Ethics for engineers falls in an unstructured gray zone

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Unlike many principles of engineering, ethics is not easy to structure or to teach. Merraim-Webster's Dictionary of English Usage defines ethic as "pertaining to morals" and ethical as "in accordance with the rules or standards for right conduct or practice, especially the standards of a profession."

A profession is a learned occupation requiring systematic knowledge and training as well as a commitment to a social good. Engineering is the creative art of applying science for the benefit of all mankind and therefore is a profession.

Because engineering is a profession, engineers must consider the impact of ethics in their behavior. The design and application of technology include the responsibility to provide quality products and services. Professional engineering includes the responsibility of creating a positive impact on society and the quality of life.

Ethical dilemmas

Solutions to ethical situations are seldom black or white issues. More often, they are shades of gray with no single right or wrong answer. In such dilemmas, engineers must search for their best personal solutions. In some cases, we need to ask not only can it be done but should it be done.

Many options will have equally important results. Various interest groups may be impacted differently but in important ways. In making ethical decisions, engineers need to be sensitive to how their decisions will affect others.

Technology impact

As the impact of technology continues to expand, the discomfort level of the nontechnical world continues to increase. Society has a high level of expectation for the performance and safety of our technical products and services. Because the general public often does not understand technology, they put their trust in those who provide it.

This trust places a greater responsibility on the engineering profession to assure personal safety and national security. This underscores the need for engineers to understand ethical behavior and to establish ethical conduct as a foundation of their career. In fact, engineering ethics is as important to good engineering practices as mathematics, physics, design skills, and other engineering fundamentals.

Professional codes of ethics

Professional engineering organizations such as the IEEE have developed codes of ethics as a guide for their members.

The preamble to the IEEE Code of Ethics indicates the importance of the application of technology on the quality of life throughout the world. This identifies the need for members of this profession to accept a personal obligation to provide the highest ethical and professional conduct to the communities in which they serve.

Most corporations have included ethical practices in their formal or informal operating practices. These may be found in corporate objectives and goals or may be more informal in the established culture of the company. Engineers should determine the ethical attitude of their corporation during job interviews and early in their career.

To assure that their ethical practices are followed, many corporations have established procedures for employees to discuss ethical situations with higher management. This may take the form of an identified individual in the Human Resources Department as the first contact. Also, it may include a formal procedure to discuss ethical situations with the immediate supervisor and, if necessary, higher levels of management.

The third, and perhaps the most important, code of conduct is based on personal values. These values are established throughout our lives, starting with the impact of our family and faith.

Personal values should be considered when selecting our employers. It is better to

0278-6648/06/$20.00 © 2006 IEEE

avoid potential conflicting situations by selecting jobs with corporations whose products and/or services are compatible with our personal values.

Personal values should be used to judge our involvement in ethical dilemmas in our career. These values are an important foundation during our identification and participation in the solution of an ethical problem.

Engineers' ethical responsibilities

Because ethical questions can place individual values in opposition to corporate goals, several steps should be taken to prepare for ethical dilemmas. These include:

1) understanding the basics of engineering ethics

2) reviewing personal values associated with engineering ethics

3) developing awareness of ethical concerns

4) learning to identify early signs of ethical situations

5) applying engineering principles to determine appropriate solutions.

Engineering process for ethical situations

In solving a technical engineering problem, the most important step is to first identify all known quantities. This is also the most important step in addressing an ethical situation. Often, a situation may appear to be unethical based on preliminary or superficial information. This may come from comments of coworkers or casual observation.

It is dangerous to make hasty judgements about an ethical situation without first determining all the facts. If a situation appears to be unethical, start by obtaining quantitative information. In addition, request the opinions of others involved to assure the situation is being properly assessed. Be sure to keep detailed documentation of this process for future use.

During the information gathering process, avoid stating or implying that this situation is unethical. A decision on the ethics of a situation should only be made after all information has been gathered. If a situation turns out to be ethical although initial statements indicated otherwise, the person making those statements may damage their reputation and career.

If sufficient information leads to the conclusion that this is an ethical dilemma, then the engineering principles of evaluating various options should be used. If possible, solicit the assistance of others who can be trusted to keep the evaluation process confidential.

For more complex ethical dilemmas, it may be appropriate to form a team of associates to review as many options as possible and consider the consequences of each. Typically, this will reveal negative and positive impacts on various individuals or groups and result in a better solution for most stakeholders.

Because many options will have tradeoffs, it is often difficult to select the best solution. This process requires a careful review of records made during the discovery process. In many instances, personal values are the final authority in making the decision to bring the situation to the attention of the proper people.

