Chapter 10

Issues of Broader Concern for Engineers

Chapter Objectives

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

- with regard to the case of Qihoo 360's P1 wireless router, explain why it is important for the public to have an adequate grasp of the ways technologies work and the responsibilities engineers have for this understanding;
- describe the reasons for and problems associated with the gulf in understanding that exists between the sciences-engineering and the humanities-public and what engineers might do to bridge this gap;
- outline the nature of and reasons for responsibilities that engineers, as a group, have to public participation, education, and engagement, giving examples from the case studies in this chapter;
- explain the relationship between laws and ethics, why strictly adhering to laws alone is insufficient, and how engineers might approach the law in international and cross-cultural contexts;
- discuss the importance of being sensitive to local needs in the formulation and implementation of international aid work related to engineering and technologies.

CASE STUDY ONE—ENGINEERING AND PUBLIC KNOWLEDGE: THE "PREGNANCY" MODE ON QIHOO 360'S P1 WIRELESS ROUTER

A Chinese man was reported as having gone door to door, asking his neighbors to turn off their wireless routers: his wife was pregnant, and he feared the wireless signals would harm his unborn child (Yu, 2015). Similarly, villagers from Dongguan, Guangdong province, China, staged protests forcing a mobile telecom company to shut down its base station: they also feared that mobile signals would adversely affect their health (Wu, 2015). These reactions could be understood as relating, in part, to the "fear marketing" of a wireless router. This case touches on issues of broader concern for engineers.

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In Jun. 2015, the Chinese technology company Qihoo 360 released the P1 wireless router. Qihoo advertised the router as having a "pregnancy" mode, a setting that would ensure the health of expecting mothers and their unborn children. To achieve this effect, the setting simply decreased the router's power level. Shortly after its release, Qihoo held a press conference and changed the name from "pregnancy" to "energy-saving" mode. These were responses to an onslaught of criticisms by both its competitors and the public: Qihoo executives had used the "pregnancy mode as a marketing tactic," intentionally playing on public ignorance to pursue profits (Kleinman, 2015).

Zhou Hongyi, the chairman and CEO of Qihoo, had established a hardware division within the company to compete with routers produced by Xiaomi, another major Chinese technology company. The development of Qihoo's router was announced on Nov. 25, 2013 (Zhang, 2013a). The decision to include a pregnancy mode was decided shortly thereafter, at the end of 2013. Although wireless and cellular devices emit radio-frequency electromagnetic fields, when designed and produced according to industry and legal guidelines, there is no evidence of health risks (Schofield, 2012; Shi, 2013).

Hence, Qihoo's marketing campaign for its router would be like one by Coca-Cola for "fat-free water." Just as water is already fat-free, so too are wireless routers harmless to pregnant women and fetuses. However, unlike water, the public is largely ignorant of the nature and consequences of new technologies. In addition to Zhou, a number of other individuals who oversaw the development of the P1 router would have known this.

Jiang Xuxian was responsible for wireless safety within Qihoo 360, and his expertise was in the field of wireless communication. Shen Haiyan was responsible for the new hardware division within the company, and Huang Xifeng was responsible for marketing at Qihoo 360. Although Huang oversaw advertising for the router, both Jiang and Shen acquiesced to the ploy, despite possessing the requisite professional knowledge to dispel such claims.[108] Insofar as Qihoo infringed on the rights of individuals "to obtain true information" regarding "the commodities they purchase and use," their action could be considered illegal ("Law," 1993). Even if the company did not act illegally, however, their actions could still be considered unethical.[109]

As has been discussed previously, in the contemporary world, engineers have great power and great responsibilities that come with this power. Although these include not engaging in illegal activities, this is far from a comprehensive account of the duties of engineers. In addition to the fact that laws can conflict with ethics, not even acting completely in accord with good laws fully encompasses the sphere of ethics. This chapter more fully considers the responsibilities engineers as a group have to the public, the relation between ethics and the law, and how engineers can engage with laws in international and cross-cultural contexts.

108. Regarding who was responsible for what, see Zhang (2013b).
109. Information in this case study is additionally based on Feng (2015) and Custer (2015).

