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INŽENJERSKA ETIKA U PROCESU RJEŠAVANJA PROBLEMA

ENGINEERING ETHICS IN THE PROCESS OF PROBLEM-SOLVING

Marijana Kolednjak, Ivana Grabar

Stručni članak

Sažetak: *Znanost i tehnika, kao pokretačke snage mnogih promjena, izazivaju kako znanstvenike tako i inženjere da sve više razmatraju etiku. Njihov svakodnevni rad podliježe etičkom vrednovanju budući da aktivnosti u kojima su angažirani uključuju rad s ljudima i za ljude, te se tako nalaze u situacijama u kojima je potrebno donositi etičke odluke. Inženjeri često izražavaju značajne razlike u mišljenju kada su suočeni s predmetima koji zahtijevaju etičko rješenje. Ovo rješenje može se postići pomoću modela rješavanja problema koji je predstavljen i raspravljen u ovomu radu. Model od pet koraka može se primijeniti u različitim stručnim okolnostima. Autori su tako uzeli u obzir razliku između etike i morala s obzirom na različite kontekste u području inženjerstva. Djelovanje jedne osobe može utjecati na opću prirodu i smjer djelovanja u društvu i njegove moralne standarde, a kojih bi inženjeri trebali biti svjesni kada se bave etičkim dvojbama.*

Ključne riječi: *etika, inženjerstvo, rješavanje problema*

Professional paper

Abstract: *Science and engineering, being the driving forces of many changes, challenged both the scientists and engineers to start taking ethics into consideration. Their everyday work is subject to ethical evaluation because the activities they are included in involve working with and for people and thus making ethical choices. Engineers often express significant differences of opinion when faced with cases requiring an ethical solution. This solution can be achieved by using the problem-solving model presented and discussed in this paper. This five-step model can be applied in various professional settings. The authors have also taken into consideration the difference between ethical and moral given the different contexts in the field of engineering. The actions of one person can affect the general nature and direction of actions in a society and its moral standards, which engineers should be aware of when dealing with ethical dilemmas.*

Key words: *engineering, ethics, problem-solving*

1. INTRODUCTION

Engineering has made an enormous contribution to providing the material wellbeing that promotes human flourishing. The everyday benefits of engineering include the provision of energy, clean water, sanitation, hygienic food production, pharmaceutical manufacture, buildings, transport, communications and computers. Many of these benefits have become so closely integrated with our everyday life that we are often unaware of our dependence on them until a failure occurs [1].

Science and engineering are the driving forces for the majority of changes witnessed in the 20th century. They require a critical mind that is free of prejudice and open to new ways of thinking, with the capability of investigators to apply honest principles. Since the rapid development of modern science and engineering began during the Renaissance, at the beginning of the 19th century, there was a remarkable rise in academic research at universities. Scientists and engineers have become increasingly interested in questions of ethics, even though they differ regarding the practice applied (scientists explore the natural world discovering new knowledge while engineers apply that knowledge to solve practical problems, often with an eye toward optimizing cost, efficiency, or other parameters). Ethics deals with values, good and bad, and right and wrong. Both scientists and engineers cannot avoid not being involved in ethics, for what they do and what they do not do is always subject to ethical evaluation.

In conventional English usage, the designation *ethics* is to a large extent used interchangeably with the designation *morality*. The origin of the word *ethics* lies in the Greek *ethikos* referring to ethos, that is, distinctive character, spirit or attitude. *Morality* comes from the Latin *moralis*, especially as used in Cicero's translations and commentaries on Aristotle, and is more concerned with which actions are right or wrong [1]. Taking this into consideration, ethics is the study of goodness and rightness [2]. Ethics at its core is about how we relate to others. In such relationships, problems may arise for several reasons, including limited resources and limited sympathy generating competition and conflict rather than mutually beneficial cooperation; limited agreement on

goals and different conceptions of *good*; inadequate rationality, insufficient information and limited understanding; poor communication [1]. Life is complex. Ethics and engineering are complex, too.

The realm of ethics is concerned with standards and requirements for socially acceptable behavior, in addition to following proper procedures for getting things done at any level of interaction – individual, group, organizational, community, governmental or regional.

