Chapter 1

Introduction: Engineering Ethics from a Global Perspective

Chapter Objectives

Having read this chapter and answered the associated questions, readers should be able to

- describe recent changes that have taken place in the field of engineering, and why this necessitates approaching engineering ethics from a different perspective;
- articulate not only the nature of ethics in general but also why it should be of particular concern to engineers;
- explain the problem of theory and interconnected roles that reason, engineers' role responsibilities, and case studies play in approaching engineering ethics from a global perspective.

CASE STUDY ONE—THE ÜBERLINGEN MIDAIR COLLISION: SYSTEMS CONFLICTS AND GLOBAL CONTEXTS

At approximately 9:35 p.m. on Jul. 1, 2002, two planes collided midair near Überlingen, Germany, killing all 71 persons on both planes. A number of human-controlled and human-automated technological systems were in place to avoid such an incident ever occurring. This collision was, thus, the result of a confluence of circumstances and conditions that illustrate the increasingly complex and global contexts of technology in modern life. Examining this case helps to introduce readers to this context and its associated problems.

The Überlingen collision occurred between a Tupolev 154 passenger plane traveling from Moscow, Russia, to Barcelona, Spain (henceforth 154), and a Boeing 757 cargo plane traveling from Bergamo, Italy, to Brussels, Belgium (henceforth 757). The pilots of both planes were well-trained, seasoned flyers. The pilots of 154 to Barcelona were Russian, and the pilots of 757 to Brussels were British and Canadian. Their nationalities are important, as we will see shortly, since training and cultural differences contributed to the collision.

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757 and 154 began communicating with Swiss air traffic controller Peter Nielsen, of the Zurich area control center at 9:21 p.m. and 9:30 p.m., respectively. Nielsen told 757 to climb to flight level 360, which it did, and, shortly after, 154 entered Zurich airspace at that same flight level. The pilots of 757 failed to report to Nielsen that they had ascended to flight level 360. When 154 entered Zurich airspace, Nielsen told the pilots to change their radio frequency to avoid interference, since 154 was initially using the same radio frequency as 757. Nielsen was unaware that the two planes were at the same flight level, and his attention was diverted for two main reasons.

First, although two air traffic controllers were working that night, one was on break at the time, leaving Nielsen by himself. Nielsen was thus in charge of two navigation stations—one for high altitudes on which 154 and 757 appeared and one for Friedrichshafen and St. Gallen-Altenrhein airports—with their own radios and screens; the screens were located a meter apart from one another, forcing Nielsen's attention to be divided between them. After instructing the pilots of 154 to change their radio frequency, Nielsen turned his attention to the Friedrichshafen and St. Gallen-Altenrhein airports screen, directing an Airbus approaching German airspace.

Second, the main telephone system used to communicate with nearby airports in Germany was—unbeknownst to Nielsen—down for maintenance, and the backup telephone system was not working as a result of software failure. Whereas Nielsen was not informed about the first, no one knew about the second. Again, after instructing the pilots of 154 to change their radio frequency, Nielsen was preoccupied with the phone system, attempting to communicate with air traffic controllers in Germany regarding the approaching Airbus. Additionally, although German air traffic controllers recognized the potential collision between 757 and 154, since both the main and backup phone systems were down, they were unable to communicate this information to Nielsen. Despite the failure of 757 to report its ascent, inattention and preoccupation by Nielsen, and failure of the main and backup phone systems, air travel and traffic control systems have built-in redundancies.

Despite the failures mentioned so far, there were two automated technologies in place that should have prevented the Überlingen collision: the short-term conflict alert (henceforth STCA) and the traffic collision and avoidance system (henceforth TCAS). The STCA is an automated alarm system that alerts controllers 2 min before any potential collision. Hence, 2 min before the Überlingen collision, this warning system should have alerted Nielsen that 757 and 154 were dangerously close. On the night of the collision, however, this system was down.

The TCAS is installed on planes, and it alerts pilots and provides instructions on how to avoid potential collisions. At 9:34:42 p.m., the TCAS alerted the pilots of 154 and 757 of the potential collision and then, at 9:34:56 p.m., directed the planes to ascend and descend, respectively. At this point, if the pilots of both planes had followed these instructions, then the tragedy could have been avoided. However, although the TCAS alerted the pilots of the danger and issued instructions on how to avoid a collision, this information was not relayed to the air traffic controller, Nielsen.

