

Ethics in Engineering Education and at Penn State Fayette

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ABSTRACT

The topic of ethics in engineering education is the focus of this paper. The importance of this part of the engineering profession is highlighted. The need for teaching ethics to engineering students is established. Ethics in one specific field of engineering which pertains to the author is given in some details. A few civil engineering cases where ethics played a big role are cited. A look at the ways in which universities and colleges treat ethics in engineering curricula is summarized. Treating engineering ethics at Penn State Fayette is explained. A recommendation on how to teach engineering students ethics is provided.

Keywords: Ethics, Engineering Education, Penn State Fayette

1. INTRODUCTION

The profession of engineering and the society has a profound interaction. Engineers serve the societies they live in by offering them practical solutions to their technical problems. They have to do so in the most efficient way and in an ethical manner. The importance of ethics in engineering has been well established and awareness about this importance has been on the rise in recent years.

Traditionally, with a few exceptions, institutes of higher education did not include discrete educational components on ethics in their engineering curricula. Engineering students are left to learn about ethics on their own especially after graduation through their professional careers. This has changed recently as more and more engineering programs are starting to address engineering ethics in more concrete ways.

The importance of ethics extends beyond our engineering profession. For instance, the latest US congress made ethics reforms a top priority following several notorious cases of ethics violation by its members. It was one of the bills passed in its famous first 100 hours. In our profession nowadays, ABET, a leading authority in the US, puts a lot of emphasize on ethics in the education process.

2. ETHICS

According to the American Heritage College Dictionary (Costello, 1993), ethics is a term used to identify the rules or standards which control and regulate the performance and behavior of an individual or members of a profession.

3. THE NEED FOR ETHICS IN THE ENGINEERING PROFESSION

Fundamentally, the engineering profession revolves about serving the society (Kosky et. al., 2006). Engineers do so through the application of sciences to practice. Engineering professionals interact extensively with the society in various capacities in this process. Accordingly, engineers inevitably have a profound impact on the society

(Fleddermann, 2004). This includes safety, economical, and well-fair components. It is therefore essential for engineers to perform their duties professionally and ethically as well.

Engineering projects have evolved from being simple to become very complex over the years. Projects nowadays involve engineers and engineering technicians and technologists from various engineering disciplines. For instance, the construction of a building starts typically with an architect or an architectural engineer but will include the services of civil, mechanical and electrical engineers among others. Environmental engineers prepare environmental impact studies before the construction of a bridge by structural engineers. This was indeed the driving force behind creating the relatively new branch of systems engineering at the MIT in the 1980's. This complexity requires engineers to be more ethical as their individual responsibilities in an engineering project will affect the integrity of the whole project. Further, engineering projects involve the services of individuals from other professionals like managers and lawyer who have their own ethics.

Despite its variance from an engineering discipline to another, engineers deal with the public sector. This public interaction can be limited like the case with nuclear engineers who usually work in well protected facilities for obvious safety concerns. It can be however very extensive like the case with civil engineers who are the most visible engineers to the public sector (Burghardt, 1995). This interaction with the public requires ethical and professional performance by the engineers.

Despite the controversial nature on how various individuals define government, engineers have a great role in government affairs. Summed up by an individual citizen, "the function of government ought to be: make sure you have good water to drink, somebody picking up the garbage, good roads to drive on, enough electricity to turn your light bulbs and your record player on, and whatever smaller amounts of regulatory assistance is necessary to make this society work," (Zappa, 2008). That is why many government agencies employ engineers to perform government's duties.

Additionally, engineers are becoming more involved with politics (Wiewiora, 2005, and Fleddermann, 2004). Policy makers at the state and federal levels consult engineers nowadays to establish new policies. Examples include the controversial global warming phenomenon and developing new energy resources. Another example is the deteriorating status of the bridges in the US after the collapse of a major bridge in the State of Minnesota in 2007. In a March 2008 campaign visit to the Penn State Fayette Eberly Campus, where the author teaches, US presidential hopeful Senator Hillary Clinton mentioned bridges several times in a span of only thirty minutes. This also emphasizes why engineers have to observe ethics carefully while performing their duties.

Globalization made ethics more important than ever. The world is becoming a small village due to the latest huge technological advancements. Engineering projects have been affected both positively and negatively by this phenomenon. In fact, positive effects to one group can be negative to another. For instance, outsourcing engineering jobs from the US to China is beneficial to the Chinese but harmful to the Americans if we look at it from an employment point of view. It is beneficial to the Americans however if we look at it from an economical point of view because this results in consumer savings. This globalization phenomenon increases the importance of ethics. It is actually an intriguing situation because ethics in one country for a certain profession like engineering may be different than those in other countries.

