CHAPTER 11: ETHICS AND DESIGN

Chapter outline

- Ethics in design
- Nature and scope of design consequences
- Good design and ethical design
- Ethical decision-making

Key guidelines related to ethics and design

- Consider the impact of your design in relation to:
  - development and testing
  - manufacture
  - users
  - society
  - end of life of the design
- Consider ethical decision-making in relation to:
  - cost-benefit analysis
  - risk assessment
  - organizational context
  - regulatory compliance

The first thing to recognize about engineering ethics, and professional ethics generally, is that they do not entail a fundamentally new and different *basis* for ethics than you already have. Professional ethics do not ask you to adopt one set of values at the workplace and another set in your personal or civic life. Logically and ethically, the founding principles of our actions must go deeper than circumstance. This means that your personal and professional ethics are not entirely divorced from one another.

Personal and professional ethics ultimately rest on the same foundation of moral commitment, even though above ground they may branch out in different directions and entail different responsibilities as the context varies. If we ignore that common foundation, we would make professional ethics an ethics of convenience or an exercise in mere rule-following. Ideally, professional ethics should be an extension of the ethical values you already hold, carefully and responsibly applied to your professional work in recognition of the duties and consequences particular to it. Without this common foundation, studying professional ethics would not mean anything.

But this is not to say that there is no difference between personal and professional ethics. Although the underlying values will have much in common, professional situations entail fiduciary obligations and involve profoundly new and different *contexts* for your actions—contexts that could entail far-reaching ramifications for others. This difference in context means that your actions take on a different significance when they are part of your professional work. This is the reason that professional organizations create and promote their own codes of ethics. For example, the National Society of Professional Engineers, NSPE, publishes a Code of Ethics for Engineers that attempts to lay out, in a general sense, the basic ethical duties an engineer assumes as a professional.

What is different about ethics in the professional context? Ethics, at its most basic level, is about taking responsibility for your actions by anticipating their potential consequences—both intended and unintended—and acting so that those consequences will be positive. As future engineers, your professional work may greatly influence your users, your community, and even society at large—perhaps in non-obvious ways. Personal integrity is essential. But integrity and good intentions are only prerequisites in a professional environment in which you are entrusted with specific responsibilities whose exercise can have complex and far-reaching implications for others. You must also gain skill in understanding, anticipating, and managing these responsibilities.

11.1 ETHICS IN DESIGN

In fact, additional responsibilities are incurred by professionals generally—from doctors to lawyers to professors. What primarily distinguishes engineering from all other professions is the subject of this course: *design*. Design means the development and creation of new products and systems that collectively can substantially affect society—for better or worse. Thus, ethics in engineering means that you—the designer and your design team—are accountable for helping shape the impact that your design (and the processes that surround it) will have. Only such an approach will allow you to manage those consequences and do what is possible to ensure that they are positive.

Of course, engineers do more than just design things. They may be consultants or advisors in a variety of contexts, and there are other aspects of ethics relevant to engineering (professional ethics, conflicts of interest, endorsements, confidentiality, teamwork, etc.). But as this is a course on the primary task of engineers—designing and building things—we'll focus primarily on ethics in design. That actually turns out to have fairly broad implications.

Ethical engineering—that is, engineering that hopes to maximize its positive effect on users and on society—requires addressing complex design questions ranging from the selection of the problem to the choice of a design solution and its manufacture; from the method of testing to the post-market life of the product. This is because these consequences exist not just in the use of the design, but throughout its whole lifecycle, from development through testing, manufacture, sale, deployment, use, disposal, and beyond. Every phase of the design's life carries social implications, and thereby presents ethical risks and opportunities.

Thus, engineers must try to anticipate likely consequences—and even unlikely ones—at each stage as much as possible. Ethics in design is not about simply having good intentions, any more than design itself is. Just like design, it is about results. The better you account for the potential impacts of your design, the more you can control the effect it will have in the real world. This is a core part of an engineer's competence—not an optional specialty. It is also one of the more difficult skills to master.

Of course, there are reasonable limits to this principle. No one can be held personally responsible for everything that follows from every action he or she takes, if for no other reason than we are not omniscient, and cannot predict (or even know after the fact) all of those consequences. But taking responsibility simply means making the effort to anticipate as many potential consequences as we can.

