

# Chapter 21

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## Ethics

### INTRODUCTION

The primary responsibility of an engineering professional is to protect public health and safety. However, engineering professionals also have a responsibility to their employers or clients, to their families, to themselves, and to the environment. Meeting these responsibilities will challenge the practicing engineer to draw upon a system of ethical values.

Well, what about ethics? Ethics means “doing the right thing” as opposed to “what you have the right to do.” But doing the right thing is not always obvious or easy. In fact, ethical decisions are often difficult and may involve a certain amount of self-sacrifice. Doing the right thing for a practicing engineer can be especially challenging. Furthermore, the corporate and government world has confused this concept by developing ethics programs that emphasize only what you have the right to do. An organization, for example, may have a list—often called a Code of Ethics or Code of Conduct—of what an employee can and cannot get away with. Employees are required to sign an acknowledgment that they have read and understood the list. The company unfortunately calls this “ethics training.”<sup>(1)</sup>

One difficulty in some situations is recognizing when a question of ethics is involved. Frequently, in the area of environmental management, a breach of ethics involves a practice that endangers public health and safety or covers up a violation of a rule or regulation. Occasionally, however, a breach may involve a case of the exact opposite. This might seem an unlikely scenario. How can someone be too honest, too caring, or too professional?

Regarding the above, one example is lying to save a life. Suppose you are standing on a street and a woman runs past you chased by two men. She screams, “They are trying to attack me!” as she dashes into the entry of a building around a corner. The men ask you, “Which way did she go?” What do you tell them? Clearly, the right thing is to lie. In this case, the value of caring overrides the value of honesty. This situation is exaggerated to illustrate that sometimes it is appropriate to violate certain values to protect public health and safety. In doing the right thing, ideally one should not have to make snap decisions and should take the time to

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*Mass Transfer Operations for the Practicing Engineer.* By Louis Theodore and Francesco Ricci  
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investigate all of the facts, e.g., whether or not the woman was a thief and the men were police.

Sometimes one must decide how much to sacrifice to ensure public health and safety. In establishing environmental regulations, the regulating agency must decide how safe and how stringent to make the regulations. For example, in the case of air toxic regulations, one standard may result in 10 cancer cases per one million people. But why isn't it for one or none? Who should decide?<sup>(2)</sup>

This chapter, in line with its title, addresses ethics and ethical issues relevant to the practicing engineer. Topics covered include:

- Teaching Ethics
- Case Study Approach
- Integrity
- Moral Issues
- Guardianship
- Engineering and Environmental Ethics
- Future Trends

The chapter concludes with three Illustrative Examples in the mass transfer arena. These case studies have been primarily drawn from the work of Wilcox and Theodore.<sup>(3)</sup>

## TEACHING ETHICS

Professionals are often skeptical about the value or practicality of discussing ethics in the workplace. When students hear that they are required to take an ethics course or if they opt for one as an elective in their schedules, they frequently wonder whether ethics can be taught. They share the skepticism of the practitioners about such discussion. Of course, both groups are usually thinking of ethics as instruction in goodness, and they are rightly skeptical, given their own wealth of experience with or knowledge of moral problems. They have seen enough already to know that you cannot change a person's way of doing things simply by teaching about correct behavior.

The teaching of ethics is not a challenge if ethics is understood *only* as a philosophical system. Parks<sup>(4)</sup> notes that teaching ethics is important but “if we are concerned with the teaching of ethics that is understood as the practice of accountability to a profession vital to the common good, the underlying and more profound challenge before all professional schools [and other organizations] is located in the question—How do we foster the formation of leadership characterized, in part, by practice of moral courage?”<sup>(4)</sup>

Moral courage requires knowing *and* acting. College and university educators, as well as those charged with ethics training in the private sector, develop a sense of uneasiness when topics such as “fostering leadership formation,” “moral courage,” or “knowing *and* acting on that knowledge” are mentioned. Such terms resurrect images of theological indoctrination, Sunday school recitations, or pulpit sermonizing.

