ENGINEERING ETHICS AND THE NEXT GENERATION OF ENGINEERS

Professors K. Markowitz, H. Marandi
New York City College of Technology
300 Jay Street Brooklyn, NY 11201

In this era of constant change, uncertainty, and accountability, the engineers of the 21st century must demonstrate a practical understanding of engineering ethics both in the workplace and in daily activities.

The highest professional behavior is demanded for all personnel involved in engineering technology. It is the engineers and technicians who will design, build, and monitor future systems used by the public. These systems must follow strict safety and environment standards. The future existence of our present civilization depends on proper and prudent engineering decisions, as well as strict adherence to a code of ethics for all technologists to follow.

The technologist of the twenty-first century must perform his or her services in accordance with the highest principles of ethical conduct to maintain high standards of integrity, public safety, health, and the general welfare of the public.

Until quite recently, engineering education has not emphasized the importance of ethics as part of the curriculum. However, as of October, 2004 the Accreditation Board of Engineering Technology now requires graduate technologists and engineers to demonstrate a practical understanding of "ethical and social responsibilities" in the engineering profession and practice (1) per criterion 2i and 2j of the current ABET Criteria.

Thus in effect, ABET is taking a position that students need to begin to think about ethical issues in engineering before things go wrong. Just as good health habits minimize the need for more serious medications later on, preventive ethics (2) may minimize or even avoid painful consequences in the future. The intent of this paper is to discuss how engineering faculty may accomplish this goal.

As educators, it is our responsibility to emphasize ethics as part of any technology program. A strong technology program rich in ethics, and carefully guided by significant psychological and philosophical principles will prepare technical graduates with a proper moral and analytical foundation to perform their duties.

By introducing ethics into the curriculum, we help students to stimulate their moral imagination, sharpen their critical thinking skills, and sensitize them to their professional responsibilities to the public.

With this in mind, a one-semester course in engineering ethics should include case studies (actual or hypothetical) covering the following topics.

- Need for engineering ethics
- Codes of ethics
- Ethical behavior in academia
- Moral thinking and moral problem solving
- Risk, safety, and liability in engineering
- Employer/employee relationships
- Obligation to clients
- Ecology and environmental concerns
- Defense industry problems
- National security concerns
- Bio ethics
- Promoting and enforcing ethics.

Engineers, like most professionals, are interested in solving real world problems. Theory of course in an important foundation, but an important way to get the attention of students is to focus on practical cases. Case studies taught in the curriculum must include scenarios that engineers are most likely to encounter in their own careers. As with law and medicine, engineering is a learned profession. As a profession, engineering constantly involves expert judgment and discretion in the performance of services. Engineers are expected to use their education and training in a manner supports public health and safety.

You may ask "why does engineering ethics need to be taught at all? Most people reach their ethical maturity by 18 years of age. What difference could a college course in ethics make?"

One answer has to do with the increasing complexity of engineering design components. In the old style small engineering shops of the 19th century, one individual usually played the roles of designer, business manager, salesperson, and service manager. Today, each of these functions, as well as many others, is done by separate organizations in a typical company. Issues of safety, liability, and business integrity can easily get lost even when all individuals are doing their assigned jobs. While in college, if engineers learn how organizations work, and study case reports of how well-intentioned designers made terrible ethical choices, they will be cognizant of similar situations in their future workplaces. Additionally, case studies are extremely important for engineers who aspire to management positions. Many, if not most, of the issues faced by engineering managers have ethical dimensions. Engineering managers must make decisions based on constraints, and a sound code of ethics.

An engineering ethics course may be classified for ABET purposes as part engineering science and part ethics. It is generally advisable to develop and teach this course at the upper division level in order to incorporate and build on concepts and knowledge students have acquired in other areas of the curriculum. This includes such topics as critical thinking, problem solving, and consideration of realistic constraints, safety, environmental concerns, esthetics, economics, etc.

Another method for students to learn ethics is to integrate an engineering ethics course into other courses in the curriculum. For example, select problems from an engineering economics course and embed engineering ethical constraints. A practical example of an embedded ethical problem using engineering economics is provided below.

(3) A small dam is being planned for a river tributary that is subject to frequent flooding. From past experience, the probabilities that water flow will exceed the design capacity of the dam during a year, plus relevant cost information are as follows:

Design of Dam	Probability of Greater Flow During a Year	Capital Investment
A	0.100	$180,000
B	0.050	$195,000
C	0.025	$208,000
D	0.015	$214,000
E	0.006	$224,000

Estimated annual damages that occur if water flows exceed design capacity are $150.000, $160,000, $175,000, $190,000, and $210,000 for design A, B, C, D, and E, respectively. The life of the dam is expected to be 50 years, with negligible salvage value. For an interest rate of 8% per year, determine which design should be implemented. What ethical considerations might be important to the selection? Performing a present worth analysis of each dam design yields the following results:

Design of Dam	Annual Expected Cost of Damage	Present Worth Analysis
A	$15,000	$363,503
B	$8,000	$292,868
C	$4,375	$262,522
D	$2850	$248,865
E	$1,260	$239,414

Clearly students can reason that the safest, most economical dam to build resulting in minimum loss of human life, if a devastating flood was to occur, is design E. If students also performed a benefits/cost analysis, design E would yield the highest benefits/cost ratio.

Another example of a design involving ethics is the design of an automobile bumper that can be easily recycled. There is a movement called design for the environment (DFE) or "green engineering" that advocates prevention of waste, improved material selection, and recycling of resources.

The authors conclude with these thoughts. Engineering ethics is an analysis of morality that can be theorized and systematized and taught through reason and logic. We can learn the principles of ethical theories and then apply them to practical situations. Most technologists plan to do their jobs ethically. However, in today's complex engineering world, good intentions are not enough. Although what we ultimately do depends on our sense of morality, engineering

ethics allows the technologists to better understand our values and the ramification of our actions. In the past, engineering ethics may have been a luxury. Let us hope that in the future it becomes a necessity for all.

(1) ABET Criteria for Accrediting Engineering Programs 2004-2005 Accreditation Cycle
(2) *Engineering Ethics*, Harris, Pritchard, Robins, 1995
(3) *Engineering Economy,* Degarmo, Sullivan, Wicks, 1997

Authors

Professor Kenneth Markowitz
New York College of Technology ET Dept.
186 Jay Street
Brooklyn, NY 11201

Professor Hamid Marandi
New York College of Technology ET Dept.
186 Jay Street
Brooklyn, NY 11201