Hence, 7 s after the TCAS initially alerted the pilots of 154 and 757, Nielsen recognized the danger and directed 154 to descend to flight level 350. His instructions were the opposite of those the pilots of 154 received from the TCAS, a conflict between human instructions and an automated system. However, the Russian training of the 154 pilots had instructed them to follow the directions of air traffic controllers, and 154 descended accordingly. There were no mechanisms or safeguards in place if the pilots failed to comply with the TCAS instructions. It should also be noted that just over a minute (1:10) passed between the time the TCAS alerted the pilots to the potential collision and the time the collision occurred. Little time was thus available for either the pilots or Nielsen to gain their bearings.

The TCAS on 757 instructed the pilots to descend more, which they did and reported to Nielsen, although they received no response. With the TCAS on 154 continuing to instruct the pilots to climb, it wasn't until 9:35:27 p.m. that 154 stopped descending and started climbing. By this time, however, it was too late, and the two aircrafts collided at 9:35:32 p.m.[1]

This case raises a number of interesting questions regarding the complex, global contexts of technology in modern life: which persons and systems contributed to the Überlingen collision? Where does primary responsibility lie? If not one person, then multiple persons? Are persons primarily to blame for this collision? If not, then where should blame be placed? What could have been done differently to avoid this collision, and what can be done to prevent such tragedies from occurring in the future? Who's responsible for the ways modern technology is used? What role did the interaction between human beings and technology play in this collision, and what does this tell us about technical and organizational designs and their implementations? These are difficult questions, the answers to which are by no means entirely clear. For precisely those reasons, these are some of the issues considered going forward.

1.1 WHAT'S CHANGED AND WHY IT MATTERS: INITIAL ASSUMPTIONS[2]

Traditional engineering practice has been relatively localized to specific cultural contexts. Therefore, ethics education for engineering students could legitimately be based on the background conditions existing in a particular society, and instructors could assume general familiarity with these among students.

1. This account is based on Bundesstelle für Flugunfallуntersuchungg (2004), Johnson (2004), Nunes and Laursen (2004), and Turney (2007).
2. Materials in this chapter previously appeared in Luegenbiehl (2010).

In the latter part of the 20th century and into the 21st century, however, this was no longer the case.

The previously existing conditions underwent significant changes, including the coming to dominance of multinational corporations, the location of plants by national corporations in other countries, the increasing international mobility of engineers, and the establishment of international supplier and customer systems. While some texts on engineering ethics ignored these developments, others have responded by adding one or more chapters regarding issues sometimes encountered by engineers dealing with foreign entities, such as questions of different ethical and religious systems and grease payments.[3] Such responses, while legitimate first attempts to deal with the new international environment of engineering, do not address the need for a fundamental reconceptualization of how ethics should be conceived and taught, assuming it is no longer sufficient to look at international issues from within the framework of national perspectives.

This text seeks to rethink engineering ethics at a more fundamental level, using the global environment of engineering as the starting point rather than a mere addition. Toward this end, it is necessary that the particular national assumptions about the practice of engineering and theoretical foundations of ethics arising from specific cultural traditions be set aside. Only those assumptions that can be justified based on the nature of engineering itself and universal human characteristics should be used as a starting point. This is important as those assumptions would be ones on which all could agree. The following are the most significant of these:

1. The first assumption concerns the nature of engineering and the world: Engineering is not value neutral, and the activities of engineers should not leave the world less well-off than it was before. A cursory definition of "engineering" could be the following: *the transformation of the natural world, using scientific principles and mathematics, in order to achieve some desired practical end.* Chapter 4 returns to different understandings of engineering and further justifies the definition given here. This initial assumption is important when considering engineering in the context of business environments, since no one wants to buy or pay for things and services that ultimately hurt him or her. The question then becomes what limits should be placed on engineering processes, and what justifies these limits. This amounts to requiring that the benefits of engineering to the world outweigh the costs. Further, no cost should be catastrophic in nature, as that would make it difficult to measure against potential benefits.
2. The second assumption concerns the nature and use of reason: the ability to use reason is a relatively universal human characteristic; its main properties

3. Although the use of footnotes and references has been kept to a minimum, the authors want to direct interested readers to resources in the fields of engineering ethics, ethics, philosophy, science, technology, and society studies, and psychology that would be relevant. A few of the major texts in engineering ethics to date include Harris, Pritchard, Rabins, James, and Englehardt (2013), Whitbeck (2011), Van de Poel and Royakkers (2011), and Martin and Schinzinger (2010).

are shared in common among all human beings. Reason is generally defined as the process of logical, discursive thought, being able to provide clear justifications for decisions. Although not all human beings possess reason or evidence reasonableness all the time, engineers—as a result of their chosen profession—should be especially committed to the use of reason.