These images contrast sharply with what the present-day professor envisions as the groves of academic freedom and dispassionate analysis. Perhaps out of fear of disrespecting the dignity of students and devaluing their critical reasoning powers or their ability to understand where the truth lies, faculty will take a dim view of academic goals that go beyond those strictly cognitive. The consequence of such values among the professoriate is the further erosion of a moral commons where an agreed-upon set of values and beliefs allows for discourse on ethics. Of course, the erosion has continued steadily from the inception of the Enlightenment Project in the seventeenth century until the present day wherever industrialized and postindustrialized societies have been subject to rapid cultural, economic, political, and technological change. It is not simply an erosion in the realm of higher education. Practitioners in the engineering and scientific communities experience the same erosion of the moral commons taking place in society as a whole.

The authors are certainly in agreement with their colleagues in higher education and those who do ethics training in the private sector, that individuals are not to be manipulated or indoctrinated. However, they are also convinced not only that students and other participants in ethics analysis must have a body of knowledge but also that they have a responsibility for the civic life of American society. Such responsibility requires leadership, moral courage, and action. Of course, none of these characteristics can be demanded or forced, only elicited. That is the great, yet delicate challenge facing the professoriate and all those charged with ethics training in other sectors. Eliciting a sense of civic responsibility as a goal of ethics analysis can be realized only as a derivative of cognitive processes and not as a direct goal. In sum, the formation of personal character and the practice of virtue are not to be subject to external control and the diminution of individual freedom through manipulation or indoctrination.

## CASE STUDY APPROACH

The authors believe that the case study method is a valuable way to take seriously Parks's response to the question "Can ethics be taught?" They also consider the method an important tool in investigating the relationship among assumptions, values, and the moral life, as well as ethical reflection on those three aspects of life. The authors are convinced that the case study method is one of the most useful ways of teaching ethics and of achieving the goals of ethics education outlined by the Hastings Center.<sup>(5)</sup>

- 1 *Stimulating the moral imagination.* The concreteness of the case study appeals to the learning style of most people. While a certain amount of ambiguity is essential to evoke interest and discussion, it is also a stimulus to enlivening the knowledge. Hopefully, the participant will begin to appreciate the moral complexity of a situation that in the past might have been thought of only as a technical or managerial problem. Practice in the art of case discussion has the larger intent of leading the individual to bring an ethical frame of reference to bear on the variety of problems faced in the discipline studied. Stimulating

the moral imagination is similar to putting on a pair of glasses that are tinted. The result is that the world is seen through that tint. As a consequence of the case study method, the editors and authors of the cases hope that each individual will see his or her field of study through the interpretive glasses of engineering and environmental ethics. He or she would then routinely ask: “What is the moral issue here?”

- 2 *Recognizing ethical issues.* The case analyst should not be content with a good “imagination.” The further challenge is the recognition of specific moral problems and how they differ from one another in terms of immediacy or urgency. Concreteness is an important asset of the case study and clearly assists in achieving this second goal. Comparing and contrasting a variety of cases through discussion is essential to recognition and leads to achievement of the next goal.
- 3 *Developing analytical skills.* Differentiation, comparison, contrasts—all of these must be related to an enhanced ability to solve the problem. To achieve this goal, the student of ethics is taught to bring the skills developed in his or her major field of study to bear on the ambiguous situation, the moral dilemma, or the competing values that must be addressed. Analytic skills are best honed through the use of examples or cases. The technical ability to analyze all dimensions of an environmental spill will have an impact on how the moral aspect of the problem is understood in terms of resolving the problem. Of course, ethical systems that emphasize the importance of consequences, the obligations inherent in a duty-based ethic, as well as theories of justice or virtue will enhance the ability to use technical or discipline-based analytic skills in resolving the problem. Knowing, however, is related to acting. This leads to the fourth goal.
- 4 *Eliciting a sense of moral obligation and personal responsibility.* Much has already been said about the importance of this goal. However, it should be clear that a sense of moral obligation does not mean there is one set of absolute answers. Dictating a solution is quite different from an internalization process whereby the individual commits himself or herself to be a “seeker,” one who takes personal responsibility for addressing and resolving the moral problems facing engineers or scientists. Both professions constitute the “guardians of the system” in the technical community. They are the first line of response to the problems and dilemmas facing the professions as such. To point to the Environmental Protection Agency, the Occupational Safety and Health Administration, the Federal Bureau of Investigation, congressional formulators of public policy, or other sovereign countries as the parties responsible for resolving acute problems is to abnegate one’s moral responsibility as a professional person. To say this is not to dictate solutions, but to alert individuals to their personal responsibility for the integrity of the respective field. Eliciting a sense of responsibility depends on an assessment of the assumptions or “images at the core of one’s heart.” Assessment of ethical systems or normative frames of reference must be connected to the actual assumptions or images that constitute a