EXERCISE ONE—ENGINEERING AND PUBLIC KNOWLEDGE (PART ONE)

With reference to the case of Qihoo 360's P1 wireless router, complete steps 1–10 of the case-study procedure, using all relevant principles reviewed thus far.

10.1 ENGINEERING AND SOCIETY: POSITIVE CONTRIBUTIONS

In many ways, the analyses up to this point have focused on restrictions to the activities of engineers—the limitations of their actions by engineering and business ethical principles. The present chapter considers broader activities in which engineers should be encouraged to engage, based on their roles in society.

Again, the first basic ethical principle for global engineering is as follows: "Engineers should endeavor, based on their expertise, to keep members of the public safe from serious negative consequences resulting from their development and implementation of technology." Thus far, this principle has been interpreted and applied in a relatively narrow fashion, used to refer to the responsibilities that arise from the connection that individual engineers have to the development of technologies. Perhaps an understanding of this principle in these terms arises naturally, as a result of conceiving engineering activities in relation to individual companies. However, technological development can be conceived in much broader terms. Thus, the focus here is on the involvement of engineers in wider contexts of public discussions of technologies.[110]

As citizens, all adults have responsibilities to participate in public life. Engineers, it could be argued, have greater responsibilities than those of ordinary citizens. This argument would be based on the expertise of engineers, again, where this expertise brings with it responsibilities. Engineers are experts in more than just the projects on which they happen to be working. Given their roles as employees, however, they tend to view themselves as simply servants following directions. Perhaps because of this, engineers are sometimes unwilling to assert their more general beliefs in public forums; this would be compounded by feelings of loyalty to their employers.[111]

These circumstances contribute to the fact that most public discussions concerning technologies are initiated and conducted by persons lacking the appropriate knowledge base, in other words, nonengineers. A situation such as this increases the possibility that poor decisions will be made or that engineers will ignore decisions made by nonengineers. Due to a disconnect between engineers

110. Concerning a shift in focus of engineering ethics—from "microethics," aimed at fostering the capacities of individual engineers to engage in ethical reflection, decision-making, and action, to "macro-" and "mesoethics," expanding to encompass the responsibilities of professional and social organizations, and focus on value systems—see Herkert (2001), Herkert (2005), and Bocong (2012).
111. For a fuller discussion of loyalty, see Baron (1984).

and the public, the potential for negative consequences increases greatly. A variety of perspectives compellingly demonstrate this claim[112]:

- Do you believe that, as citizens, all adults have responsibilities to participate in public life? Why or why not? Explain what public life means to you.

10.1.1 The Two Cultures View

In his famous *The Two Cultures*, Charles Snow discusses two fundamentally different approaches to conceiving the world, one by scientists and engineers and one by humanists (Snow, 2001). In large part, he wrote this book to help overcome divisions between the two cultures. Unfortunately, however, problems associated with these divisions seem to have become more acute since the publication of this work in 1959.

According to Snow, on the one hand, scientists conceive the world in rational terms, where the notion of progress and efficiency dominates. Scientists believe the future lies in their hands and that this future is filled with the wonders of technologies—a view generally associated with "technological optimism." On the other hand, the humanities conceive the world in intuitive terms, where reason can only provide partial and biased answers. The central concerns of the humanities are human meaning and the fulfillment of broader missions.

Each culture is suspicious of the other, believing justifications provided are simply means of attaining greater control. As a result of this mutual suspicion and the fact that these two cultures use fundamentally different vocabularies, they have had—and continue to have—significant difficulties communicating with each other. Communication is necessary, however, since the future involves everyone. This can only occur if each side is empathetic to the other, explicitly recognizing the value of the other.

10.1.2 The Traditional Versus Superculture View

Kenneth Boulding has stated this same problem in another way: in the modern world, two cultures exist in tension, traditional culture and superculture.[113] According to Boulding, on the one hand, traditional culture is composed of folk technology, an emphasis on nations, the dominance of religious values, and loyalties to ethnic identities. On the other hand, superculture is composed of technological development, English as a common language, formal education, equality, and scientific ideals. To ensure true

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112. The following two accounts are by no means comprehensive pictures of conceptualizations regarding the relations between the sciences/engineering and the humanities/public. For other interesting accounts that touch on such issues, the reader is referred to the work of Bruno Latour, Isabelle Strengers, and Donna Haraway, for instance, Latour (2005), Stengers (2010, 2011), and Haraway (1991).
113. See especially Boulding (1969).

progress, claims Boulding, these two cultures must work together: whereas traditional culture cannot ensure progress, superculture alone does not possess an adequate value base to achieve its objectives. A balance is thus required between the two, where the transmission of traditional values is balanced with an emphasis on creativity.