3. The third assumption concerns human nature and economics: human beings exhibit a tendency to seek out their own gain, although not exclusively so, and the dominant manifestation of this tendency in the contemporary world has come about through the adoption of some form of capitalistically motivated action. In part, this explains why the activity of business will be stressed in a text on engineering ethics, discussed at length in Chapter 4. This assumption does not mean, however, that human beings cannot or will not seek out the benefits of others, acting in an altruistic fashion. Chapter 3 examines the nature of professions and professionalism. There it is explained that, as professionals, engineers should actively promote the well-being of not only the professional community but also that of society as a whole.
4. The fourth assumption concerns cultures and values: different cultures have, at a fundamental level, different value systems, and these may conflict with those of other cultures. These systems can change, and no one is justified in assuming any one of these value hierarchies is necessarily the correct one or better than others. Chapter 7 explains and examines these assumptions regarding the natures of and relations between cultures and values in greater depth.
5. The fifth and final assumption concerns the nature of ethics and religion: a secular approach is the most appropriate for the study of global engineering ethics. In many societies, there is a close connection between ethics and religion, to the extent that, in some, religious perspectives dominate all discussions about morality and its justification. The problem with this is that there are a number of major religions whose ethical commitments concerning how people should act tend to be closely tied to their metaphysical commitments regarding the nature of reality. This means that what, at one level, could be very similar ethical claims are, at another level, interpreted differently, precisely because of their differing religious contexts. Thus, religion exhibits a tendency toward obstructing possible agreement regarding ethics among different peoples of the world. As a global standard of ethical conduct for engineers is sought here, the religious perspective will be set aside, while at the same time recognizing its importance to the daily lives of people in different cultures. This assumption touches on the difference between one's personal ethical commitments and those that follow from one's professional role:

   - How do you think your religion—or lack thereof—influences your ethical outlook?
   - Do you agree with the assumptions outlined above? Why or why not? If you disagree, then what would you change?

1.2 WHAT IS ETHICS?

Here the terms "ethics" and "morality" will be used interchangeably. A variety of different ways of defining these terms are in common use, but many of them rely on technical differences in interpretations. The definition proposed for use in this text is that *ethics is about actions that have the potential to seriously impact the lives of others.* The meaning of the word "serious" is, of course, vague but will be clarified in subject matter analysis.

It should be noted that, for the purposes of this text, ethics concerns human beings, although significant discussion exists about whether or not that should be its limit. For example, some people have argued that animals should have moral rights, based on their capacity to suffer. Our limitation does not mean, of course, that either animals or the environment should not be discussed ethically, since our actions toward other beings and things often have consequences for the lives of human beings. Here global warming as such, for instance, would not be of ethical interest, but considering that what people do to the environment can seriously harm human beings, it becomes a matter of ethical concern. Many discussions in ethics also take place regarding who is to be defined as a "person," but the theoretical ramifications of that issue will not be explored here.[4]

It should also be noted that, according to this definition, ethics is concerned with potential effects on others. Some ethical theories have proposed that ethics is about the furtherance of self-interest. As people do not require encouragement to seek out and further their own self-interests, the position here is that there is no need to develop rules about behaviors of this sort—human beings do so quite naturally.[5] Much of ethics is ultimately about setting restrictions on or limits to behaviors.

Especially in the context of a global ethics, it must also be noted that this definition of ethics is framed in terms of actions. Questions regarding the character of individuals, for example, are thus left unresolved. There exist a number of ethical traditions that stress character development or spiritual state of persons. Neglecting this issue in framing an ethics for engineers is not to indicate that this is an unimportant dimension of ethics but, rather, that it is often not suitably assessed by an outsider.[6]

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4. For discussions of such issues, see Smith (2010). Regarding animal rights and ethics, see Singer (1975), Rowlands (2002), and Carruthers (1992). Concerning environmental ethics, see Naess (1973), O'Neill (1992), and Jamieson (2001). This issue is taken up further in Chapter 11, regarding the nature of rights.