person's world view. Challenging the individual to examine that world view in relation to a case and ethical systems is the first step in joining doing to knowing. Closely related to the achievement of this goal is the following one.

- 5 *Tolerating—and resisting—disagreement and ambiguity.* An essential component of case discussion is the willingness to listen carefully to the points-of-view held by others. Cases, by their nature, are ambiguous. They are bare-boned affairs meant more to be provocative than to lead to a clear-cut jury decision. The purpose of the case is to stimulate discussion and learning among individuals. As a result, there will be much disagreement surrounding the ethical issues in the case and the best option for resolving it. Toleration does not mean “putting up with people with whom I disagree.” Respect for the inherent dignity of the person and a willingness to understand not only another position, but also a person's reasons for or interest in that point-of-view, should be part of the case discussion. Toleration does not mean all opinions must be of equal value and worth. It is true that respect for and listening to another person's argument may lead one to change a position. However, a careful description and discussion of the other person's position may also lead to a greater conviction that one's own position is correct. What is clearly of central concern is the belief that the free flow of ideas and carefully wrought arguments, presented from all sides without fear of control manipulation, threat, or disdain, is at the core of human understanding and development. This hallowed concept of academic freedom is the catalyst that allows human communities to be committed to the search for truth without at the same time declaring absolute possession of the truth.

## INTEGRITY

Scenarios are, for the most part, designed to reflect ambiguity in work situations. The ethicist hopes to get his or her hands dirty, dealing with the bottom-line motives of survival, competitiveness, and profitability as well as the mixed motives of self-interest, respect for the rights of others, and altruism. Obtaining an ethical solution to a difficult moral problem or dilemma is based on much more than choosing the correct ethical framework with its normative frame of reference. One must also be ready to examine fundamental assumptions and the values to which the assumptions give rise. Carter has made this point recently in a discussion of “integrity.”<sup>(6)</sup>

- 1 *Honesty in relation to integrity.* Carter explores integrity in relation to the value society places on honesty. On this subject, one of the best-known and most popular ethics books of the last few decades is Bok's *Lying: Moral Choice in Public and Private Life*, 1978.<sup>(7)</sup> Without taking away from the merits of *Lying*, Carter notes: “Plainly, one cannot have integrity without being honest (although, as we shall see, the matter gets complicated), but one can certainly be honest and yet have little integrity.”<sup>(6)</sup> Honesty is far easier to practice than the tough work of figuring out what it takes to have

integrity in a situation. Integrity requires a high degree of moral reflectiveness. Honesty may result in harm to another person. Furthermore, “if forthrightness is not preceded by discernment, it may result in the expression of an incorrect moral judgment.”<sup>(6)</sup> The racist may be transparently honest, Carter declares, but he certainly lacks integrity because his beliefs, deeply held as they might be, are wrong. He has not engaged in the hard work of examining his fundamental assumptions, values, beliefs.

- 2 *Personal integrity without public responsibility?* It would appear that one cannot have integrity without responsibility since any consideration of integrity addresses the effects of our conduct on other people. In our work life and our community life, we have public responsibilities for our clients and fellow citizens.

## MORAL ISSUES<sup>(8)</sup>

The conflict of interest between Chief Seattle (and Native Americans in general) and President Pierce (and the European–American expansion) provides a perfect example of how ethics and the resulting codes of behavior they engender can differ drastically from culture to culture, from religion to religion, and even from person to person. This enigma, too, is noted again and again by Seattle:<sup>(9)</sup>

I do not know. Our ways are different from your ways. . . . But perhaps it is because the red man is a savage and does not understand. . . . The air is precious to the red man, for all things share the same breath . . . the white man does not seem to notice the air he breathes. . . . I am a savage and do not understand any other way. I have seen a thousand rotting buffaloes on the prairie, left by the white man who shot them from a passing train. I am a savage and I do not understand how the smoking iron horse can be more important than the buffalo we kill only to stay alive.

