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Ethics Education in Engineering: Practices on and off the Campus

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Research Article

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Introduction

This paper will focus on two major methods for educating engineers in ethics. It is important to realize that two sets of standards exist within the field of engineering, both from the professional standards set within industries and from the personal moral standards held by engineers themselves. This article first examines the education of ethics within the workplace as some engineers have no previous training in ethics. Second, it discusses how ethics is introduced to engineers through university undergraduate and graduate courses. It will also evaluate whether ethics courses are more effective than the real-world application found through the professional setting. It concludes that it is best to incorporate a part of all of these methods of ethical training, but the least useful is that of teaching ethics to students in undergraduate programs with the hope of measuring these results by tests and assessments. Rather, it is more important to build students' personal values, virtues, and then their ethical training will naturally occur, and result in engineers being more motivated to adhere to these ethical practices.

As for research methods, information was gathered through database searches for articles relating to ethics within the engineering workplace. These articles were studied to determine the multiple ways of creating ethical standards for engineers. This process was completed by consideration for the historical development of these standards for promoting more ethical engineering.

Importance of Ethics in the Workplace

Ethics are important in the workplace because those within the profession are expected to uphold virtues of honesty and integrity (Zhu & Jesiek, 2017, p. 2). These are critical factors as engineering focuses on projects and innovations. Especially within the disciplines of civil, chemical, and industrial engineering, ethics are important to environmental well-being in the industries. Lack of ethics can often threaten the lives, safety, and long term welfare of the general public and those engineers working on the projects (Basart & Serra, 2013, p. 3).

One specific example of failure to adhere to ethical practices and the catastrophic results that occur is the TV antenna failure of 1982 (Department of Philosophy and Department of Mechanical Engineering Texas A&M University, 2012). One engineering firm, Antenna Engineering Inc., built an antenna and another firm, Riggers Inc., was hired to implement and assemble the antenna. Antenna Inc. submitted the plans to Riggers Inc. The company approved the plans, which used lugs. As the crew was building the antenna, they used a makeshift extension. In short, the semantics of the design of the antenna along with the methods used for building the antenna failed, and the antenna collapsed. This resulted in the death of several riggers who fell over a thousand feet. This was an error of ethical behavior as the crew had used a makeshift extension to the lug. The outcome would not have been tragic if the crew had kept in mind their ethical responsibility to provide safety for the workers, and had made certain the mechanics of their building equipment were correct.

This example shows why ethics are critical for the profession of engineering. Therefore, to ensure that these ethical practices are adopted, engineers new to the field must be taught ethics through some path or another. The following section focuses on what those educational paths are and the effectiveness of each.

Ethics as Taught in the Workplace

It is a common trend within the field of engineering for newly hired engineers to have little experience or knowledge of ethics of their work. As a result, ethics are needed to be taught or introduced in the workplace. Without an introduction to ethics, the engineer is at a loss as how to work ethically on a team, on projects, or within their own ethical standards. There are multiple ideas and camps of thought on how this could be best done. Personal ethics are important so that the engineer can have a framework to draw from within their career.

Wang, Zhang, and Zhu (2015) examine how engineering ethics training often presents itself in purely professional ethics. Consequently, the professional side of things may seem unreachable and unrelatable to the common undergraduate engineer in that an engineer at that level of education will not have had exposure to real world experiences. Therefore, a more practical approach may be needed. An approach of teaching ethics within the professional workplace rather than relying on the university to be responsible for ethical training. One aspect of Wang, Zhang, and Zhu's work focuses on the interpretational approach, where the engineers concentrate on having a mindful interpretation of ethics in their work. As explained by the authors:

> Such an interpretative activity will expand the content and context of both ethics and engineering. In respect to content, ethical principles and moral norms, ethical feelings, ethical behaviours, and social impacts will all need to be clarified in the interpretational process. Engineering ethics education often emphasizes ethical principles and moral norms, but slights ethical feelings, ethical behaviours, and social impacts. The interpretational process needs to pay explicit attention to feelings and emotional factors along with such factors as moral consciousness, cognition, imagination, expectation, and intuition. (p. 66)

It is pointed out that engineers struggle to understand the effect of their project past the practical application. A resolution would be to widen this view so that the engineers could understand the effects on society would be particularly useful. This stance is partially significant in response to criticism from ethicists who view engineers as lacking an ethical perspective in their work (Wang, Zhang, & Zhu, 2015, p. 66). The same writers also suggest having a set model between a dialogue of engineers and ethicists:

> Dialogue additionally provides a platform for engineers to defend themselves, and helps ethicists and the public to better understand the professional activities of engineers, which is conducive to cultivating the moral ideal of engineers, making engineers more active in the construction of good engineering. (p. 67)

Such practice would open communication lines between the two main professions of engineers and ethicists in order to aid in this struggle. As engineers can become very involved and focused on the technical side of their projects, this communication would provide outside opinion and advice to keep other non-technical aspects of the project.

