ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #36510

Engineering Ethics Education: Why a Liberal Arts Ethics Class is Not Sufficient for Tomorrow's Engineers

Dr. Claire Lynne McCullough, High Point University

Dr. McCullough received her bachelor's, master's, and Ph.D. degrees in electrical engineering from Vanderbilt, Georgia Institute of Technology and the University of Tennessee, respectively, and is a registered professional engineer in the state of Alabama. She is a member of I.E.E.E., Tau Beta Pi, Sigma Xi, and Eta Kappa Nu. She is currently Professor and Founding Chair of Electrical and Computer Engineering at the High Point University, and teaches courses in such areas as Engineering Ethics, Controls, and Engineering Design. Dr. McCullough has over 30 years' experience in engineering practice and education, including industrial experience at the Tennessee Valley Authority and the US Army Space and Missile Defense Command. Her research interests include Image and Data Fusion, Automatic Target Recognition, and Bioinformatics. She is a member of the ABET Engineering Accreditation Commission, and is the delegate of the Women in Engineering Division of ASEE to the Committee on Diversity, Equity, and Inclusion.

Engineering Ethics Education:

Why a Liberal Arts Ethics Class is Not Sufficient for Tomorrow's Engineers

Dr. Claire L. McCullough, PE
High Point University

Abstract

While ethics has always been a concern for the engineering community, there has been a continual debate among engineering educators as to whether it is necessary to have a dedicated engineering ethics curriculum, or whether ethics education can be safely left to the liberal arts portion of the students' education. This paper examines the differences in emphases and perspectives in the two types of courses at High Point University and discusses why, in the author's view, that ethics taught from a liberal arts point of view alone, is not sufficient to prepare engineers for ethical professional practice, thus necessitating dedicated engineering ethics coverage in the engineering curriculum.

Keywords

Engineering Ethics, Engineering Education, Liberal Arts

Introduction

While the discussion regarding the place and necessity for ethics education in engineering disciplines has been on-going for some time, the growing emphasis on equity, diversity and inclusion in the ABET Engineering Accreditation Criteria[1] has increased this dilemma for engineering educators. The author has been involved in engineering ethics education for over 15 years, both in teaching an independent engineering-only ethics course, and co-teaching a course with a classically educated philosophy professor, cross listed between engineering and philosophy departments, and certified as a General Education course. The opportunity to share the course with a philosopher who specializes in ethics provided a window, rare for an engineer, into ethics as it is taught from a liberal arts perspective. Changes in the General Education requirements at High Point University, including required General Education categories and guidelines for each, have made continuing the existing combination course impractical, and necessitated a decision as to whether an ethics courses, taught solely from the liberal arts viewpoint would be adequate ethical education for prospective engineers, or whether a dedicated engineering ethics course, in addition to the liberal arts course and outside the general education venue, was a necessary part of the engineering curriculum. While the examination of the new requirements for ethics courses under the new general education guidelines at High Point University is instructive, it has been the observations in the co-taught course of what materials are used in a liberal arts focused course, how case studies are chosen, how they are presented, and how they are discussed from a philosophical perspective that have led the author to the view that a dedicated engineering ethics course, taught from the standpoint of an experienced

professional engineer, is a necessary part of educating young engineers for their future roles. While the discussion in the paper is primarily related to the author's observations and involvement in teaching the shared course at High Point University, it is also informed by her experience at her previous university, the University of Tennessee at Chattanooga, where she taught a computer ethics course for many years and participated in a relevant ethics work group. This paper discusses differences in purpose of study between philosophy and engineering based courses, differences in perspective, differences in materials, and differences in goals, then gives concluding thoughts on the necessity of an ethics course taught from a professional engineering viewpoint, in addition to the liberal arts ethics education included in a standard general education curriculum.

Difference in Purpose of Study

One of the main differences between ethics taught from the perspective of philosophy and from the perspective of engineering is that of purpose of the ethics study. According to the criteria for ethical reasoning courses at High Point University, the goal of liberal arts education as a whole is "forming well-rounded, informed citizens for our democracy and increasingly interconnected world."[2] In ethics courses specifically, students are to "pose fundamental questions, in light of rigorous traditions of philosophical inquiry…about how human life gets oriented toward its most encompassing ends, and about what that looks like in practice."[2] Thus, the goal of ethics as taught from a liberal arts perspective at High Point University is the development of the student, in his or her understanding of normative concepts from philosophical traditions and ability to "address fundamental questions about the moral guidance of human action, life, and being." While these are worthy goals, and can be a valuable part of a student's development as an ethical person, the goals for engineering ethics are very different.