Chief Seattle sarcastically uses the European word “savage” and all its connotations throughout his address. When one finishes reading the work, it becomes obvious which viewpoint (President Pierce’s or his own) Chief Seattle feels is the savage one. What his culture holds dearest (the wilderness), the whites see as untamed, dangerous, and savage. What the whites hold in highest regard (utilization of the Earth and technological advancement), the Native Americans see as irreverent of all other living things. Each culture maintains a distinct and conflicting standard for the welfare of the world. Opposing viewpoints and moralities such as these are prevalent throughout the world and have never ceased to present a challenge to international, national, state, community, and interpersonal peace.

It is generally accepted, however, that any historical ethic can be found to focus on one of four different underlying moral concepts:

- 1 *Utilitarianism* focuses on good consequences for all.
- 2 *Duties Ethics* focus on one’s duties.
- 3 *Rights Ethics* focus on human rights.
- 4 *Virtue Ethics* focus on virtuous behavior.

*Utilitarians* hold that the most basic reason why actions are morally right is that they lead to the greatest good for the greatest number. “Good and bad consequences are the only relevant considerations, and, hence all moral principles reduce to one: ‘We ought to maximize utility.’”<sup>(9)</sup>

*Duties Ethicists* concentrate on an action itself rather than the consequences of that action. To these ethicists there are certain principles of duty such as “Do not deceive” and “Protect innocent life” that should be fulfilled even if the most good does not result. The list and hierarchy of duties differs from culture to culture, religion to religion. For Judeo-Christians, the Ten Commandments provide an ordered list of duties imposed by their religion.<sup>(9)</sup>

Often considered to be linked with Duties Ethics, *Rights Ethics* also assesses the act itself rather than its consequences. Rights Ethicists emphasize the rights of the people affected by an act rather than the duty of the person(s) performing the act. For example, because a person has a *right* to life, murder is morally wrong. Rights Ethicists propose that duties actually stem from a corresponding right. Since each person has a *right* to life, it is everyone’s *duty* to not kill. It is because of this link and their common emphasis on the actions themselves that Rights Ethics and Duty Ethics are often grouped under the common heading *Deontological Ethics*.<sup>(10)</sup>

The display of virtuous behavior is the central principle governing *Virtue Ethics*. An action would be wrong if it expressed or developed vices—for example, bad character traits. *Virtue Ethicists*, therefore, focus upon becoming a morally good person.

To display the different ways that these moral theories view the same situation, one can explore their approach to the following scenario that Martin and Schinzinger present:<sup>(9)</sup>

On a midnight shift, a botched solution of sodium cyanide, a reactant in organic synthesis, is temporarily stored in drums for reprocessing. Two weeks later, the day shift foreperson cannot find the drums. Roy, the plant manager, finds out that the batch has been illegally dumped into the sanitary sewer. He severely disciplines the night shift foreperson. Upon making discreet inquiries, he finds out that no apparent harm has resulted from the dumping. Should Roy inform government authorities, as is required by law in this kind of situation?

If a representative of each of the four different theories on ethics just mentioned were presented with this dilemma, their decision-making process would focus on different principles.

The Utilitarian Roy would assess the consequences of his options. If he told the government, his company might suffer immediately under any fines administered and later (perhaps more seriously) due to exposure of the incident by the media. If he chose not to inform authorities, he risks heavier fines (and perhaps even worse press) in the event that someone discovers the cover-up. Consequences are the utilitarian Roy’s only consideration in his decision-making process.

The Duties Ethicist Roy would weigh his duties and his decision would probably be more clear-cut than his utilitarian counterpart. He is obliged foremost by his duty to obey the law and must inform the government.

The Rights Ethicist mind-frame would lead Roy to the same course of action as the duties ethicist—not necessarily because he has a duty to obey the law but because the people in the community have the right to informed consent. Even though Roy’s



inquiries informed him that no harm resulted from the spill, he knows that the public around the plant has the right to be informed of how the plant is operating.