Another idea presented for providing ethical structure within the engineering workplace was that of drafting an established code of ethics for engineers. "Drafting a Code of Ethics for Engineering Education" by Cheville and Heywood (2015) attempts to study four different professional fields in order to create an ethical code for engineers. The article assumes that engineering education is a profession, and argues for a set of ethical codes that are common and standard between professions. After examining these codes, the authors suggest their own set of more specific rules. These rules can be altered to better suit the different professions of engineering, as suggested, "To be useful codes need to be written for a given audience; the code above was written for engineering educators to acknowledge the ethical dilemmas potentially introduced by the multiple roles they inhabit" (Cheville & Heyworth, 2015, p. 3).

Finally, the article puts weight on universities teaching engineers to provide a means of ethical education. This is taken to begin to look at providing guidelines for each specific discipline of engineering. This is done by breaking down the code into seven clauses to be the "common core" for ethics within engineering. Those seven clauses are then based upon what is usually referred to as a Paramountcy Clause, which focuses on engineering protecting the health, wellness, and safety of society. Other engineering disciplines maintain their own codes, including those of the National Society of Professional Engineers (NSPE), Institute of Electrical and Electronics Engineers (IEEE), and American Society of Mechanical Engineers (ASME). These codes all maintain the position of serving for a framework of the engineering profession to refer to. However, it is important to keep in mind that the use of these codes does not come without controversy; as stated by Eugene Schlossberger (2016) in his investigation of ethics within engineering, "Because the codes are brief and the language fairly general, most clauses in most societies' codes are widely accepted and relatively easy to justify" (p. 1336).

Another viewpoint argues for the use of virtue ethics (Han, 2015). Virtue ethics are ethics which are focused on the person creating the action and are based in character traits: As Virtue ethics "differs from deontology and consequentialism by focusing on the person who acts, rather than the action itself; the emphasis is on

being good, rather than just doing good" (Schmidt, 2013, p. 992). The idea suggests a structure for the use of virtue ethics within the field of engineering and puts forth a code specifically for virtuous engineering. This method leans more heavily on the idea of creating moral motivation to encourage engineers to uphold ethical standards. This is the use of intrinsic motivation, which is potentially the most reliable when instilled in the engineer:

> While the previous paradigm of science and engineering ethics education, which concentrated on rule-based ethics education, would be difficult to form a significant, strong, and direct conceptual connection between professional ethics and a successful career as virtues for being a successful scientist or engineer, this virtue-based positive approach to ethics education would easily associate the content of ethics education and professional career development. (Han, 2014, p. 3)

This virtue ethic method does not then benefit the engineer in terms of giving them structure, but gives them the tools for the engineers to comprehend, develop, and create their own ethical standards.

It is important to keep in mind that this motion for engineering ethics also specifies that this is not meant to replace the current ideas of ethics in engineering, but rather be added to them. Virtue ethics is not meant to replace a set standard of ethical rules such as codes, but rather provide ethical education from the other end of things, that being the engineer's own motivation and interests.

Essentially, there are multiple different ideas of how to change the current approach to ethics in engineering. An open dialogue between engineers and ethicists is suggested in order to bridge the gap of ethical awareness between the two professions, and therefore create a practical path for improvement (Wang, Zhang, & Zhu, 2015, p. 66). In drafting a code of ethics for engineering education, an established set of codes is also suggested (Schlossberger, 2016), and is derived from examining four separate professional fields and retaining the applicable parts to engineering. Finally, there are recommendations to introduce virtue ethics as a supplement to the existing code and methods of ethics (Han, 2015). After studying and reviewing the above articles, the blend of these studies seems to be the best approach to bridge the gap between ethics and engineering. The structure of the set of codes is useful and helpful to engineers, and could be used as a reference within

the professional field, and to develop and refine these through a communication of ethicists and engineering would be helpful to both parties.

Ethics Taught through Undergraduate and Graduate Studies

The other side of ethics training comes from students being introduced to it within their undergraduate or graduate studies. Some regard this approach as the more logical course of education, as the students enter the workplace with an idea of how ethics are used within the field of engineering (Keefer, Wilson, Dankowicz, & Loui, 2014, p. 2). This approach has been attributed such importance that all Accreditation Board of Engineering and Technology (ABET) programs are required to have ethics included within their course curriculum. This is partially because the introduction through coursework allows the students to consider how this will affect their professional lives, as well as making the transition from the university to the professional world easier for the students. It is important to remember for this method, however, that not all engineering students will have exposure to the ethics training at their university depending on the course and program of the specific university.