10.2 THE RELATION OF ENGINEERS TO THE PUBLIC: PRINCIPLES OF INVOLVEMENT

To achieve both material progress and human fulfillment, adequate interaction between scientific/engineering and humanistic concerns is essential—greater understanding of each by the other. Assuming the public has considerable difficulties understanding the work of engineers, a great deal of this responsibility for communicating and interacting falls to engineers. In recognition of this fact, several principles follow.

Unlike the previous principles, however, these would not be ethically required of individual engineers. Strictly speaking, individual engineers are only ethically accountable for their own work.[114] As a group, however, engineers have broader responsibilities to the public through their employment of technology. "Technology" is an ambiguous terms, referring to more than simply isolated sets of devices, processes, and techniques. The employment of the combinations of technologies—understood in broader terms—has significant systemic implications. Someone should assume responsibility. Again, for nonengineers, however, much of what occurs in relation to technologies is fundamentally obscure, and the lack of understanding precludes autonomous choice. As a whole, engineers should be involved in this process.

Given their role in society, as a group, engineers have a responsibility to establish communication with nonengineers, insuring that broader nontechnical concerns are considered. Simply because a group is responsible does not mean each of the individuals belonging to that group is equally responsible. Individual engineers cannot be ethically required to fulfill responsibilities associated with public participation, education, and engagement, resulting from a more general problem regarding the nature of collective guilt.[115] As a group, however, engineering should encourage individual engineers to participate in processes of communication and participation with the public, such that the responsibility of the group would be fulfilled. On this basis, three principles can be formulated.

114. For a fuller account of the nature of responsibility within engineering, see, for instance, Van De Poel, Fahlquist, Doorn, Zwart, and Royakkers (2012).

115. A situation where the group as a whole would be responsible, but not necessarily any one individual within that group, is known as one of "many hands." For a fuller discussion of this problem within the sphere of engineering, see Van De Poel et al. (2012) and Van de Poel, Royakkers, and Zwart (2015). Within the political domain, see Thompson (2004).

10.2.1 Principle of Public Participation: Engineers Should Seriously Consider Participating in Public Policy Discussions Regarding Future Applications of Technology

Again, the basis of this principle is the expertise of engineers, bringing with it responsibility. Engineers should be encouraged to actively engage in public discourse surrounding technologies, as opposed to doing so only when requested—since that might never occur or occur only infrequently. Where their input would be appropriate, engineers should seek out opportunities to engage in public discussions. However, participation should be understood appropriately.

"Participation" does not mean that engineers should make final decisions about the implementation of technologies independently of other stakeholders. A process such as this would result in "technocracy," government by those responsible for technologies, based on the technological ideals of rationality and efficiency. Since decisions about the future of technologies involve more than simply technological factors, this would be an unfortunate outcome.

As discussed before, the most important of these factors is the role of social values, about which engineers generally know no more than other members of society. Additionally, in relation to technological fields, other members of society, such as scientists, have expertise equivalent to that of engineers. A consensual approach to decision-making is, therefore, the most appropriate, where the interests of all affected stakeholders are considered.

10.2.2 Principle of Public Education: Engineers Should Seriously Consider Helping the Public to Understand the Applications of Technologies in Broader Social, Global Contexts

Again, technologies never exist in isolation: they exist in specific cultural contexts and tend to have global effects. A contextual understanding of technologies is necessary to adequately understand their implications and effects. At present, generally, neither engineers nor members of the public have such understandings. Engineers typically view technologies in terms of their technological contexts and immediate effects. Members of the public generally have only a vague understanding of technological processes. Education is thus necessary to overcome this divide. The question then arises as to where such education should be directed.