Vices and virtues would be weighed by the Virtue Ethicist Roy. The course of his thought process would be determined by his own subjective definition of what things are virtuous, what things would make him a morally good person. Most likely, he would consider both honesty and obeying the law virtuous, and withholding information from the government and the public as virtueless and would, therefore, tell the authorities.

## GUARDIANSHIP

Despite the great teaching advantage that comes with case use, there are two important questions that case discussants must keep in mind when they assess the ethical problem:

- 1 *Who are the guardians of the system?* This question addresses the issue of who, among engineering or science professionals, is responsible for the ethical standards in the organization. If professionals point the finger at senior management, the legal department, the Environmental Protection Agency, or the Department of Justice, they have indeed misunderstood the nature of a professional calling. The first line of defense is the willingness of professionals themselves to maintain and enhance the integrity of the engineering or scientific profession through their own personal adherence to the highest standards of conduct and to assume responsibility for commitment to these standards within the companies where they work. Moreover, ethics is a positive task, not a list of dos and don'ts. To achieve excellence in one's work presumes a commitment to the client's contract, public safety, and environmental integrity, among several factors that are all too often thought of as "management" issues. They are, in reality, the ethical standards of the work itself. Thus, the ethical engineer or scientist is the one who identifies with the profession and all that is involved in the work assigned or contracted.
- 2 *Who gives support to the guardians of the system?* This second issue goes to the heart of the assessment problem, but also has an impact on the first issue. Unless the organization backs those who assume positive responsibility for the ethical tenor of the group, very little will change. Why would someone risk ostracism or retaliation by confronting a person engaging in unethical behavior or illegal behavior if there is no institutional support for the one assuming responsibility?

Effective guardianship is facilitated if:

- 1 There are clear-cut standards of behavior and high expectations of the membership.
- 2 The standards are brought to the attention of the members through a well-developed training program.



- 3 The standards are taken seriously by the senior leadership team of the firm. They must demonstrate that seriousness by taking an active role in the training, without, at the same time, creating a chilly climate stifling discussion and participation in the training. The ethics program must be seen not as frosting on the cake or as a value added on to forestall legal problems through better compliance. The CEO needs to demonstrate a commitment to the values and principles that drive the business. Ethics training is no add-on. Ethics is what *drives* the organization: trust, integrity, fidelity to the client.
- 4 It is evident that the leadership “walks the talk” in all aspects of its decision making and actions.
- 5 There are mechanisms in place to address the concerns of the members, mechanisms such as an ombudsperson, a hotline, etc.
- 6 Those who adversely affect the integrity of the business are effectively and fairly disciplined.

Another way of addressing the question of who supports the guardians is to emphasize the importance of organizational or corporate culture. A positive response to the six points just raised has a great impact on the culture of the organization. Unless there is what is sometimes called a “thick” culture, wherein respect for and adherence to guardianship and the tenets of integrity and trust are palpable, individually ethical persons can do very little to raise the moral climate. An organization is more than the sum total of the individuals who constitute the membership. The attitudes conveyed, values expressed, and ways of doing business in an organization profoundly affect the perceptions of the members therein and set the tone of the company. Having a positive impact on culture is a great challenge which is not easily achieved. Culture is so subtle that one often does not even realize or understand its dimensions until a significantly different culture is experienced.

An organization will not have effective guardianship of the system unless there is a concerted attempt to create, enhance, or reinforce a culture where values and ethics are clear and fully supported. There is little doubt, however, that the twin issues of guardianship and culture are much more difficult to address than the institutionalization of the ethics program itself.

## **ENGINEERING AND ENVIRONMENTAL ETHICS<sup>(11)</sup>**

In the ethical theories presented here, established hierarchies of duties, rights, virtues, and desired consequences exist so that situations where no single course of action satisfies all of the maxims can still be resolved. The entry of environmentalism into the realm of ethics raises questions concerning where it falls in this hierarchy. Much debate continues over these questions of how much weight the natural environment should be given in ethical dilemmas, particularly in those where ecological responsibility seems to oppose economic profitability and technological advances.