4. ETHICS IN CIVIL ENGINEERING

The author is a civil engineer. This gives him some liberty to expand on ethics in this engineering field. Civil engineering is the oldest engineering discipline (Eide et. al., 1998). Further, as stated above, civil engineers are

the most visible engineers to the society (Burghardt, 1995). Their services include the design, construction, and maintenance of our infrastructure including buildings, bridges, tunnels, dams, and roadways. Based on the nature of their profession, civil engineers assume a great responsibility (Eide et. al., 1998). Further, civil engineers outnumber their engineering peers. In the US for instance, standing at the top of the list, 16% of all engineers are civil engineers (Graduate Engineering Magazine, 2006). All of this along with several high profile failure cases involving civil engineering works highlight the importance of ethics in this important engineering field.

More than one hundred people were killed and two hundred other individuals were injured in the infamous Hyatt Regency Hotel Collapse in Kansas City, Missouri, US in 1981 (Eide et. al., 1998). This became the greatest structural disaster in US history (Petroski, 1982). This tragedy occurred because the construction team made a seemingly harmful very simple change in the original design in a small walkway rod. Many law suits followed this accident and the contractors were found negligent and thus legally responsible for this tragedy (Eide et. al., 1998).

In August 2007, a bridge over the Mississippi River on Interstate Highway 35 in Minneapolis, Minnesota in the US made headline news when it collapsed, and as a result, thirteen people were killed in addition to more than one hundred injured individuals. The US government is suggesting that the bridge was not properly designed to start with.

More recently, a construction crane collapsed in New York City in March 2008 killing seven individuals and injuring more than twenty other persons. The authorities in New York have arrested an inspector alleging that he falsified inspection reports and records (Chan, 2008) although they have emphasized that this is not an established cause for the collapse.

Although these cases belong to the US, many other similar cases exist around the World. This is not the place to list such cases. The above three accidents were cited to highlight the importance of ethics in the field of civil engineering.

5. ETHICS IN ENGINEERING EDUCATION

Until recently, the topic of ethics was not included in engineering education in general. This is based on the opinion and personal observations of the author. It was left for the students to learn about ethics on their own after graduation. There might have been occasional but brief treatment of this subject in one way or another at some institutes of higher education. An increasing demand to include ethics in the engineering education prompted many universities and colleges to address ethics in their curricula. It has been finally realized that a formal education on this important topic is becoming an integral part of the engineering profession.

In its Criteria for Accrediting Engineering Programs, ABET actually mandates the inclusion of ethics in the engineering education process (ABET, 2007). Specifically, criterion 3(f) states: "Engineering Programs must demonstrate that their students attain an understanding of professional and ethical responsibility."

In its vision for educating the engineer of the year 2020, the US National Academy of Engineers specifically states that need for attaining the ability to understand and develop strong ethical standards (National Academy of Engineers, 2004).

6. HOW DO UNIVERSITIES TEACH ETHICS IN THEIR ENGINEERING PROGRAMS

The author looked at the ways in which universities and colleges treat ethics in their engineering curricula. An unofficial survey was made. Dozens of engineering programs were looked at. The sample is statistically small, but it was big enough to safely state that there is a large variance in which the topic of ethics is treated. This variance includes one extreme where engineering programs do not seem to treat ethics at all in the curriculum, to the other end of the spectrum where some engineering programs mandate their students to officially take a specific course on ethics. Many universities and colleges fall in between these two models.

The author found out that the majority of institutes of higher education do not make ethics a part of the curriculum. This is apparent from their list of courses in their study plan. This group includes Penn State University, the mother institute of the author, and Duke University among many other institutes of higher education.

A few engineering programs accept an ethics course as an elective. In this case a student can take such a course from other departments. However, some engineering programs offer this course as an elective to their students. A case in point is North Carolina State University. The Division of Multidisciplinary Studies at this institute offers the course MDS - 320: Ethics in Engineering to all engineering students.

It was interesting to find out that a specific engineering program requires a specific course of ethics from their students, perhaps, due to the compelling need of such a course. In this category, examples include the Biomedical Engineering Department at Oregon State that mandates the course BIO 420 - Social Ethics in Engineering from biomedical engineering students.

Another group of engineering programs include the topic of ethics in general engineering courses. For instance, the 4 credit course ENGR - 162- Introduction to Engineering at the University of Virginia explicitly contains the topic of ethics in its syllabus.