Although not always the case, members of the public typically show disdain toward gaining expertise in technological understanding.[116] Evidence of this

116. This is by no means always the case. In the fields of science and engineering studies, works by the likes of Stephen Hawking, Carl Sagan, Henry Petroski, and Don Norman have been relatively successful in captivating general audiences. Additionally, despite whatever shortcomings the genre might have, TED talks (http://www.ted.com) provide a forum in which scientists and engineers can more easily communicate with the general public.

would be failures to captivate the interests of humanists through the establishment of science, technology, and society education programs. For this reason, the more fruitful option seems to be educating engineers to better understand the broader implications of technologies—engineering education involving the concerns of social sciences and humanities related to technologies.[117]

Given their expertise, engineers would be able to increase public understanding, since they should not be the only or ultimate decision-makers. Only an informed public can make appropriate decisions regarding technologies, and engineers could be a source of information to educate the public. Thus, a part of engineering education should show engineers the importance of this role, since it cannot be ethically required of individual engineers.

10.2.3 Principle of Engineering Engagement: Engineers Should Seriously Consider Becoming Involved in Helping to Improve the Technological Futures of Those Less Fortunate Than Themselves, on a Voluntary Basis

Individuals are inadequately served by technologies. The reasons for this include economic poverty, social rejection, and geographic remoteness. Although technologies are not the solution to all—or even many—social problems, their applications can undoubtedly improve human life. The need exists to fulfill the basic conditions of human life, and, as long as that need exists, a corresponding responsibility to fulfill that need.

The fulfillment of this responsibility—and alleviation of human suffering more broadly—requires a combination of various efforts, primarily those relating to finance and policy. Additionally, efforts should include the creation of technologies appropriate to cultural contexts. Here engineers are in the best possible positions to meet these efforts and, therefore, have a responsibility to do so.

As a group, engineers should encourage individual engineers to assist in the alleviation of social problems through the application of technologies. It should be kept in mind, however, that not all problems can be corrected with a "technological fix," and engineers are not the sole decision-makers.[118] To reiterate, engineers should be educated to develop technologies appropriate to given social contexts, not simply apply cutting-edge technologies that fail to meet human needs—a mistake that has been repeated time and again. Finally, it should be noted that this principle encourages volunteerism. This results from the fact that waiting on adequate financial support can often be a fruitless endeavor.

117. To a large extent, ABET's criteria for student outcomes aim at this end, especially outcome h, requiring that programs impart to students "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" (Criteria).

118. For a fuller discussion of what might and might not be expected of technologies, see Weinberg (2003).

Just as in the process of applying ethical principles in general, it is important to keep in mind that the implementation of the above principles requires the education of engineers in matters that are not strictly technical in nature, although these matters are related to technical concerns[119]:

- Although they have been explained as applying to engineers as a group, do you believe there would be instances in which the principles of involvement would be ethically required of individual engineers? Why or why not? Give examples to clarify/justify your answer.
- Explain instances in which you have used a "consensual approach to decision-making" in the course of your engineering education and/or work. Why is this type of approach especially important to the development of technologies?
- Although volunteerism is strongly encouraged for engineers, could paid projects produce similar results? Why or why not? Provide any relevant examples with which you are familiar.

10.3 ETHICS AND THE LAW: THEIR SIMILARITIES AND DIFFERENCES

In studying ethics, students are often puzzled by the relationship between ethics and the law, probably because many so closely identify the one with the other—assuming that by strictly following the law, one is also acting ethically. However, especially in international contexts, this would be a mistaken assumption.

On the one hand, laws vary greatly from place to place and time to time. Even in relatively homogenous cultures, different localities adopt different laws. On the other hand, laws and ethics have similar functions. Both function to help people get along with each other and establish behavioral expectations. However, the two differ in the range of actions they cover and their normative force. To begin to understand these differences, considering the rationales for the law is important.

In *Leviathan*, a famous work on "social contract theory," the English political philosopher Thomas Hobbes proposed the hypothetical "state of nature" (Hobbes, 1982). This state would lack rules to govern behaviors; everyone would be primarily concerned with his or her own interests. If no rules exist, then all actions furthering self-interests are permissible. For example, in the state of nature, if I wanted to take food from you by force because I was hungry, then I would be justified in doing so. Obviously, however, you would also be justified in doing the same to me. As a result of this absence of rules, claimed Hobbes, human life would be "short, nasty, and brutish," since respect for the lives of others in the pursuit of self-interests would not be a requirement. Hobbes believed that all would ultimately recognize that this mode of existence is not

119. For more on the broader, positive duties professions have to society, see Davis (2002).

beneficial, appointing a strong authority—a sovereign, the Leviathan, or something like a dictator—who would provide control and, therefore, protection.