Those wrapped up in this technology/economy/ecology debate can generally be divided into three groups:

- 1 Environmental extremists.
- 2 Technologists to whom ecology is acceptable provided it does not inhibit technological or economic growth.
- 3 Those who feel technology should be checked with ecological responsibility.

Each is briefly discussed below.

After his year-and-a-half of simple living on the shores of Walden Pond, Henry David Thoreau rejected the pursuit of technology and industrialization. While most would agree with his vision of nature as being inspirational, few would choose his way of life. Even so, the movement rejecting technological advances in favor of simple, sustainable, and self-sufficient living is being embraced by more and more people who see technology as nothing but a threat to the purity and balance of nature. Often called environmental extremists by other groups, they even disregard “environmental” technologies that attempt to correct pollution and irresponsibilities, past and present. They see all technology as manipulative and uncontrollable and choose to separate themselves from it. To them, the environment is at the top of the hierarchy.

On the other extreme are the pure technologists. They view the natural world as a thing to be subdued and manipulated in the interest of progress—technological and economic. This is not to say one won’t find technologists wandering in a national park admiring the scenery. They do not necessarily deny the beauty of the natural environment but they see themselves as separate from it. They believe that technology is the key to freedom, liberation, and a higher standard of living. It is viewed, therefore, as inherently good. They see the environmental extremists as unreasonable and hold that even the undeniably negative side effects of certain technologies are best handled by more technological advance. The technologists place environmental responsibility at the bottom of their ethical hierarchy.

Somewhere in the middle of the road travels the third group. While they reap the benefits of technology, they are concerned much more deeply than the technologists with the environmental costs associated with industrialization. It is in this group that most environmental engineers find themselves. They are unlike the environmental extremists since, as engineers, they inherently study and design technological devices and have faith in the ability of such devices to have a positive effect on the condition of the environment. They also differ from the technologists. They scrutinize the effects of technologies much more closely and critically. While they may see a brief, dilute leak of a barely toxic chemical as an unacceptable side effect of the production of a consumer product, the technologists may have to observe destruction—the magnitude of that caused by Chernobyl—before they consider rethinking a technology they view as economically and socially beneficial. In general, this group sees the good in technology but stresses that it cannot be reaped if technological growth goes on unchecked.

The ethical behavior of engineers is more important today than at any time in the history of the profession. The engineers’ ability to direct and control the technologies

they master has never been stronger. In the wrong hands, the scientific advances and technologies of today's engineer could become the worst form of corruption, manipulation, and exploitation. Engineers, however, *are* bound by a code of ethics that carry certain obligations associated with the profession. Some of these obligations include:

- 1 Support ones professional society
- 2 Guard privileged information
- 3 Accept responsibility for one's actions
- 4 Employ proper use of authority
- 5 Maintain one's expertise in a state-of-the-art world
- 6 Build and maintain public confidence
- 7 Avoid improper gift exchange
- 8 Practice conservation of resources and pollution prevention
- 9 Avoid conflict of interest
- 10 Apply equal opportunity employment
- 11 Practice health, safety, and accident prevention
- 12 Maintain honesty in dealing with employers and clients

There are many codes of ethics that have appeared in the literature. The preamble for one of these codes is provided below:<sup>(9)</sup>

Engineers, in general, in the pursuit of their profession, affect the quality of life for all people in our society. Therefore, an Engineer, in humility and with the need for Divine guidance, shall participate in none but honest enterprises. When needed, skill and knowledge shall be given without reservation for the public good. In the performance of duty and in fidelity to the profession, Engineers shall give utmost.

## **FUTURE TRENDS<sup>(11)</sup>**

Although the environmental movement has grown and matured in recent years, its development is far from stagnant. To the contrary, change in individual behavior, corporate policy, and governmental regulations are occurring at a dizzying pace.

Because of the Federal Sentencing Guidelines, the Defense Industry Initiative, as well as a move from compliance to a values-based approach in the marketplace, corporations have inaugurated company-wide ethics programs, hotlines, and senior line positions responsible for ethics training and development. The Sentencing Guidelines allow for mitigation of penalties if a company has taken the initiative in developing ethics training programs and codes of conduct.

