creep would have been a factor that was accounted for in the design and in the planning of the tunnel. If this was taken into consideration this disaster would have been prevented all together. The report referred to the (ASCE) American Society of Civil Engineers, stating that professionals and engineers should educate themselves on the materials and possible factors like creep to be aware of [4]. They also must think of how the different factors of materials may change under different uses or scenarios. This would be to help prevent something like this in the future if more engineers were thinking of how the materials such as epoxies used could fail and cause catastrophe. If all things are considered like this all the issues of collapse or other problems will be less likely to happen. This was a real-life and clear example for students to learn and understand that intentionally withholding information about your company and their services or product is morally and ethically wrong and can lead to serious consequences. [5] The health and wellbeing of the public/clients should always be the priority and that should reflect in the workplace culture and environment. Students are also able to see how renowned and trusted organizations such as the ASCE makes decisions and how they make sure their members are educated on the problems that arise, including how to prevent them.

Conclusion

In summation, the study of ethics in education is crucial for society to progress in the engineering field. It is the duty and responsibility of students and educators to allow the journey of moral problem starting to begin long before entering the workforce. Without previous exposure to different ethically compromising situations, it may be difficult for students to make moral choices in their future careers. As engineering students earn their degrees and progress their way into the field it is of upmost importance that these individuals conduct themselves honorably, responsibly, lawfully, and ethically. With the exposure and experience of ethics in education, students will be more equipped to recognize ethical issues and test their moral decision-making. The study of ethics in engineering education may also aid in understanding that while the codes of ethics are handy, they may only sometimes provide clear-cut answers. Engineers are obligated to bring competence and integrity to their work but considering the public's welfare is equally important. Ensuring that a workplace keeps ethics and morals in mind whilst decision making will not only reflect well on the reputation of the individuals and the entire company, but will only further the trust engineers have with the public and how society view the profession.

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