Another specific method of introducing ethics to students is that of whether or not it is the teacher's responsibility to teach not only professional ethics, but also the personal ethics of the students. The advocates of developing ethics from the personal values of students realize that with the quickly changing demands of technological and engineering jobs, it is quite impractical to attempt to teach students that would be job specific (Keefer, Wilson, Dankowicz, & Loui, 2014, p. 2); rather, the goal is to provide the students with foundational personal ethics and skills such as critical thinking that the student will be able to reference in the future. Specific implementations of the method could be found in several papers concerning preparation for career and college beginnings (see for instance, Rateau, Kaufman & Cletzer, 2015; Robles, 2012). When these papers were reviewed by Thomas Loveland (2017), six key characteristics were found: self-management, collaboration, integrity, communication, optimism, and adaptability. The students and future employees were then taught these traits by working on a design team, or by instructors altering deadlines in order to heighten the workload and perceived stress. Additionally, the article mentions that the optimism of the team or class self-management, collaboration, integrity, communication, optimism, and adaptability can be determined by that of the teacher, as the students would tend to imitate the

overall personality of the teacher. In terms of working in flexible work environments, “This experience of adjusting to new things and other ideas to accomplish goals can promote personal flexibility. Teachers should try to teach students that there is value in change” (Loveland, 2017, p. 18).

Overall, the goal of this school of thought is to promote personal values and goals within everyday life with the hopes that this will in turn create positive ethics in the workplace. A great deal of the responsibility, therefore, lies upon teachers to lead with their own attitude and ethics, while providing tasks and real world situations for students to experience stress and other elements of the workplace. While the limitation of this approach is that the success will not be apparent for years to come, teachers should realize that it is a part of their job to create moral consciousness within their students.

Some problems are created when the university makes it a point to attempt to teach students skills of ethics with results found in assessments and tests. Not only are these skills difficult to measure but the great variation in approaches, objectives, and assessments depending on the university’s education system allows for great ambiguity between what students are learning, and debates whether or not any of this information will actually assist students in the future. This is obvious in the article “The Importance of Formative Assessment in Science and Engineering Ethics Education: Some Evidence and Practical Advice” (Keefer, Wilson, Dankowicz, & Loui, 2013). In this publication, the issue of whether or not students are actually learning information in their course and the extend of actual application of the learned ethics is examined. The difference between the instructors can be an issue in itself: “[M]any instructors responsible for developing their own courses come from a wide variety of disciplines and are often teaching a subject that is not their primary area of expertise” (p. 2). These inconsistencies can cause students to be at a loss when instructors are trying to teach them things specific to their careers, as this will then create a gap in backgrounds for most students as they enter the workplace.

Attempting to Use This Information to Improve the Ethics within the Field of Engineering

For the most part, this paper focuses on the ethics of engineering of the new professionals within the field. These professionals tend to fall into two categories: those who were taught ethics through their studies at a university, and those who learn all of the ethics of their field at their job and through their professional

experience. While both of these groups provide for a great amount of ambiguity and difference between backgrounds and learning methods, those methods taught through the workplace tend to be more similar than those taught by the university. This conclusion comes from the basis that the students of a university will be greatly affected by not only their own background and pedigrees, but also by their professors' backgrounds. This would create a gap between all students of where they studied, what their teachers specifically taught them, and therefore create a negative difference in their abilities to work with and understand the methods of their peers. This process has begun through ABET accredited programs all requiring ethical education, but this leaves much room for ambiguity between the separate curriculums.

The best way for students to learn about ethics while maintaining the option of personalizing the ethics to their own morals may then be through the example of attitude of the teachers, especially when the teacher creates simulated events like group projects, and then gently guides the students how to ethically work their issues and problems. This approach provides a type of framework for the students to refer to as they will face different types of stress and ethical problems as they each maintain different jobs in their professional lives.

This general teaching of ethics in the university coupled with the open lines of communication between engineers and ethicists would provide a viewpoint for the engineers outside of their field. These two methods combined would provide the engineer with references and examples of how their superiors handled ethical issues within the university, as well as the ongoing discussion between the two career fields to maintain current information and opinions on the projects and work conducted by the engineer. While a general code of ethics may also be recommendable, it would be advisable for this code to avoid becoming too restricting. This may sacrifice the liberty of the engineer to use their own judgment, views, and liberties when working within the field.

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