11.2 NATURE AND SCOPE OF DESIGN CONSEQUENCES

Like design itself, ethics involves more than just safety. A design is not automatically a good one merely because it is safe; still, an unsafe design is probably *not* a good one. Similarly, an unsafe design is probably *not* an ethical one; but a safe design is not automatically an ethical one, either. Safety is just one necessary aspect to both good and ethical design. An understanding of the full lifecycle of a design, and the many other impacts it can have, is crucial to understanding what else may be involved. Let's consider the main areas in which a typical engineering design may make its impacts.

1. <u>Development</u>. First, a design must be developed and tested. This means selecting a problem to be solved—ideally, if the option presents itself, one that will address a basic unmet need for many people rather than, say, just offering another consumer good. Though fewer engineers are fortunate enough to have this opportunity, it is worth noting that this initial decision—what need will my design fill?—is probably the most important determinant of just how much good the effort can yield. In any case, once an initial design has been arrived at, it must be tested. But this testing can carry inherent risk to the subjects. The source of the subjects can also present ethical concerns, particularly in medical trials.
2. <u>Manufacturing</u>. Second, the engineered product will very likely involve the use of natural resources—for example, steel or petroleum-based plas-

tics in the finished product or in the parts that go into it. These natural resources are finite, and so should be used wisely. Obtaining these resources also presents economic, environmental and social costs, especially when these resources are found only in politically or economically unstable regions of the world (for example, demand for the mineral Coltan used in cellular radios has helped fuel civil war in the Congo). In addition there is the manufacturing phase itself, which consumes further natural resources in the form of energy and can also significantly influence the health and safety of the workers.

3. User Impact. Here safety is the most apparent factor, but it is not the only one. Users may be positively or negatively impacted in many ways; for example, a design failure may not hurt anyone physically, but could still present personal or financial costs to the user. This area of impact is reflected in the engineering design goals; but only if those goals account for *all* the ways the product may impact the user will the design goals include the ethical dimension. It is not always easy to tell when this is the case. Also note that some of these effects may only become apparent after a product is released and used on a large scale in different environments.
4. Social Impact. Not all impacts are borne by the users. Many of them make themselves felt much more broadly—even by all of society. Among the examples here are automotive emissions, which affect everyone, regardless of whether or not they drive. Technologies may also have profound effects on the structure of society, as has, for example, the Internet, or the increasing costs of medical technology. These are often the most difficult effects to predict, control or account for, but they are also among the most consequential in all of engineering. Anything that can be done to ameliorate these negative ramifications can pay major dividends, both ethical and economic.
5. End of Life. Finally, there are the impacts your design may make at the end of its useful life. Just as the consequences of your product began to be felt even before it was made, its impact continues after it is disused. When a product is disposed of, there is a range of potential positive and negative consequences. On the one hand, if the product contains valuable natural resources that can easily be recovered, its disposal presents an opportunity to prevent further natural resource consumption. If on the other hand it contains toxic elements that cannot easily be reprocessed, the end of life of the product can present a worse health and environmental threat than it did during its manufacture or useful life. In addition, these costs are often not borne equally across all economic strata of society, presenting further ethical considerations. For example, certain poorer parts of Asia have become dumping grounds for old electronics containing toxic materials.

Note that while it is helpful to consider these various areas of impact individually, in practice all of them are unified in the design process. After all, the nature of the design determines, or at least heavily influences, the materials, manufacturing, safety, and end-of-life issues. Of course, issues in some of these areas may also arise after the design has been completed; at that point the available options for how to respond to the issue will not include design alternatives, and ethical solutions independent of design will be required. Table 11.1 provides an overview of the lifecycle stages of a design along with examples of the accompanying ethical considerations.