The main purpose of engineering ethics education is to prepare students to ethically practice engineering as a *profession*. There are many definitions of this term, but one particularly applicable to engineering comes from the Australian Professional Standards Council:

> A **profession** is a disciplined group of individuals who adhere to ethical standards. This group positions itself as possessing special knowledge and skills in a widely recognised body of learning derived from research, education and training at a high level, and is recognised by the public as such. A profession is also prepared to apply this knowledge and exercise these skills in the interest of others.[3]

It is easy to see that engineering meets this definition, simply by examining the requirements for accreditation as an engineering program[1].

Students are required to demonstrate

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.

4. 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.
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire a nd apply new knowledge as needed, using appropriate learning strategies.[1]

In addition, students must be prepared for practice by a curriculum including a minimum of 30 semester hours of mathematics and basic sciences, and a minimum of 45 hours of engineering topics appropriate to the discipline, "consisting of engineering and computer sciences and engineering design, and utilizing modern engineering tools."[1]

The minimum requirements above would certainly indicate that students from ABET accredited engineering programs graduate with "special knowledge and skills in a widely recognised body of learning derived from research, education and training at a high level."[3]

Those in professions are "governed by codes of ethics, and profess commitment to competence, integrity and morality, altruism, and the promotion of the public good within their expert domain. Professionals are accountable to those served and to society." [3] These requirements, and our accountability to society, hold engineers to a much higher standard than the general population, and thus require specific preparation for ability to meet that higher standard.

Difference in Perspective

One main difference in perspective has to do with the standard of comparison for ethical alternatives. General education ethics courses at High Point University require "engagement with rigorous traditions of philosophical inquiry…Identifying/understand, and evaluating/applying a number of overlapping and contrasting normative concepts…[and] a study of texts, traditions, or ways of life that draws on methods typical of …moral philosophy and applied ethics."[2] Some of the skills to be developed in these courses are certainly relevant to ethics in engineering. The learning outcomes for these courses are given as

- Discern, paraphrase, and present in-depth information from relevant sources representing distinct points of view or approaches.
- Identify ethical issues present in a described general scenario (e.g., rights, autonomy, honesty, coercion, loyalty, selfishness, character, duty, utility, fairness, etc.).
- Distinguish morally relevant facts in a scenario from facts that are not morally relevant in a scenario.
- Reflect critically on their own values in light of alternatives.
- Apply ethical theories to contemporary or hypothetical scenarios.[2]

All of these would be appropriate as learning outcomes in an engineering ethics course, and could easily be met in such a course. However, it is required that these be met from a liberal arts perspective—that is, in terms of "rigorous traditions of philosophical inquiry"[2], which is not the most effective tool for examining issues from a professional engineering perspective. The most commonly recognized standard for engineering behavior is the codes of ethics which govern the profession, developed by states and by engineering societies such as the Institute of Electrical and Electronics Engineers (IEEE), the American Society of Mechanical Engineering (ASME), and the National Society of Professional Engineers (NSPE).

Although there are many relevant codes of ethics for engineers, one which is widely recognized and which applies to all engineering disciplines is the code of ethics of the National Society of Professional Engineers. The preamble to the code identifies engineering explicitly as a profession requiring "highest standards of honesty and integrity….[and] highest principles of ethical conduct."[4] Recognizing the "direct and vital impact on the quality of life for all people," the document further states that engineering "require(s) honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare." [4]

The fundamental canons of the code of ethics require that

> Engineers, in the fulfillment of their professional duties, shall:
>
> - Hold paramount the safety, health, and welfare of the public.
> - Perform services only in areas of their competence.
> - Issue public statements only in an objective and truthful manner.
> - Act for each employer or client as faithful agents or trustees.
> - Avoid deceptive acts.
> - Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession. [4]

The tenets of this code of ethics differ considerably from the commonly discussed ethical theories in a philosophy-based ethics course. The text used in the formerly shared course at High Point University for the philosophy portion of the course, *The Elements of Moral Philosophy*[5], includes readings in cultural relativism, social contract theory, utilitarianism, divine command theory, ethical egoism, Kant, and ethics of care. This coverage appears typical of treatment in texts with this focus and at this educational level.[6, 7, 8, 9,] However, the thing that quickly becomes evident in reading or discussing this material is that the ethical theories have nothing on which all agree. For example, theories such as utilitarianism can justify lying under certain circumstances, depending on the weighted consequences of that action and the number affected, where others, such as those espoused by Kant, state that "To be truthful…in all declarations…is a sacred and absolutely commanding decree of reason, limited by no expediency."[5] As philosophers recognize no ultimate authority, and do not accept as binding any existing body of knowledge, there is no means by which this conflict can be resolved in a consistent fashion. As stated in the introduction of the text used at High Point University in the shared course:

> Philosophy is not like physics. In physics, there is a large body of accepted truth that beginners must master. Of course, there are unresolved controversies, in physics, but they

> take place against a backdrop of broad agreement. In philosophy, by contrast, everything is controversial—or almost everything. Some of the fundamental issues are still up for grabs. Newcomers to philosophy may ask themselves whether a moral theory such as Utilitarianism seems correct. However, newcomers to physics are rarely encouraged to make up their own minds about the laws of thermodynamics. [5]

In engineering, there is an accepted body of scientific information which must be mastered and applied, and codes of ethics such as that of the NSPE, which must be applied. For example, it is not acceptable in engineering practice for the engineer to use philosophical arguments or ethical theories to justify deception, either on the basis of balance of consequences or intention—deceptive acts are not permissible.[4] And while NSPE is a voluntary organization, and has no true manner of enforcement of this code, the codes of ethics for professional engineers in the individual states have the force of law, and have penalties ranging from fines and loss of license to criminal prosecution. These codes are also sometimes more stringent than that of the NSPE. For example, in the code of the state of Alabama, where the author is licensed, the code not only prohibits deceptive acts, but "omissions … assertions or representations which are fraudulent, deceitful, or misleading, or which in *any manner whatsoever tend to create a misleading impression*"[10] (emphasis added)—a much more stringent condition. It is also not permissible for professional engineers to operate in an area in which they are "not qualified by education, examination or experience to form a dependable judgment."[10] Thus, the matter of authority for ethical judgments for the engineering profession is considerably different than the accepted standard, or lack thereof, set in deliberations in the philosophical tradition.

Differences in Materials

While some of the discussion in this section is applicable to philosophy-based ethics classes in general, it is primarily based on the author's experience in co-teaching the course at High Point University with a philosophy professor specializing in ethics. The text selected by the philosopher for the philosophy portion of the course is *The Elements of Moral Philosophy*[5] which includes a standard presentation of the usual ethical theories discussed earlier. Many of the examples given to, and discussed with, students, would be familiar to many undergraduate philosophy students: the "trolley problem,"[12] the ring of Gyges,[8] "the Inquiring Murderer,"[5] and "The Ones Who Walk Away from Omelas."[11] Some contemporary issues, such as cyberbullying and file-sharing, are brought up in lectures and given as case studies, but are covered briefly, and include no discussion of the technical issues involved.

One major class discussion and case study used is the Ford Pinto case from the 1970s. The material given to the students in this assignment is a compilation developed by the philosophy professor from a variety of sources, some of which have been debunked, such as "Pinto Madness."[13] (see for example "Pinto 'Madness' as a Flawed Landmark Narrative: An Organizational and Network Analysis."[14]). The students are given no relevant historical context (e.g., federal regulations or information about other vehicle crash performance at the time), and are asked to make a judgment based on what the author refers to as a "God's eye view"—that is, they are to consider the incident without regard to what could possibly have been known at the time, but including information that could only have been known after the fact, and with a perspective of years. This lack of context, and failure to consider the perspective of the engineers involved in the design process, led the students in the combined course at High Point University

to cut-and-dried conclusions, such as “Lee Iacocca didn’t care if the killed people,” and it didn’t occur to any of the students to consider what information could reasonably have been known at the time that engineering decisions had to be made. Searching the internet for “the Pinto case” and “ethics” will convince the reader that this is a commonly used example in philosophy and business ethics courses at many universities other than High Point University, and that the lack of context, and the sources included, are also typical of the coverage.