5. The position that ethics *is* about the furtherance of self-interest is known as "descriptive" egoism. The position that ethics *should* be about the furtherance of self-interest is known as "normative" egoism. For more on descriptive egoism, see Feinberg (1999), Mercer (2001), and Rachels (2003). For an overview of normative egoism, see Shaver (2015).

6. Stemming from the thought of ancient Greek philosopher Aristotle, ethical questions regarding the character of individuals are included under the broad purview of "virtue" ethics. Concerning recent psychological and philosophical criticisms of the understanding of moral psychology on which this ethical position is based, see Wilson (2004) and Doris (2005).

A further concern is with the distinction between what has been called the descriptive and normative dimensions of ethics. "Descriptive" ethics refers to the way individuals *actually* act or rules that exist in a society. "Normative" ethics refers to how people *should* act, independently of how people actually act and existing social rules. Because this text is concerned, in part, with taking into account particular local conditions in establishing norms for engineers, it proposes an interplay between the descriptive and normative dimensions of ethics. This would include the frank recognition of cultural and regional value hierarchies—for example, the awareness that some cultures place greater emphasis on loyalty than honesty, and others place greater emphasis on honesty than loyalty—in identifying and resolving ethical issues. Chapter 2 outlines this process in detail. Thus, unlike some philosophical approaches to ethics, it holds that engineers must account for real-world conditions.[7]

Given the emphasis on cultural diversity, it is especially important to recognize the limited scope of ethics. In the first place, actions that affect only one's self will not be considered in the scope of ethics. For example, the private thoughts of an individual—as repulsive as those thoughts might be if they were known by others—if they do not have effects on others, will not be considered within the scope of ethics. In the second place, matters of courtesy or custom—although others not following them may cause offense—will not be considered within the scope of ethics. For example, although I might recoil in horror if you fail to take off your shoes when entering my house, I would not be seriously harmed by this action:

- Do you think animals should be considered in ethical discussions? Why or why not?
- Do you think human beings should consider their effects on the environment, beyond merely how these effects affect human life? Explain your answer.

1.3 WHY ETHICS FOR ENGINEERS?

Matters of ethics are—or at least should be—of concern to everyone. In order for people to exist within communities, including the global community, there must be rules to prevent destructive behaviors toward others. Otherwise, the world would descend into chaos. Laws help to establish such rules, and they serve as a foundation for the enforcement of these rules.

However, as will be explained more fully in Chapter 10, laws are insufficient for this purpose—at least in part because laws are politically arrived at instruments. Due to this fact, laws might even contradict generally accepted ethical

7. This approach is thus informed by advances in "behavioral ethics" and "experimental philosophy." For readable accounts of recent advances in these fields, see Bazerman and Tenbrunsel (2013) and Alexander (2012), respectively.

norms. Ethics is thus necessary both as a supplement and counterbalance to law. For example, to make it illegal to ever lie to others would be an unenforceable law, and, thus, laws typically restrict themselves to making it illegal to lie under oath or to an official authority. Some traditional ethical theories would claim lying is wrong even in conditions that cannot be covered by law, thereby covering a greater range of actions than is possible by law. Further, illegality is not the same as unethicality. For example, although it is illegal to drive one's car on the left-hand side of the road in the United States—and similarly illegal to drive one's car on the right-hand side of the road in the United Kingdom—before the law has been established and promulgated, there is nothing inherently more ethical about driving one's car on the right- or left-hand side of the road. Finally, as political instruments, laws sometimes reflect the interests of the powerful, as opposed to the interests of justice. Thus, laws can contradict the requirement not to seriously harm others, for instance, through the establishment of institutions such as slavery and serfdom.

If ethics is or should be of concern to everybody, however, the question still remains of why ethics is and should be of special concern to engineers: why not simply offer a course in ethics rather than engineering ethics? There are several reasons.