Even without the appointment of a dictator, however, it is obvious that human interactions should be governed in a manner to avoid chaos. Toward this end, violations of laws are associated with forms of punishment. Laws, thereby, establish minimum standards all are expected to follow.[120] Ethics, by contrast, involves more than simply minimum standards. It involves care and concern with the effects of actions on the lives of others. Having different foundations, laws and ethics are instantiated in different ways. The following is a brief list of the ways laws and ethics can differ, some of which have been discussed previously:

- Laws establish minimum standard for behaviors and are legally enforceable. By contrast, ethics establishes standards for good—rather than simply minimally acceptable—behaviors and might not be legally enforceable.
- Laws are instruments of compromise arrived at through legislative decision-making, while ethics aims at the good and is based on the use of reason.
- Laws can be immoral and amoral, since anything can be made legal or illegal in a given social context, while ethics are concerned with actions that have the potential to seriously affect the lives of others, thereby applying to a potentially more limited domain.
- Laws are slow to develop, covering new sets of circumstances, while individuals can reflect on and reason about ethics at any time.
- Laws vary from society to society, while ethical principles should provide relatively consistent results, or differences in their results should be principled.

- For each of the instances listed above, give examples of ways laws and ethics differ. Where necessary, be sure to clarify/explain your examples.

10.4 ENGINEERS AND LAWS, INTERNATIONALLY AND CROSS-CULTURALLY

Having discussed the nature of laws, it is necessary to consider the relationship engineers should have to the law, especially in international and cross-cultural contexts, since laws vary and might be immoral. Given these conditions—and the previously outlined duties of engineers and employees—engineers might approach the law as follows:

1. Engineers have a *prima facie* (as an initial response) duty to obey laws. If no countervailing considerations exist, then this becomes an actual duty, regardless of the country or locality in which engineers are working.
2. Engineers should obey all local laws, assuming these laws do not have moral implications, in other words, that obedience to such laws would not have the

120. This is a conception of law based on "retributive justice."

potential to seriously harm others. Laws that strictly embody local customs and traditions, for example, should be obeyed.

3. When engineers are involved in several local contexts simultaneously, they should obey the strictest version of relevant nonmoral laws. In other words, if one set of laws captures all the major features of a second one but the second one does not capture all the major features of the first, then the first set of laws should be followed. In circumstances where nonmoral laws conflict, however, some prioritization might be necessary. In situations such as these, engineers should consider the specific set of circumstances in which they find themselves or adopt an additional principle, such as following the laws of the locality in which they are physically present.
4. Engineers should do their best to refuse to follow local laws that violate business and engineering ethical principles. The phrase "should do their best to refuse" is included to account for mitigating circumstances—an example of which is mentioned below. If no such conditions exist, however, then engineers would not be justified in violating ethical principles. In many cases, engineers will have to make individual judgments regarding the extent to which circumstances could be considered conditions excusing one from adhering to ethical principles.
5. Forms of coercion by local governments constitute mitigating circumstances, conditions that would excuse engineers from adhering to ethical principles.
6. Engineers should use their influence in local contexts to change laws that violate ethics. Even in circumstances where engineers have excusing conditions for violating ethical principles, they have obligations to try to bring about change.

- How might engineers use their influence in local contexts to change laws that violate ethics? List any examples of this with which you are familiar.

EXERCISE TWO—ENGINEERING AND PUBLIC KNOWLEDGE (PART TWO)

Referring back to the work you did in exercise one on Qihoo 360's P1 wireless router, reconsider steps 6–10 of the case-study procedure, noting any additional principles or concepts that might apply to your analysis of this case.

CASE STUDY TWO—ALIGNING INTERNATIONAL RESPONSIBILITY WITH LOCAL NEEDS: ENGINEERING AID WORK

Service in Engineering: Opportunities and Challenges

This chapter has highlighted some of the positive responsibilities of engineers, one of which is employing technologies to improve the situations of those in need. Engineering associations and nongovernmental organizations (NGOs) engage in such activities collectively, organizing and pooling resources. These engagements can face particular difficulties.