This is not appropriate for engineering ethics education for a number of reasons. One is that engineers must make ethical decisions in real time, using the best information available at the time. According to *Engineering Ethics: Concepts and Cases*,[15] “Engineers, like other professionals are … tied to the post of use,” meaning that they “ do not have the luxury of thinking indefinitely about moral problems.” Rather, engineers

> must make decisions about particular designs that will affect the lives and financial well-being of many people, give professional advice to individual managers and clients, make decisions about particular purchases, decide whether to protest a decision by a manager, and take other specific actions that have important consequences for themselves and others.[15]

Another reason this treatment is not appropriate for engineering students is that the material given to the students is combined, collated, and simplified, and often demonstrates to even a cursory reading what the “correct” answer to the dilemma is according to the perspective of the professor. As part of ABET accreditation, engineering students are required to demonstrate “an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments. “[1] When students are given simplified scenarios with the ethical issues, and sometimes desired ethical conclusions, conveniently identified and summarized, students do not have the opportunity to develop the necessary skill of being able to *identify* ethical issues in the world of engineering practice. Thus the author, where possible, gives the students the original source material, and begins discussion by having students identify the ethical issues present in a complex scenario, better preparing the students to be able to recognize ethical issues in a work context.

Finally, this coverage is not sufficient for engineers simply because the Pinto incident and the other previous examples cited, were all from over 50 years ago. While historical coverage can be a useful tool, the ethical issues in engineering are developing and changing so rapidly that significant coverage of contemporary issues is also a necessity. The majority of the ethical issues facing engineers today did not exist, and could not have been predicted, when the author completed her undergraduate engineering education, and it is similarly difficult, if not impossible, to predict the issues today’s students will face during their careers. As stated in the author’s previous paper,

> Who could have predicted, except as science fiction, the capability of cities to track their citizens’ movements by means of cameras on public streets; the amount of data routinely collected electronically on average people who do not even access the internet; the opportunity for everyone with approximately $60 to use Global Positioning Systems to track their own movements, or those of others; or the advances such as neural implants or Computer Aided Tomography (CAT) scans combining medicine, computing, and

> engineering to provide healthcare options unimagined only a few years ago? Even if every existing ethical issue now … could be identified, and all could agree on the correct ethical position (a highly unlikely proposition), this would not prepare our students for the issues they will face in the future. Rather, it is necessary that students learn to identify relevant ethical issues; assemble and evaluate appropriate sources of information; form, assess, and defend ethical positions; and persuade others to adopt ethical practices, as well. [16]

Thus, the materials covered in a philosophy-based ethics course such as the one the author observed are considerably different in several aspects than those necessary to develop an understanding of engineering ethics.

Differences in Goals

A final difference in the teaching of ethics from a philosophical perspective compared to an engineering viewpoint is the goal of the study and of the ethical evaluations. The author participated in a professional ethics focus group related to fallacies for a semester at her previous university, the University of Tennessee at Chattanooga. The group consisted of a philosophy professor leading the group, an English professor, a History professor, and the author. Some of the unstated assumptions that became apparent in the group during this participation were that the goal of the study was to be able to make a strong intellectual argument, and that there were no right or wrong answers, but only good arguments and poor ones—this was obvious throughout the extensive and continuing discussions. This contrasts sharply to engineering, where the goal is to prepare engineering students to successfully uphold the primary directive of the NSPE ethics canon, "Hold paramount the safety, health, and welfare of the public."[4] Thus while there may be multiple "right" answers in an engineering situation, from the perspective of an engineering professional, there are also answers which are *very* wrong, and some principles, such as public safety, which cannot be compromised regardless of the rationale or the strength of the argument supporting it.

Additional Considerations

An additional consideration in including an engineering ethics course in an engineering curriculum is the way it can be used to assess several of the outcomes necessary for ABET accreditation. The course as taught at High Point University includes a research paper and a related oral presentation, so in addition to outcome 4, "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments," [1] the course is also used to assess both outcome 3, "an ability to communicate effectively with a range of audiences," [1] and outcome 7, "an ability to acquire and apply new knowledge as needed, using appropriate learning strategies."[1] Further, the class includes a team-based project on a topic related to diversity, equity, and inclusion, and so can also be used to demonstrate outcome 5, " an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives," [1] and to address expected changes to Criterion 5 for the 2023-24 accreditation cycle: "a professional education component that is consistent with the institution's mission and the program educational objectives and promotes diversity, equity, and inclusion awareness for career success." [1] Thus,

there are few courses in an engineering curriculum which can be more useful for ABET assessment than an engineering ethics course!

Concluding Thoughts

Studying ethics from the outlook of philosophy can be a valuable educational experience for students, leading to development of reasoning skills and personal moral growth, but is it sufficiently comparable to engineering ethics to serve the needs of educating our future engineers? Given the many differences between ethics as taught from a philosophical viewpoint, and ethics as necessary for professional engineers, such as perspective, time-scale, body of accepted work, recognized authority and materials typically covered, it is clear that the two are not equivalent. However, it is the differences in necessity for making decisions in real-time with the best available information, and the critical nature of consequences to society if unethical decisions are made that led the engineering programs of High Point University to conclude that a separate engineering ethics course must be a necessary part of the engineering program of study. Whether this be in the form of a separate course, as at High Point University, or in modules included in other courses such as the engineering capstone, it seems clear that some form of engineering ethics curriculum, in addition to ethics from the viewpoint of philosophy, is necessary to prepare students for the ethical and effective practice of engineering as a profession.