The first reason is that engineers are singularly important to the world. Engineers themselves are often unaware of the powers they exercise, of their abilities to affect the lives of others. Instead, they tend to think of themselves as small cogs in big machines, with little influence over the course of events. A major purpose of engineering ethics could, thus, be termed "consciousness raising," helping engineers to become aware of their powers and the responsibilities that go along with the exercise of these powers.[8]

The second reason is that engineers are, in fact, different from the general public. They have specialized knowledge and skills that are only acquired and acquirable through long periods of intensive study and training. These characteristics are associated with professions and professionalism, about which more is said in Chapter 3. To the public, the knowledge of engineers is the equivalent of a black box: what goes on inside that box is a mystery. The public thus exists in a relationship of dependence on engineers. It must trust the work engineers do on its behalf. Through the study of ethics, engineers can help assure the public that they are worthy of this trust.

The third reason is that several specific ethical obligations for engineers are derived from the nature of engineering itself. That means that these obligations are ethical duties specific for engineers that are not applicable to all persons, only those in the specific roles of engineers. A further explanation of this basis, these principles, and their justification comprises the largest part of this text, in Chapters 3–10. A discussion of general ethics would, thus, be insufficient for understanding ethical concerns within engineering.

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8. Regarding the way that unethical actions result more from "blind spots"—biases constituting human psychology that make it difficult for persons to realize they are confronting ethical dilemmas—than reflectively making poor ethical decisions, see, again, Bazerman and Tenbrunsel (2013).

The final reason is that the positions of engineers entail not only responsibilities but also rights, explained in Chapter 11. To exercise these appropriately, on behalf of themselves and the public, engineers must first become aware of these responsibilities and rights. Unfortunately, due to their work in business environments, engineers might sometimes be subject to undue and unjustified pressures, to which they might respond inadequately without the ability to justify their decisions:

- What advantages would an engineer trained in global ethics have over an engineer who has no such ethical training? Explain your answer.

1.4 A GLOBAL PERSPECTIVE

Given the role of engineers and engineering in the contemporary world, here a global approach to engineering ethics is taken. While this might make sense to students growing up now, it is, in fact, a departure from the tradition.

Engineering ethics is an area of study that originated in the United States. Because the US model of engineering ethics was first, it has become somewhat of a global standard.[9] The problem is that this model carries within it some uniquely US or Western features, such as an emphasis on ethical theory and the ideal of professions. Some of these features are neither readily nor appropriately adaptable to other parts of the world.[10]

It is thus necessary to rethink engineering ethics from the ground up, which is the approach taken here. One could, of course, begin with a cultural perspective other than that of the United States, but that would raise the same issues of being too focused on one cultural perspective at the expense of others.[11] Consequently, the approach here consists in beginning to study engineering ethics without any cultural presuppositions, bringing in questions of culture later. This is the meaning of a “global perspective” on engineering ethics.

As will become clear in the remainder of the text, a number of important consequences follow from the adoption of a global approach. In the first place, no current perspective on engineering ethics is privileged simply because of its origin. Rather, of importance is that discussions follow from the assumptions laid out. Further, there will be a lack of emphasis on traditional Western ethical theories, since these are not shared in common on a global basis. In thinking about engineering ethics independently of a particular society, it might instead be helpful to think about engineers themselves as a community with a shared set of values. A bond is created among engineers based on these values, just as there typically exists a set of common core values in other societies. These values

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9. Concerning the history of engineering ethics, see Davis (1995).

10. With regard to the nature of professionalism specifically, see Luegenbiehl and Fudano (2005) and Didier (2010).

11. Regarding the contributions of Chinese and—more broadly—“Eastern” values to engineering and engineering ethics, see, for instance, Chang and Wang (2008) and Wang and Zhu (2012).

provide for an element of trust and legitimate defense against forces that would undermine the appropriate application of technology. A major task here will be to enunciate the values suitable for global engineers.

1.5 FOUNDATIONS FOR THE ANALYSIS OF ETHICAL ISSUES

1.5.1 Problems of Theory: Theoretical and Cross-Cultural Disagreements

Many engineering ethics texts currently available begin with a discussion of ethical theories. Such theories have been developed over several centuries, to serve as foundational principles for ethical analysis. Dealing with specific ethical issues that arise in the world has, consequently, become known as "applied ethics," indicating that, procedurally, it is the ethical principles that form the basis of discussion. A move away from this approach has begun, because of difficulties students find in applying these general principles, and because there continues to be serious disagreement among philosophers as to which principle or set of principles should be used.[12]

When ethics is viewed on a global basis, these problems become magnified, since foundational ethical principles as the major source for decision-making are specific to the Western philosophical tradition.[13] Consequently, many students not familiar with that tradition have a difficult time understanding that approach in the first place, before even questioning whether they agree or disagree with a particular instantiation of that approach. In such cultures, courses in applied ethics face the danger of becoming introductions to Western philosophical thought, at the expense of actually considering specific, applied issues. Fundamental disagreements about the appropriateness of utilizing ethical theory—perhaps based on the claim that ethical theory seeks to operationalize a uniquely Western perspective and impose it on the rest of the world—also stand in the way of reaching agreement on how specific ethical issues should be resolved.