In engineering aid work, projects are often initiated and planned by people living in places and circumstances different from the anticipated beneficiaries of these projects, resulting in a potential disconnect between those designing technologies and those using them. Additionally, aid projects are generally funded with other people's money—donations or government funds collected through taxation. Efforts should thus be made to ensure that resources are allocated in an efficient manner—to maximize the benefits and minimize the costs associated with such projects. Insofar as engineers possess professional expertise, from a technological perspective, they are in a position to assess the anticipated benefits and costs of these projects.

To better understand the nature of engineering aid work and ethical issues associated with this work, the following case study examines three projects. Since water, energy, and food provide the very conditions of life—and the pursuit of these resources has often affected the environment in negative ways—the focus here is on projects related to the acquisition of these resources in Malawi, Nepal, and Indonesia. In addition to particular instances of good and bad, these projects also draw attention to more general problems associated with aid work and potential solutions. These include the potentially divergent objectives of those who initiate and provide funds to engineering aid projects and the beneficiaries of such projects and the importance of sensitivity to local practices and needs.

Water in Malawi: From Failure to Long-Term Sustainability

In 2009, Engineers without Borders, Canada, an engineering-related NGO, completed a gravity-fed water system in Machinga, Malawi. The systems consisted in a series of pipes running from clean water higher up in the mountains to water taps in the village. Just over a year after the completion of this project, less than half of the water taps installed still functioned. Although disheartening, this situation is not unique: many similar projects have been started—and failed—in this same rural village.[121]

Despite its proximity to Lake Chiuta, Machinga lacks a reliable source of clean water. Women and children often walk several hours to collect drinkable water. A variety of NGOs and nonprofit organizations worked to develop and implement solutions to Malawi's water problems and, in 2009, Engineers without Borders Canada (henceforth EWBC[122]) took on the task.

121. Perhaps the situation is not as bleak as it might initially seem: regarding the centrality of failure to innovation within engineering, see Petroski (1985).

122. Engineers without Boarders, Canada, falls under Engineers without Borders (hereafter EWB), an umbrella organization of NGOs. For more information on EWB, see their website at http://www.ewb-usa.org.

After the completion of the project, EWBC sent a team to evaluate the system, discovering many of the taps were not working, 81 of 113. Community members had attempted to patch pipes and fix broken taps, but due to a lack of available parts, they were unable to make the repairs. In addition to broken taps from the EWBC project, the team discovered taps from similar projects sponsored by other NGOs that had failed shortly after their completion.

Whether the installation of water taps or solar energy panels, consideration of long-term sustainability is one of the major problems with such projects. EWBC did not plan for either the long-term maintenance or the funding of the system. The funding structures of such projects present unique challenges as well. Unlike projects in either the private or corporate sector, the donors for aid projects do not necessarily have direct ties to the beneficiaries of these projects. As a result, the projects are often designed according to short-term interests of the donors rather than the long-term interests of the beneficiaries. This is common within the developmental sector, raising issues regarding the design and implementation of such projects.

Such questions have prompted changes in the ways such organizations deal with failures: EWB now publishes an annual failure report, so others can learn from and avoid similar mistakes, essential to the long-term sustainability of engineering aid work.[123] In recent years, an emphasis on user-centered design is another strategy employed to avoid or minimize failures associated with engineering aid projects:

- In your opinion, who is primarily responsible for the failure of this project? Justify your response.
- Should engineers have responsibilities to work on projects that benefit people geographically so far removed from themselves? Why or why not?

Biogas Digesters in Nepal: The Importance of Culture in User-Centered Design (Successes)

In 2008, the student chapter of EWB at the Technion—Israel Institute of Technology (hereafter Technion) worked closely with the 8000-person village of Namsaling, Nepal, to improve the design and creation of biogas digesters—devices used to produce gas for cooking and fertilizer for growing. Through consultation and work with local stakeholders, the student team gained a sense of the culture, needs, and values of those in Namsaling, resulting in the implementation of less costly digesters.

Biogas digesters can solve a variety of energy, environmental, and health issues in rural communities. Biowaste—animal and sometimes human excrement, along with weeds or other biological waste—are placed in the digester.