Various types of professionals, including engineers, often express significant differences of opinion when faced with cases requiring an ethical solution. Scientific and engineering disciplines are considered to be highly ethical professions in which scientists and engineers exhibit behavior of the highest ethical and moral standards [3].

What is the right thing to do in circumstances involving ethical issues in the engineering profession? There are many perspectives that this question can be considered from. For example, from an economic perspective, the right thing to do is whatever is the most profitable; or, from a personal interest perspective, the right thing to do is whatever maximizes one's own wellbeing. Besides the aforementioned perspectives, there may be other ones such as religious, political, social, etc. However, the perspective to be considered in this article is the moral, or ethical, perspective. We want to know what is the morally correct, or right thing to do when faced with situations involving questions of right and wrong, good and evil, virtue and vice.

2. THE FRAMEWORK OF ETHICS

Ethics is based on feelings and instinct, which provides information that allows ethical choices to be made. In addition, ethics does not necessarily involve following cultural law. Some cultures may be ethical while other cultures are corrupt or ignore ethical concerns – following the old adage, *when in Rome, do as the Romans do*, is not a satisfactory ethical standard. On the other hand, ethics provides many reasons for how scientists and engineers *ought* to act [3]. One of the hurdles of applying ethics to science and engineering is to find the correct place to start.

Ethics (morality) is a core branch of philosophy that attempts to define right and wrong; what a scientist does. In philosophical studies, ethics is usually divided into three sub-fields: meta-ethics, normative ethics, and applied ethics. *Meta-ethics* includes investigation of whether or not ethical claims are capable of being true or false, or if they are expressions of emotion. *Normative ethics* attempts to arrive at practical moral standards that would tell, for example, the scientist or engineer what is right or what is wrong. *Applied ethics* is the application of theories of right and wrong and theories of value to specific issues such as honesty and lying [3].

It is clear that:

1. scientific and engineering ethics (morality) require a *human agent* (the scientist or engineer) to carry out the actions and often, but not always, also a human as the recipient of the action;
2. the moral action requires the capacity within the scientist or engineer to reason with the actions, and then understand whether such actions are ethical or unethical (moral or immoral); and
3. the scientist or engineer must be responsible for his actions and have the freedom – in some cases it is designated as *academic freedom* – to act otherwise.

3. ETHICAL TERMS AND DEFINITIONS

In contemporary literature, for example, in W. K. Frankena [4] and J. Rawls [5], the term 'ethics' often refers to reflective and theoretical perspectives of right and wrong, what dictionaries call *moral philosophy*. It also refers to the system or code of morals practiced by a particular person, group, or profession. The term morality refers generally to actual principles of conduct practiced by individuals or groups of individuals or to ethics. Because of the obvious overlap in the meaning of these terms, we generally find both being used interchangeably in the literature [6]. For this reason, the words morality and ethics will be treated as synonyms in this article.

In their broadest and most familiar meaning, morality and ethics are concerned with many forms of belief about good and bad, right and wrong, appropriate and inappropriate human behavior, rights, virtue, and vice. Morality and ethics are studies of what we *ought* to do and how we *ought* to behave from a moral viewpoint, as opposed to an economic, religious, political, or prudential viewpoint. From these perspectives, what we ought to do may be very different from what we ought to do from a moral perspective. For example, if one wants to get to an important interview on time, it might be prudent to exceed the speed limits while driving to one's appointment. In this case, he or she ought to speed. However, if it is morally wrong to speed, then the moral thing to do is not to speed. In this case, *there is a* difference between what a person ought to do morally, the so-called *moral ought*, and what he or she ought to do to further some non-moral goal (such as an economic goal), which is sometimes referred to as the *prudential ought* [6].

The kinds of situations that are particularly challenging in ethics are those that involve an *ethical dilemm*a. An ethical dilemma exists whenever moral reasons or considerations can be offered to support two or more opposing courses of action. For example, respect for individual self-determination could be offered as a moral reason to support a person's decision not to wear seatbelt while respect for the value of human life might be used to support, or justify, mandatory seatbelt laws [6].

4. PROBLEM-SOLVING IN ETHICS

Problem-solving that may be needed when dealing with various ethical issues can be approached by using a five-step model. This model can be applied in various professional settings as it is displayed in Figure 1.