In the near future, these same Guidelines will apply to infractions of environmental law. As a result, the corporate community will undoubtedly welcome ethics integration in engineering and science programs generally, but more so in those that emphasize environmental issues. Newly hired employees, particularly those in the

environmental arena who have a strong background in ethics education, will allay fears concerning integrity and responsibility. Particular attention will be given to the role of public policy in the environmental arena as well as in the formation of an environmental ethic.

Regulations instituted by federal, state, and local agencies continue to become more and more stringent. The deadlines and fines associated with these regulations encourage corporate and industrial compliance of companies (the letter of the law) but it is the personal conviction of the corporate individuals that lies in the spirit of the law, and the heart of a true ecological ethic.

To bolster this conviction of the heart, there must be the emergence of a new *dominant social paradigm*.<sup>(10)</sup> This is defined as “the collection of norms, beliefs, values, habits, and survival rules that provide a framework of reference for members of a society. It is a mental image of social reality that guides behavior and expectations.”<sup>(10)</sup> The general trend in personal ethics is steadily “greener” and is being achieved at a sustainable pace with realistic goals.

A modern day author suggests the following. “The flap of one butterfly’s wings can drastically affect the weather.”<sup>(12)</sup> While this statement sounds much like one conceptualized by a romantic ecologist, it is actually part of a mathematical theory explored by the contemporary mathematician Gleick<sup>(13)</sup> in his book *Chaos, Making a New Science*. The “butterfly” theory illustrates that the concept of interdependence, as Chief Seattle professed it, is emerging as more than just a purely environmental one. This embracing of the connectedness of all things joins the new respect for simplified living and the emphasis on global justice, renewable resources, and sustainable development (as opposed to unchecked technological advancement) as the new, emerging social paradigm. The concept of environmentalism is now *widely* held; its future is becoming *deeply* held.

Finally, one should note that an ethical analysis generally produces no absolute answers. This can be quite disconcerting because engineers expect valid, correct, and useful answers to problems. When one studies statics, for example, one knows what the rules are and all agree on the right answer. In ethics, however, the best an individual can do is argue that some answers are better than others, and, of course, these answers are always open to disagreement.

Engineers, as professionals, have a special responsibility to the public, and this responsibility is often expressed in terms of professional ethics. Engineers invariably face situations where values become variables in the decision-making process. Indeed, the ethical aspects of a decision often prove more difficult than the technical. Recognizing this, the engineering profession has strongly encouraged engineering schools to introduce more professional ethics into engineering curricula. Professional ethics has rightly become an integral part of engineering education.

Engineering ethics is tricky enough when it concerns only how engineers relate to each other and the public; it becomes trickier still when one also considers how engineers ought to react to the non-human environment. That is, when one asks “what is the engineers’ environmental ethic?”

Environmental ethics, to an even greater degree than ordinary ethics, is a subject without definition and without consensus. And yet, every person on this planet makes

everyday decisions that relate to environmental ethics. Questions as simple as “What should I eat?” or “How should I move from place to place?” all raise environmental and ethical issues.

Environmental ethics is especially important for engineers because so much of their work affects the environment. How should the engineer balance the human gains of development against environmental damage? When should the engineer maintain client confidentiality in the face of potential environmental problems?

## APPLICATIONS

The three Illustrative Examples below have been drawn from the work of Wilcox and Theodore,<sup>(3)</sup> keying primarily on mass transfer issues. Each application is presented in case-study format, containing both a Fact Pattern and Questions for Discussion.

### ILLUSTRATIVE EXAMPLE 21.1<sup>(3)</sup>

#### *Fact Pattern*

Laura is an engineer working in a chemical plant. She has recently received a job offer from another company, which she accepts because she knows that the new job could be a big step in her career.

Laura is responsible for one of the production lines in the plant she will soon be leaving. She has always been a reliable worker and an effective manager. However, having handed in her letter of resignation, she has been less attentive to her work over the past couple of weeks. She figures that there is no need to worry about this job anymore; she has to concentrate on her future.