In addressing a global audience, therefore, references to specific ethical theories and the identification of duties based on particular religious and philosophical traditions are avoided. Instead, the claims included here are based on three features: human reason, role responsibilities, and case study. There is a universal dimension to be found in this approach. However, it will also be clear to the discerning reader that there are, at times, implicit connections to

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12. Concerning the move away from professional as "applied" ethics, see Chadwick and Schroeder (2002a).

13. For a very readable but highly informative account of the relation between ethics, advances in cognitive science, and East Asian philosophical and religious thought, see Slingerland (2015), and with regard to the foreignness of the formulation and application of ethical theories to concrete situations within Confucian thought, for example, see Ames (2011) and Hall and Ames (1987).

traditional claims of philosophy and religion.[14] It is left to students more knowledgeable about these subjects to make such connections explicit for themselves, analyzing the adequacy of their use.[15] However, there is not a sense of exclusivity or "final court of appeal," traditionally associated with the use of Western ethical theories and particular religious doctrines. The hope is that the typical engineering student will be spared the need for a separate study of theories in finding a basis for communicating about ethics with other students—and eventually colleagues—from different cultural backgrounds.

1.5.2 The Role of Reason: Its Universality and in Engineering

In general, the ability to reason is a characteristic common to all adult human beings—the ability to logically think through problems. Central characteristics of reason include consistency, reversibility, deliberation, dispassionateness, and universality. So central to human existence is the ability to reason that, some have claimed, it is the core of human identity—what separates humans from other creatures. Whether this is true may be subject to debate, but without the ability to reason, engineering—at least in its modern manifestation—could not exist. Engineers should, therefore, accept the assumption of the validity of an approach to life using reason. They have committed to the use of reason through their chosen professions as engineers. While other elements of humanness are also significant—such as an emphasis on emotions, for example—only reason is expected to manifest itself in a uniform fashion across cultures. Given the above characteristics, the use of reason as an assumption in a cross-cultural and global foundation for the development of ethical principles in engineering seems justified[16]:

- Are there benefits to having different ethical paradigms around the world? Why or why not?

1.5.3 Role Responsibilities: Special Duties

Here the idea of "role responsibilities" is one of the foundations for analysis. Role responsibilities, as the name indicates, are duties associated with a particular position one occupies in life. All of us have many roles, and different

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14. This would include, for example, the presumed universality of human reason and Western philosophical understandings of personhood in dualistic terms, based in the thought of Plato and Descartes.

15. The basis of these texts have been used in courses on engineering ethics and science, technology, and society studies in the United States, Japan, Taiwan, and mainland China, and the authors encourage both instructors and students to share their experiences, especially when these would prove useful in developing future versions of this text and its associated study materials.

16. Regarding the claim that some types of reason would not be universal, see, for example, Boas (1940), Geertz (1993), and Whorf (1956).

duties may be associated with each of these roles, arising out of the nature of the role itself rather a more general principle. Parents, for instance, have a special responsibility to nourish and support their children, much beyond the responsibility that strangers or the state might have. Similarly, teachers have special responsibilities to ensure that their students learn, and physicians have special responsibilities to the health of their patients.[17]

In making a list of one's roles, it is quickly discovered that these are numerous. An engineer might also be a parent, golfer, sibling, student, customer, driver, and so on. Once one identifies theses roles, two things should occur: first, deciding what special duties are associated with the roles—or at least to be informed by others what these should be—and, second, prioritizing the relationships among the many roles. Chapter 3 begins the process of determining the responsibilities associated with being an engineer, based on the nature of engineering professionalism itself.