Table 11.1: Examples of ethical considerations in each lifecycle stage

Lifecycle stage	Example ethical considerations
Design, development and validation	Setting design goals, user testing, clinical trials
Manufacture, assembly, distribution	Mining, petroleum and energy inputs, outsourcing, worker safety
Direct impact on users and customers	Safety, reliability, performance, cost
Social/environmental impact of design in use	Internet, auto emissions
Social/environmental impact of design at end of life	Pollution, disposal, recyclability

It may seem that many of these impacts, while important, are too large for any individual engineer, or even any single design, to be able to influence. It would, for example, certainly be difficult for engineers on a medical device team to do anything meaningful about the high costs of healthcare to which their product might contribute—though they might be able to do something to hold down costs for their own product.

Nevertheless, all engineers should still be thinking about these impacts for a number of reasons. First, it is important for each of us to better appreciate the full context of our work for personal reasons and as informed citizens in a democracy. Second, if everyone on a project had such awareness, the positive changes possible would become greatly magnified, just as they would if everyone in an industry attained such awareness. And third, you may be in a position later in your career, as a team leader, project manager, or even a CEO, where you will be able to exert a more substantial effect.

Moreover, many of these impacts will be under your influence for at least your product. While it will always be more difficult to influence the global scale, the differences in your product alone—preventing a failure mode or refining the user testing—could make all the difference in the lives of those who come into contact with it.

11.3 GOOD DESIGN AND ETHICAL DESIGN

Ethical consideration must be integrated into the design process because it is in design that all consequences are best accounted for, and negative ones minimized or eliminated as possible. Can we say, then, that the ethical dimensions are already accounted for in ordinary engineering design? That ethical design just *is* good design? There is some truth to this. But it is not the whole truth, because not all important ethical considerations—i.e., not all the impacts a design may have—are directly built into normal engineering design goals. Indeed, many of the most important social impacts a design makes may not factor into typical engineering design criteria.

For example, vehicle fuel efficiency can be a selling point for the buyer and at some level is likely to be an explicit engineering design goal; but this consideration does not reflect the full social impact of burning fossil fuels, especially when gas is cheap. Likewise, safety has aspects that affect the users and aspects that could affect others. The aspects that affect others, such as pedestrian safety, are not likely to factor directly in customer safety needs, such as crashworthiness. Therefore, without regulations (which now exist), pedestrian safety would not always factor into the explicit design goals. But a more ethical design approach would proactively identify and address these factors, since they are important consequences of the product in the real world.

So considering the user's (or client's) needs remains central to the design process. But ethical, responsible design will consider other needs as well. Engineers, like all professionals, have a responsibility that extends beyond our users or customers and encompasses our broader role in society. This is one crucial aspect that distinguishes engineering ethics from ordinary "good" engineering. It isn't *exclusively* about your immediate users and customers, because—as we have just seen—the impacts of engineering touch us all, directly and indirectly, before and after use. Engineering ethics ultimately means expanding the metrics used to evaluate a design, considering aspects that begin with but might go beyond immediate and obvious user needs. Engineering ethics is a matter of *scope*.

This scope, as we saw above, also extends beyond consideration of the product *per se*, and includes the processes that inevitably accompany it—from testing to manufacture to disposal. Explicit engineering design goals traditionally focus squarely on the product itself. They may implicate peripheral processes—for example, manufacturability—but typically only as they relate to the end result of the product itself (for example, simplifying manufacturing to keep the unit cost low). Engineering ethics, on the other hand, must be concerned with processes for their own sake—for example, whether the testing phase is conducted safely or whether the product can be efficiently recycled. For all these reasons, ethics is not an extraneous layer added on top of engineering design; it is integral to good design—and yet it is not reducible to good design alone.

11.4 ETHICAL DECISION MAKING

Thus, in ethical design, thinking through the many potential impacts of your design, and the choices you've made, is essential. But it is only the first step. Once you have identified areas of concern, what should you do about them? There is no simple answer to this question, if only because every design, every problem, and every environment is different. But there are some basic guidelines, scenarios and information that can be helpful.