References

1 ABET Engineering Accreditation Commission, *Criteria for Accrediting Engineering Programs*, ABET, Baltimore, MD, 2021.

2 General Education Committee, "Ethical Reasoning and Religious Traditions Course Proposal Criteria," High Point University, 2021. Available from https://highpointuniversity.sharepoint.com/sites/GeneralEducationCouncil/Shared%20Documents/Forms/AllItems.aspx?ga=1&id=%2Fsites%2FGeneralEducationCouncil%2FShared%20Documents%2FGeneral%2FUpload%20to%20website%2FCourse%20Proposal%20Guides%20%28PDF%29%2FEthics%20and%20Religion%20Course%20Proposal%20Guide%2Epdf&parent=%2Fsites%2FGeneralEducationCouncil%2FShared%20Documents%2FGeneral%2FUpload%20to%20website%2FCourse%20Proposal%20Guides%20%28PDF%29 accessed 11/12/2022

3 Professional Standards Councils, "What is a profession?" https://www.psc.gov.au/what-is-a-profession, accessed 11/6/2022.

4 National Society of Professional Engineers, "Code of Ethics," https://www.nspe.org/resources/ethics/code-ethics, accessed 11/6/2022.

5 Rachels, James and Rachels, Stuart, *The Elements of Moral Philosophy*, McGraw Hill, New York, NY, 2019.

6 Burnor, Richard, and Raley, Yvonne, *Ethical Choices: An Introduction to Moral Philosophy with Cases*, Oxford University Press, Oxford, UK, 2011.

7 Deigh, John, *An Introduction to Ethics*, Cambridge University Press, Cambridge, UK, 2010.

8 DeNicola, Daniel, ed., *A Reader in Moral Philosophy,* Broadview Press, Ontario, Canada, 2022.

9 Driver, Julia, *Ethics: The Fundamentals*, Blackwell Publishing, Malden, MA, 2007.

10 Board of Licensure for Professional Engineers and Professional Land Surveyors, Alabama Law Regulating Practice of Engineering and Land Surveying Code of Alabama 1975, Title 34, Chapter 11 Last amended – July 1, 2018, https://bels.alabama.gov/wp-content/uploads/2022/03/2022LawandCode.pdf, accessed 11/10/2022

11 Le Guin, Ursula, *The Ones Who Walk Away From Omelas*, Creative Education, Mankato, MN, 1993.

12 Philippa, "The Problem of Abortion and the Doctrine of the Double Effect" *Virtues and Vices*, Basil Blackwell, Oxford, UK, 1978 (originally appeared in the Oxford Review, Number 5, 1967.)

13 Dowie, Mark, "Pinto Madness," *Mother Jones*, October/November issue, 1977.

14 Lee, Matthew T., and M. David Ermann. “Pinto ‘Madness’ as a Flawed Landmark Narrative: An Organizational and Network Analysis.” *Social Problems*, vol. 46, no. 1, 1999, pp. 30–47. JSTOR, https://doi.org/10.2307/3097160. Accessed 12 Nov. 2022.
15 Harris, Charles, *et al*., *Engineering Ethics: Concepts and Cases*, fifth ed., Wadsworth, Boston, MA, 2014.
16 C. L. McCullough, “Ethics for the Information Age,” presented at the American Society for Engineering Education Southeastern Section Conference, Starkville, Mississippi, April 2012.

Dr. Claire L. McCullough, PE

Dr. McCullough received her bachelor's, master's, and Ph.D. degrees in electrical engineering from Vanderbilt, Georgia Tech and the University of Tennessee, respectively, and is a registered professional engineer in the state of Alabama. She is currently Professor and Founding Chair of Electrical and Computer Engineering at High Point University, and teaches courses in such areas as Engineering Ethics, Controls, and Engineering Design. Dr. McCullough has over 30 years' experience in engineering practice and education, including experience at the Tennessee Valley Authority and the US Army Space and Missile Defense Command. Research interests include Data Fusion, Bioinformatics, and Diversity and Under-representation in STEM fields.