The second process of prioritizing among different roles is too complicated to be carried out in the abstract and should also be flexible over time. The recognition that one has many, varied role responsibilities thus points to the need for students of applied ethics to be able to evaluate specific situations on their own, for no entirely pregiven matrix is ever available. This is not to say, however, that one cannot learn from others, from the experiences of those who have come before. In not only engineering ethics but also business education and ethics, this fact provides a large part of the justification for a case-study approach.

1.5.4 Consideration of Cases

Working with specific sets of circumstances requires the ability to analyze a series of events. This fact points to the importance of case analysis in engineering ethics education. Studying a variety of cases serves several important purposes. Analyzing cases

1. emphasizes the process of active learning, which has been shown to facilitate student understanding;[18]
2. helps students to build up an experience base regarding ethical issues before they actually have to deal with these issues in their professional lives;
3. helps students to develop their ability to analyze and solve problems, in terms of not only ethics but also engineering, enabling them see the connections between ethics and engineering more clearly;[19]

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17. Concerning the relation between professional role responsibilities and ethics in general, see Frankel (1989). Regarding the nature of professional role responsibilities and ethics within the fields of education and medicine, see Strike and Ternasky (1993) and Chadwick and Schroeder (2002b), respectively.

18. Regarding the way active learning facilitates understanding, see Prince (2004).

19. See Whitbeck (2011) regarding the ways that the activities of engineering design and ethical analysis employ similar modes of reasoning that mutually enforce each other.

4. aids in the ability to generalize by looking at a variety of specific instances and, thereby, helps students to form a more general ethical perspective.

1.6 PREVIEW: WHAT'S TO COME…

The remainder of this text seeks to establish the basic elements of a global approach to engineering ethics. In doing so, two important elements are stressed: first, the connection of engineering to the global business environment and, second, the need to understand that a variety of cultural value systems exist in the world, which must be recognized and accounted for. This approach, therefore, asks more of students than that typical of engineering ethics education, where a common set of shared values between the instructor, students, and other students are assumed. It also requires that students place the activity of engineering in a real-world framework, rather than viewing it as an ideal phenomenon that can be analyzed independently of external considerations. While these tasks are challenging, facing them is the best preparation for students to become ethical engineers in the 21st century.[20]

It should also be noted that, in utilizing this approach, at times the text takes a prescriptive tone, asserting that specific obligations and rights for engineers should be agreed to in global contexts. It does not follow from this, however, that the proposals made in the text are beyond debate. In fact, students are encouraged to question the propositions put forward in the text and arrive at their own conclusions regarding specific ethical issues raised. In doing so, they contribute to the field of engineering ethics.

CASE STUDY TWO—ENGINEERING A BETTER GLOBAL FUTURE: FUSION POWER ACROSS BORDERS

After the 1985 Geneva Convention, Mikhail Gorbachev, secretary general of the Soviet Union, and Ronald Reagan, president of the United States, released a statement that "emphasized the potential importance of the work aimed at utilizing controlled thermonuclear fusion for peaceful purposes" and "advocated the widest practicable development of international cooperation in attaining this source of energy" ("The ITER initiative," 2005). This statement signaled to scientists a focus on thermonuclear fusion and launched an international collaboration of immense scale. In the decades since, thousands of scientists and engineers, from 35 countries, have cooperated on the design, management, and construction of an international thermonuclear experimental reactor (henceforth ITER).

20. Again, the importance of this ability would consist—first and foremost—in being able to discern the ethical dimensions of engineering and engineering-related situations since, according to Bazerman and Tenbrunsel (2013), the greatest impediment to acting ethically are innate psychological biases that prevent persons from being able to recognize the ethical dimensions of situations.

As the world faces an ever-increasing population and decreasing resources, using new technologies to supply demand becomes correspondingly important. Central to such endeavors is the development of green technologies that would result in less pollution, such as fusion energy. Additionally, since the behaviors of disparate national populations affect each other as never before, coordinating the efforts of citizens, politicians, and scientists on a global scale is necessary. To envision and encourage such large-scale international technology projects, the ITER project can serve as an example, one of the largest global engineering collaborations in history.