123. Based on Damberger (2011), Kampala, Chigwenembe, and Rabbani (2009), Mpaka (2015), Mpumulo (2014), Schmidt (2010), and Scott (2012).

As the material decomposes, it produces gas that can be pumped out and used as cooking fuel and to heat homes. The remaining waste can be used as a fertilizer for local farms and gardens. This gas reduces the amount of wood burned, therefore reducing deforestation and exposer to the toxic smoke and fumes produced by traditional wood-burning stoves, in turn reducing respiratory problems (Tugend, 2011). Therefore, the use of natural gas from biogas digesters contributes to environmental sustainability and the health of rural communities.[124]

When the Technion student project began in 2008, Nepal already had 200,000 biogas digesters in use (Stricker, 2010), although their construction cost considerable time and money. To build a digester of this kind, a large pit was dug and soil used to create a dome, often by the children of the community. Concrete was then laid over the dome, and soil removed to create the main chamber of the digester. Digging the pit, fashioning the soil dome, laying the concrete, and removing the soil afterwards required tremendous time and effort. Technion students believed they could design a cheaper, easier way of building biogas digesters.

Students made several trips to the village, "to work with villagers in defining and collecting data required for the design of sustainable and appropriate projects" (Lichtman, n.d.). Additionally, they worked closely with the Namsaling Community Development Center (NCDC), Biogas Sector Partnership (BSP), and families from Namsaling. The NCDC and families in Namsaling not only assisted in the development of a solution but also funded a third of the project (Tugend, 2011). With these partners, the team redesigned the dome mold used in the construction process.

Instead of using soil to build the dome, the team used bamboo—a material widely available in Namsaling. After the concrete on top hardened, the mold could be removed from the pit more easily and reused to create other digester chambers. This significantly reduced the amount of money and time needed to create digesters. After this new design was implemented, villagers reported a 36 kg reduction in daily wood use per family (Lichtman, n.d.). The Technion team's "deep acquaintance with the community" in Namsaling undoubtedly contributed to the success of this project (EWB, n.d.).

Students from Technion spent considerable time with the community stakeholders, learning more about their values and economic needs, for example, the Nepalese emphasis on family and respect for community members, which was important to the construction and use of the digesters. Additionally, the economic benefits associated with digester fertilizer are particularly significant: the fertilizer is used in Namsaling to grow important cash crops such cardamom and ginger (Namsaling village, n.d.). The success of this project emphasizes the importance of considering the values, needs, and circumstances of the Nepalese

124. See Forte (2011) for additional information on the use of biogas digesters in Nepal.

people affected by engineering aid projects. Even with the best of intentions, neglecting these considerations can result in the failure of engineering aid projects:

- In your opinion, who is primarily responsible for the success of this project? Justify your response.
- Did the financial contributions of the Namsaling community help this project to succeed? Why might the financial support of beneficiaries be helpful to the success of a project—versus projects funded entirely by external organizations?

Cook Stoves in Indonesia: The Importance of Culture in User-Centered Design (Failures)

To prepare food, make medicine, and heat water and homes in the winter, households in rural communities rely on open-fire cook stoves. However, these stoves cause various problems to the environment and to the health and safety of those using them. In Indonesia alone, an estimated 24.5 million households depend on these stoves, resulting in 165,000 premature deaths each year from stove-related air pollution. Additionally, women and children spend hours gathering wood to burn each day, taking up time and contributing to deforestation.

Different NGOs have worked to develop safer, more energy-efficient stoves, but the adoption and therefore effects of new stoves have been limited. In the last 50 years, redesigned stoves have been distributed to almost 830 million people worldwide, but studies estimate the number of people relying on traditional, open-fire cook stoves will not change in the next 15 years. These findings highlight the importance of considering local needs and circumstances in the formulation of engineering aid projects, and considering the case of an Indonesian government initiative is instructive.

To reduce household reliance on kerosene and biomass, in 2007, the Indonesian government launched a program encouraging a switch to the use of liquefied petroleum gas (LPG) stoves, which pollute less and are more efficient than traditional stoves. Despite providing households with free start-up kits that included both a stove and LPG, a survey taken a few years later found that, although many used the LPG stoves, over 50% of households also used the traditional, wood-burning stoves. In designing this program, the Indonesian government failed to consider all the needs of households and the ways they used the stoves.