On Laura’s next-to-last day of work at the plant, Harry, a coworker on the same production line, finds out that there is a problem with the purity of the product: The level of impurities is a little higher than acceptable. Harry decides to consult Laura.

He says, “The product coming out is below the required purity. I think you should investigate it so we can solve this problem.”

Laura replies, “I would love to help you, Harry, but tomorrow is my last day here. I don’t want to start dealing with this problem because it could take a while to solve. Let my replacement worry about it.”

Harry answers, “Laura, if we let this problem go, we’ll continue to have a product that doesn’t meet regulation. The problem could also get *worse*. You are the expert here, so you could easily fix this mess.”

“Harry, you’re a friend of mine. Please don’t ask me to get involved in this problem. It’s not my concern anymore. I just want to relax during my last two days at work,” pleads Laura. “It’s not like the plant will blow up. Wait for two days. You can pretend that you didn’t notice anything until then.”

Reluctantly, Harry agrees. “I know you’re really looking forward to your new job. It’s just that I’ll feel guilty knowing that something is wrong, and I’m not doing anything about it. But I guess I can wait for two days.”

“Harry, don’t worry. Take it easy for a couple of days. Just think of it as a minor delay,” replies Laura.

**Questions for Discussion:**

- 1 What are the facts in this case?
- 2 Do you think Laura should stay focused on her current job?
- 3 Should Laura handle the problem?
- 4 Do you think it’s okay for Harry to ignore the problem for the next two days?
- 5 Should Harry consult someone else now that Laura has refused to deal with the problem? ■

**ILLUSTRATIVE EXAMPLE 21.2<sup>(3)</sup>**

***Fact Pattern***

Joe Murray, a chemical engineer at the HairMagic Company, is in charge of the production of a new hair coloring product, which is expected to be ready for mass production in a month. Joe has been reviewing the results of the hair coloring tests conducted on volunteers, which show that when the product was used on dark-haired men and women, it changed the color of the hair with an accuracy of 99.2 percent. However, on fair- and light-colored hair types, it had an accuracy of only 89.3 percent. Joe realizes that the product needs to be refined further and that some substitutions should be made in its chemical makeup.

Joe decides to go to his manager and explain that production will have to be delayed. His manager, on the other hand, feels that production should be initiated and that further refining can be done during production so as not waste any more money or time.

Ethically, Joe feels strongly that this is wrong: the refining needs special attention and production should not even be considered when the product is not yet perfected. Joe’s only alternative is to go above his manager and try to convince upper management to delay production. However, doing this could anger his manager and could also lead to Joe’s dismissal. But it might also make him appear to be confident and conscientious, and could also serve to publicize his abilities as an engineer.

**Questions for Discussion:**

- 1 What are the facts in this case?
- 2 What issues are involved?
- 3 What are the choices Joe must make?
- 4 What could be the consequences of each decision he could make? ■

**ILLUSTRATIVE EXAMPLE 21.3<sup>(3)</sup>**

***Fact Pattern***

Tom is preparing for his final exam in mass transfer operations, a course that he has been struggling with all semester long. He desperately needs to pass this exam because as it stands he has a D in the course and not passing this final exam means he will have to repeat the class.

One night Tom sees a janitor that he is acquainted with and they begin to talk about his course difficulties. The janitor, whose name is Mike, likes Tom and thinks he's a good kid. Mike offers to help Tom with his mass transfer exam.

The student, bewildered as to how the janitor can help, asks, "Did you take mass transfer while you were in school, Mike?"

"No, Tom, I went only as far as high school but I know for a fact that your professor keeps all of his exam papers on his desk. I saw them when I was cleaning his office one night."

Mike says he can let Tom into his professor's office to look around for the final exam. Tom is excited about the idea of getting it ahead of time and feels a sense of relief.

On the other hand, Tom realizes that if he gets caught, he can get thrown out of school and that would not be good. He has two options: to study hard for the exam (and possibly still not do well) or obtain the exam (at the risk of getting caught). Which is the best alternative?

### Questions for Discussion:

- 1 What are the facts in this case?
- 2 What is the ethical problem with what Tom is doing?
- 3 Do you think Tom should try to get the exam ahead of time? ■

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