When the decision is made to discuss an unethical situation with others, it should include recommendations for an action plan to remedy the dilemma. These recommendations should be based on as many facts as possible, not just personal feelings or unsubstantiated comments from others.

Although ethical behavior is based on personal values, there are guidelines to help professional engineers make ethical decisions. These decisions may not be easy, and their results can have negative impacts on our careers. However, to be professional, engineers must accept the responsibilities associated with ethical behavior and the relationship of their work to the overall society in which they live. The time to start developing ethical attitudes and skills to handle future ethical situations is during the undergraduate education process.

Teamwork is a resource for ethics and professional issues

Teamwork is a powerful tool for technical professionals, and teams often replace individuals as the primary unit of operation. This is especially true in the more innovative organizations in business, industry, government, research, and academia. Teams can also be an important resource when facing an ethical dilemma.

Chacteristics of a successful team

A successful team is a unified group of individuals with special and unique talents that work together to achieve

The IEEE Code of Ethics

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members, and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree

1) to accept responsibility in making engineering decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment
2) to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist
3) to be honest and realistic in stating claims or estimates based on available data
4) to reject bribery in all its forms
5) to improve the understanding of technology, its appropriate application, and potential consequences
6) to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations
7) to seek, accept, and offer honest criticism of technical work, to acknowl edge and correct errors, and to credit properly the contributions of others
8) to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin
9) to avoid injuring others, their property, reputation, or employment by false or malicious action
10) to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

—Approved by the IEEE Board of Directors, August 1990

common objectives. Strong and effective teams blend the various abilities and strengths of each individual to accomplish a greater result than merely the sum of individual contributions. Characteristics of successful teams include

- clear objectives
- strong leadership and appropriate roles for all members
- good communication and trust and openness to new ideas
- cooperation and the ability to deal with conflict
- the ability to balance innovation, quality, speed, and cost effectiveness.

Team development process

A) Forming

- Team is established and members become acquainted with each other.
- Personal information or agendas usually remain hidden.
- Team establishes mission and project goals.
- Team establishes ground rules and identifies member roles.

B) Storming

- Individuals introduce their ideas and goals.
- Members listen to other ideas and determine their value.
- Members assert own ideas and question or challenge ideas of others.
- Ground Rules need to be followed to minimize chaos.

C) Norming

- Team leader takes control and moves team into a cooperative mode.
- Hidden agendas may be disclosed to solicit support.
- Individuals begin to compromise to arrive at a team solution.
- Team solution is clarified and members identify assignments.

D) Performing

- Group becomes committed to achieving goals and completing mission.
- Members review assignments and start work in a cooperative spirit.
- Leader reviews work progress and encourages completion.
- Team communicates results to appropriate management levels.

For additional information relating to ethics visit <http://www.ieee.org/portal/site> and search for ethic links.

About the author

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Gamesman solutions

Problem 1

You can see how this works if you just write out the operations.

Problem 2

Let x and y be the numbers of pens priced at € 9.5 and € 5.5 . Then

$$9.5x + 5.5y + 0.5(100 - x - y) = 100$$

or

$$y = \frac{50 - 9x}{5}.$$

A little thought shows that the only positive integral values of x and y are 5 and 1. The number of pens priced at € 0.5 is

$$100 - x - y = 94.$$

Problem 3

Starting with one piece containing N squares, each break increases the number of pieces by one. So to get N pieces, we need $N - 1$ breaks.

Problem 4

If Bulb 4 is removed, the resistance between nodes A and B increases. The current in the remaining circuit decreases, so Bulb 1 gets dimmer. Since more of the applied voltage is now across Bulbs 2 and 3, they get brighter. If this qualitative explanation isn't clear, do some calculations.

Problem 5

If you put any number of zeros after an integer and divide by 9, the remainder is always the same. For example,

$$(800/9) = (88)(9) + 8$$
$$(80/9) = (8)(9) + 8$$
$$(8/9) = (0)(9) + 8$$

Let's choose a number, say 863, and write it as

$$863 = 800 + 60 + 3$$
$$= [(88)(9) + 8] + [(6)(9) + 6] + [(0)(9) + 3].$$

Notice that the sum of the remainders is $8 + 6 + 3 = 17$. Now let's scramble 863 to 386 and write

$$386 = 300 + 80 + 6$$
$$= [(33)(9) + 3] + [(8)(9) + 8] + [(0)(9) + 6].$$

The sum of the remainders is still 17, because it doesn't matter how many zeros we put after each of the three digits, 8, 6, and 3. So the difference $863 - 386$ has no remainder and is therefore a multiple of 9.