According to Humphreys [6], these five steps are as follows.

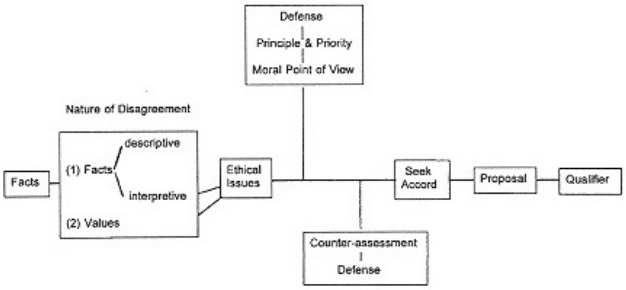

Figure 1. Problem-solving in ethics

By formulating the exact nature of the ethical problem or dilemma as the first step of the model proposed, we would be able to recommend a solution or give advice relevant to the interested parties.

In the next step, we identify the facts that we have and gather all the relevant facts available and make sure we understand them. This will enable us make an informed decision relevant for the case. Nevertheless, adequate knowledge of the facts is no guarantee that a morally appropriate decision will be reached. However, anything less would make the decision-making process both arbitrary and impertinent. Another reason is that sometimes a problematic looking issue is not really a disagreement over sensitive moral issues or values but a disagreement over the *descriptive nature of the facts*. These are the cold, hard facts, such as whether it is raining today in Zagreb or not, that we have to interpret in terms of certain moral values and genuine beliefs that we have, which is consequently morally debated.

The third step is used to assess the strengths and weaknesses of competing moral viewpoints as carefully and critically as possible by making the best possible case for them and defending them as thoroughly as possible. The reasons that have been offered must be ultimately justified. Moral reasoning is what forces us to consider the interest of others as equivalent and sometimes prior to our own interests. Morality on one side and prudence and self-interest on the other side sometimes do not coincide precisely because morality generally imposes obligations to promote the interests of others over one's own interests. Truth telling, for example, is a moral duty that imposes an obligation to tell the truth even though one's personal ends might be better served by lying. In other words, we are attempting to justify our position by offering a solid defense grounded in compelling reasons.

Case ethics requires immediate reaction/decision since there is no time for leaving the problems unsolved. The following step is taking a stand since the competing positions have been considered. The practical issue that arises is how to decide which of the competing moral viewpoints is the most compelling or most correct. For example, if an individual is making a decision, it will be a personal estimation, no matter how good it is. However, when a committee is making a decision, it is likely to be decided by a vote of all the committee members, which makes it less personal and biased.

Because a consensus is sometimes not unanimous, committees must qualify the recommendations they make by describing the level of consensus achieved, which means the final, fifth step has been taken.

5. WHAT IS THE ISSUE?

At its best, engineering changes the world for the benefit of humanity. However, there are significant imbalances in the application of engineering knowledge. In some instances, appropriate technology is available but is not being applied.

A prominent example is water treatment. The provision of drinkable supplies through more effective management and treatment of freshwater resources and through desalination of sea and ground water is one of the most significant challenges that the world is faced with. Appropriate water management and treatment processes, both simple and advanced, are available. Therefore, it might be expected that the design, installation and operation of such processes would be accepted as being unequivocally good and would be given the highest priority. However, this is not the case. As a result, 2 billion people are affected by water shortages in over forty countries, 1.1 billion people do not have safe drinking water and 2.4 billion have no provision for sanitation. The consequences are severe: it is estimated that 25,000 people die every day from water-related hunger (some specifically from thirst) and that 6,000 people, mostly children under the age of five, die every day from water-related diseases [7].

6. PRACTICAL OUTCOMES

What is obviously ethical and moral in one context may be quite the opposite in another. In engineering, the distinction between black and white is often even less clear. Engineers operate in a multinational, multicultural business environment in which what is considered moral and ethical often varies from one location to another. In some cultures it is legal and morally acceptable business practice for substantial gifts to be exchanged between those desiring to do business in that area and those seeking to have the work done. In Western cultures, this is considered to be bribery and is illegal.