Families generally use different stoves for different tasks, from cooking food to heating water. Some of these tasks are done inside, while others are done outside. Some of the new stoves were not mobile enough to be used both inside and outside. Additionally, larger families generally cook larger meals to feed more people, and the new stoves simply did not have the capacity to do so. This lack of attention to the social dimensions of technology contributed to the failures of the LPG stove project[125]:

125. Based on Aristani and Desa (2015), "Building Capacity," (2015), "Indonesia," (2013), Johnson and Bryden (2013), and "Clean Stove," (2014).

- In your opinion, who is primarily responsible for the failure of this project? Justify your response.
- Aside from those discussed above, list any engineering aid projects with which you are familiar. Would you consider these projects successes or failures? Why? What factors do you think contributed to the successes or failures of these projects?

Conclusion: The Benefits and Costs of Globalization in Engineering Aid Work

Technologies have the capacity to affect human life and the environment as never before, and engineers should strive to employ technologies to help those in need. As part of this trend, teams of engineer from one part of the world will increasingly work to design and implement engineering projects as solutions to the problems of groups in other parts of the world. While these trends in globalization have great benefits—improving processes and products by bringing more, different types of ideas and people together—they can also have costs.

Technical know-how alone in designing and implementing engineering aid projects is insufficient. Consideration should be given to the needs, values, and circumstances of the people engineering projects are meant to help. Geographic distances and cultural diversity are also features of globalization, and they can inhibit gaining knowledge of these needs, values, and circumstances. To move forward as a global society, however, acquiring such knowledge and understanding its impact on the adoption of technology is more necessary than ever.

EXERCISE THREE—ALIGNING INTERNATIONAL RESPONSIBILITY WITH LOCAL NEEDS

With regard to one of the cases above, complete steps 1–10 of the case-study procedure, using all relevant principles reviewed thus far.

10.5 SUMMARY

The case of Qihoo 360's P1 wireless router highlights problems associated with the public's ignorance of technologies. Although individual engineers have ethical duties associated with the work they perform, as a group, engineers also have responsibilities to the public—participating in public policy discussions on technologies, educating the public on the natures and consequences of technologies, and engaging with technologies to serve those in need. These responsibilities follow from the gulf that exists between understandings of technologies by engineers and the public, and the professional expertise of engineers. Although laws can aim to address and correct these problems, laws are not the same as ethics, and alone laws are incapable of addressing and correcting such problems. For these reasons, it is important that engineers be cognizant of differences between laws and ethics and how to engage with laws, especially in international and cross-cultural contexts. As the case of Aligning International Responsibility with Local Needs makes clear, in carrying out aid work, engineers should take into consideration the needs, values, and circumstances of the beneficiaries of these projects. This is especially true in international, globalized environments, where a failure to do so can result in wasted time, effort, and money.

REVIEW QUESTIONS

1. Describe three ways engineers abused their power and ignored their responsibilities toward the public in the case of Qihoo 360's Pl wireless router.
2. With reference to the work of Charles Snow, explain the difference between how the sciences conceive the world and how the humanities conceive the world.
3. Explain the differences between the traditional and superculture views, as outlined by Kenneth Boulding. Do you think this perspective is more accurate than that of Snow? Why or why not?
4. Describe one broader responsibility that engineers have to the public and why this responsibility is the basis for a principle of involvement.
5. Provide an example of engineers fulfilling each of the principles of involvement described above. Why should these apply to groups of engineers rather than individual engineers?
6. Explain three differences between laws and ethics and provide examples of each.
7. List and explain two circumstances contributing to the fact more engineers are not involved in public discussions concerning technology. What consequences could this lack of involvement have on the public?
8. What is a major difference between the principles outlined in this chapter and the principles outlined previously? Why is this significant?
9. How should engineers go about educating the public? Give two examples.
10. Why should engineers disregard local laws that violate engineering ethical principles? At what point does a law cease to be ethical? Again, give two examples.
11. With reference to the second case of Aligning International Responsibility with Local Needs, list two reasons for successes and two reasons for failures of engineering aid projects.

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