Thermonuclear fusion consists in two nuclei colliding and fusing to form a heavier nucleus, releasing an incredible amount of energy in the process. For fusion to occur, particles must be exposed to extremely high temperatures for sufficient periods of time. A tokamak reactor uses powerful magnetic fields to direct particles through its "doughnut-shaped vacuum chamber," which confines these particles for a long enough time, at a high enough temperature, to cause them to collide and fuse ("What is ITER?"). Unlike energy resulting from either fossil fuels or nuclear fission, the waste products of energy resulting from nuclear fusion could be harmless. Upon its completion, the ITER will be the largest tokamak reactor in the world and the first nuclear fusion device to produce more electricity than it consumes. The goal of the ITER project is twofold: producing 500 MW of fusion power and aiding scientists in researching the possibility of commercially viable fusion-based electricity.

The ITER project was officially started in the early 2000s and has involved collaboration between China, India, Japan, Korea, Russia, the United States, and countries in the European Union. The reactor was scheduled for completion in 2016 with an estimated cost of €5 billion. Due to difficulties involved with organizing thousands of people from so many countries, however, now, the completion date has been pushed back to the mid-2020s, and the budget increased to €15 billion. Michael Classens, head of ITER communication, claims, "the main challenge for the project is not the science and technology itself, but the management as a whole, the way these 35 countries cooperate" (Gupta, 2016).

Robert Iotti, chair of the ITER Council, traces these problems to the organization of the council itself: the responsibilities of countries were based on monetary contributions rather than which could best build the required parts. Additionally, the ITER council has little central power. All major decisions essentially need unanimous approval, which requires more time for discussions. The project relies on different nations completing different parts, so pieces of equipment that arrive later cause delays to the entire project, resulting in the later projected completion date.

Ronald Reagan "saw the potential positive impact of American and Soviet engineers living and working together for some period of time" (Degitz, 2015). He promoted the ITER project not only for scientific reasons but also as a kind of social experiment in international collaboration. At the beginning of the project, considerable time was spent just determining a way for different nations to work together. Michael Roberts, chair of the ITER Council Working Group on Export Control, said that "nearly all the articles in the ITER Agreement deal principally with the practical aspects of collaboration at government level and not with the technical aspects of fusion" (Degitz, 2015). Given all the initial work that went into all the parties finding common ground as a way to understand each other and work together, he believes this framework can be applied to future projects in different fields.

Given the ever-increasing need for cross-cultural/cross-national collaborations, the ITER project can serve as an example, "a model for other large international science collaborations" (Arnoux, 2009).[21] Some of the greatest scientific achievements have been the result of teams with diverse backgrounds. In terms of not only their goals but also their administrations, the nature of such projects draws attention to the need for broad but commonly agreed-upon principles with ethical import. Projects like ITER involve peoples from different cultural and national backgrounds, which have the potential to seriously impact—for better and worse—peoples worldwide. These facts highlight the need to consider the ethics of engineering from a global perspective, moving beyond any one cultural or national paradigm:

- Explain how large-scale, cross-cultural/cross-national technology projects such as ITER can help to engineer better futures.
- How is the ITER project both a good and bad example of international collaboration?

1.7 SUMMARY

As the case of the Überlingen midair collision makes clear, the modern contexts in which technology is employed are becoming ever more complex and global, involving human-operated and automated systems worldwide. As a discipline of study and practice, engineering ethics began in the United States and has been largely based on national, Western assumptions—especially those regarding theory-based approaches to ethics. In the 21st century, such an approach is no longer sufficient. A global approach to engineering ethics should base its foundational assumptions on universally shared characteristics regarding the nature of engineering and being human, while at the same time recognizing the role that cultural value differences play in engineering contexts. Central to the approach taken here is the use of reason, role responsibilities of engineers, and case studies, and the global business environment of engineering is an important point of reference as well. The ITER project helps to illustrate the importance of scientists and engineers, politicians, and citizens working together across national and cultural divides to address needs related to sustainable global development. Doing so involves issues of ethical import, highlighting the need to rethink the ethics of engineering from a global perspective.

21. This account is additionally based on Arnoux (2015), Clery (2015), Lucibella (2015), and Olivero (2016).

REVIEW QUESTIONS

1. What five assumptions frame this book's treatment of engineering ethics?
2. What is the definition of ethics for the purposes of this text?
3. Describe the differences between "descriptive" and "normative" ethics.
4. Why are laws insufficient in regulating peoples' behaviors, making ethics necessary?
5. Identify and discuss three reasons why engineering ethics should be distinguished from ethics in general.
6. List two issues or complications associated with applied ethics. Explain your answer.
7. List two reasons case studies are helpful in studying engineering ethics. Explain your answer.

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