Clearly, ethics is not black or white – it is many shades of gray depending upon the given situation. Nevertheless, engineers do have guidance in determining what ethical standards they should apply to their life and work applying the codes of ethics of their professional societies. For the engineer, these codes define what is acceptable and what is not. They define what engineering ethics is and what it is not. Every engineer and engineering student should become thoroughly familiar with the code of ethics of his or her disciplinary engineering society [6].

7. ETHICAL CHALLENGES IN ENGINEERING, CONSTRUCTION, AND PROJECT MANAGEMENT

According to Humphreys [6], the myth of amoral business persists and indeed a common observation is that the phrase *business ethics* is an oxymoron. But such a view is dependent on the subjugation of personal interests that insist on business people acting under the guidance of a moral philosophy that is often contrary to business itself.

Humphreys states that the nature of projects themselves presents many ethical concerns. First, in the project initiation and feasibility stage, there are concerns about such things as falsification of estimates, invalid requests for proposals that are really only an effort to obtain project ideas, and concerns about the ethical responsibilities of external consultants.

Then, when the project progresses to the planning and organization stage, many more areas of ethical concern arise such as bid rigging (which involves divulging of confidential information to some bidders in an effort to influence the amounts of the bids or to give some bidders an unfair advantage over other bidders), low balling (contractors attempting to buy the project by bidding low in the expectation of recovering any costs via subsequent change orders, contract renegotiations, or simply by cutting corners), bribery (particularly in international project work), firms declaring their capability to perform while not truly being able to do so, falsified estimates of cost and schedule, discrimination in hiring, and many others.

In the implementation and execution phase many additional concerns may arise including padding of expense accounts, using substandard materials, compromising health and safety standards, withholding information from clients, owners, or superiors, etc.

Finally, at project closing, problem areas such as failing to honor commitments to project personnel, failure to recognize or admit project failure, and sloughing off to protect one's position can occur.

Ethical dilemmas are common for engineers, project managers, and construction managers. Among those identified in discussions with a number of project professionals are:

- being offered gifts from contractors or vendors
- pressuring to alter status reports with backdated signatures or faded documents to mask reality of project status
- compromising quality
- falsifying reports of charges for time and expenses
- lowering the quality of communication with co-workers and management and clients
- abusing power and openness and transparency of information.

8. CONCLUSION

Personal thoughts and behavior can override the influence of any other factor, including the Codes of Ethics of professional bodies. The ability to manage emotions during the processes of scientific and engineering research orients many individuals to act on feelings and engage in unethical practices. This is reflected in the increasing frequency of reports of misconduct in the scientific and engineering disciplines [3].

Indeed, the actions of one person can have an impact on the actions of others and, as such, the general nature and direction of actions in a society may affect the choices of others and their level of consideration for moral standards. Such actions influence concerns for the common good, levels of egoism and altruism, and the eventual emergence of rights, duties and entitlements.

Engineers should place service before profit, the honor and standing of the profession before personal advantage, and the public welfare before all other considerations.

Professionalism is not a visual appearance or a facade one puts on to impress others, nor is it a masochistic desire to sell your soul to the company store. Instead, it is an attitude, a desire to do a good job, to do it in an ethical and cost-effective manner, to strive to do an even better job in the future, to continue to educate yourself and expand your scope of knowledge, and to assist others who come along behind you to emulate what you do and know and to do it better for the benefit of future generations [6].

The continuity of civilization depends on people, i.e. scientists and engineers, interacting in a genuinely ethical manner.

Ethics has sometimes been viewed by engineers as a somewhat arcane theoretical aspect of philosophy having little relevance to their practical activities in the world. However, ethics is in essence practical, for the way in which we choose to act and live is the primary objective of such analysis and contemplation. Ethical decisions, like engineering decisions, may have significant consequences for human wellbeing [1].

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Kontakt autora:

Marijana Kolednjak
Sveučilište Sjever
Sveučilišni centar Varaždin
104. brigade 3
42000 Varaždin
e-mail: mkolednjak@unin.hr

Ivana Grabar
Sveučilište Sjever
Sveučilišni centar Varaždin
104. brigade 3
42000 Varaždin
e-mail: igrabar@unin.hr