Some engineering programs mandate a specific course on ethics from their students. The best example perhaps is the University of Texas A&M. The engineering programs at this institute require their students to take the 3 credit course ENGR 482 - Engineering Ethics in their senior year. Outside the US, the Alhosn University in the United Arab Emirates requires its engineering students to take the course FA - 108 Ethics. It was found out that very few other programs follow this practice.

7. ENGINEERING ETHICS AT PENN STATE FAYETTE

Faced with a need to teach engineering students ethics but without the ability to devote a specific course for it, the author has to look for other options at Penn State Fayette, the Eberly Campus. The course ENGR 100S which is a one credit course has been modified over the past years to meet this challenge as well as other pressing issues. The topic of ethics has been established as an important component of this course. In this regard, the students are introduced to the concepts of ethics in engineering in addition to learning specific case studies where ethics are the focus of attention.

The author teaches several other introductory engineering courses like Statics, Strength of Materials, and Engineering Mechanics - Dynamics. These courses provide a great opportunity to discuss ethics in the profession. A few classes at an appropriate time are devoted totally to discuss ethics. . This treatment of ethics fits naturally and smoothly as the connection between ethics and several topics in these courses is emphasized and utilized. Further, the author teaches concrete and steel construction courses. The topic of ethics is easily treated

in almost any part of these courses. This is utilized and the students are taught and trained on this important part of the engineering profession.

8. A PROPOSED APPROACH TO ETHICS IN ENGINEERING EDUCATION

In the opinion of the author and based on his own teachings and his own observations, ethics should be included in the curriculum of all engineering programs at the beginning and at the end. A one credit common course on ethics should be given to all engineering students in their first year of education. This is to instill the importance of ethics in the engineering profession in these students at an early stage, and to start building a framework of ethics in their backgrounds. Engineering students take courses in general engineering in their second year and start to take courses in their specific majors in their third year. The fourth year is usually for elective courses specifically in the intended major. The best time to train engineering students about ethics in their specific major will then be at the final year. It is proposed that an additional different one credit course should be required at this year from each engineering student. As different disciplines have different sets of ethics, it is then appropriate that each discipline offers its own course to cover its own specific ethics standards and cases.

9. CONCLUSIONS AND RECOMMENDATIONS

Ethics is becoming increasingly important in the engineering education process. There is a demand to treat ethics in one way or another. Many institutes of higher education are taking this seriously and are including a treatment of ethics in their engineering curricula, but much more is needed in this area. The author believes that official courses on ethics have to be included in the curricula, but if this is not possible, a few other options should be utilized. Engineering students can be taught ethics in the introductory to engineering course if it exists or at least in other engineering courses as appropriate.

REFERENCES

- Costello, R.B.- Executive Editor (1993). *The American Heritage College Dictionary*, 3rd edition, Houghton Mifflin Company, Boston and New York, US.
- Fleddermann, C. B. (2004). *Engineering Ethics*, 2nd edition, Prentice Hall, Upper Saddle River, NJ, US.
- Burghardt, M. D. (1995). *Introduction to the Engineering Profession*, 2nd edition, Harper Collins College Publishers, NEW York, US
- Kosky, P., Wise, G., Balmer, R., Keat, W. (2006). *Exploring to the Engineering*, Academic Press, Boston, US.
- Zappa, Frank, Quote DB (2008), <http://www.quotedb.com/quotes/3644>, April 5, 2008. (date accessed)
- Wiewiora, J. (April 2005). "Involvement of Civil Engineers in Politics". *Journal of Professional Issues in Engineering Education and Practice*, Vol. 131, Issue. 2, pp 102-104.
- Eide, A. R., Jenison, R. D., Mashawa, L. H., Northup, L. L. (1998). *Introduction to Engineering Design and Problem Solving*, 2nd edition, McGraw Hill, NY, US
- Editor. (Fall 2006). "Stats Class". *Graduating Engineers and Computer Careers*, p. 16.
- Petroski, H. J. (1982). *To Engineer is Human*, St. Martin's Press, New York, US.

Chan, S. (2007), “*City Inspector Is Charged in Crane Collapse Case*”, The New York Times, March 20, 2008 issue.

ABET (2007). *Criteria for Accrediting Engineering Programs*, ABET Engineering Accreditation Commission, Baltimore, MD, US.

National Academy of Engineering (2004). *The Engineer of 2020*, The National Academy Press, Washington DC, US

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