11.4.1 Cost-benefit analysis

One common approach to addressing problematic design consequences is the cost-benefit analysis. This seemingly simple idea involves comparing the costs of fixing the problem with the cost of the impact if nothing is changed (or comparing the costs of various fixes with each other). This theoretically straightforward approach offers an important perspective, but it is actually fraught with complex ethical questions. The foremost among these is that, if the identified impact involves the risk of death or injury, it requires placing a dollar value on human suffering or even on human life. Only then can the costs be compared on a dollar basis. On one level, this valuation may seem abhorrent. But there are many cases where this is necessary, particularly when the scale of the issue is very great. For example, in crafting safety regulations that will govern entire industries, the government agency in charge must use some dollar figure to compare the benefits in saved lives to the cost of the proposed rule. If they did not, we would go broke trying to eliminate every conceivable risk. But this approach requires tremendous care. History is replete with cases where a company cut corners figuring that the cost or risk was cheaper than doing things right—and people paid with their lives.

The other major ethical dimension involved in a cost-benefit analysis concerns how the costs are counted. Even when a dollar value is used to count lives saved, those lives must be accounted their full value regardless of whether or not they represent *literal* costs to the company. If not, a cost-benefit analysis could ignore those harmed so long as they do not represent actual monetary expenses that the company is likely to bear. If those harmed do not figure into the calculations, the result can be to justify deeply unethical decisions based solely on the company's own financial interests.

It is worth noting that, historically in those cases, when the company's reasoning became public, the damage to the company's reputation often became an enormous cost, one that had also not factored into the analysis. These impairments to reputation can take years to recover from. Many firms never do.

11.4.2 Risk assessment

Whether or not a cost-benefit analysis is used, the likelihood and prevalence of the impact requires attention. That is, how likely or common is the negative impact to be and for whom? Is it a risk that all users bear or only users in certain circumstances? Is it a risk that can be avoided if users follow directions and use the design properly? If so, how likely are they to do that? And will the users be aware of the risk? Alternatively, the issue may not be a risk for the user, but for someone else—perhaps a factory worker assembling the product or the person who disposes of it. It may also be a risk that is not specific to anyone but is socially distributed, such as groundwater contamination after disposal. It may even be one that presents itself to an entirely different population than your user base, as when electronics containing toxic elements are crudely recycled in poorer parts of the world. In any case, evaluating the magnitude of the risk can be a very thorny technical problem, and attempts to place numbers on it can profoundly influence the decision of what, if anything, to do about it. These technical issues cannot be addressed here, but the ethical duty can be: to be honest and unbiased in the attempt to assess that risk, and recognize to whom it applies.

Once a problem has been detected, and its nature and risk level examined, the obvious next question is what to do about it—whether that means changing the design itself, the materials used, the processes to manufacture it, or simply issuing safety guidance to the user. Clearly, whatever is decided on, that alternative presents a new variation of the design—which then itself must be analyzed. This is the normal, iterative design process, but, as above, with additional metrics in mind. Also note that, as with the regular design process, choosing what to do about a negative impact will involve the creative generation and comparison of many potential alternatives, not just the first solution you think of. There may not even be a clear-cut "fix." The goal, as always, is to find the best compromise solution.

11.4.3 Organizational contexts

In the foregoing, it was assumed that you, as the engineer, have direct influence on the design and the choices that go into it. In DTC, although you work within a team and with a client, this is largely the case. In industry or other professional environments, however, the context is very different. You may still be part of a design team, but you will most likely also be part of a larger, complex hierarchical structure. You will report to a manager; and above him or her, there is an executive management team, a corporate board, perhaps even shareholders. In addition, there may be other teams competing for resources, higher-level corporate goals, company policies, market conditions, indeed, innumerable other factors that may influence the conditions of your work. All of these may constrain your ability to make decisions.

So, if you are working on a design and have identified an undesirable outcome it is likely to have, the first question that arises is what scope you have to make changes that would help. In many cases, if it is an ordinary design refinement, consulting with your team and manager to arrive at a superior design will suffice. However, some changes may be more fundamental or may involve other aspects of the overall project. In such cases, you may need to raise the issue with those in higher level positions or with those working on the relevant aspect of the project. Companies will often have explicit channels for raising such concerns, but typically it will begin with notifying your team leader or manager, who then assumes the responsibility for seeing that the problem is communicated to those with the authority to do something about it.

There may even be cases where the impact is serious or specific enough that those who would actually be impacted (e.g., end users or community members) should be brought into the decision-making process to offer their own input. This is especially true in cases where there is a particular, inevitable and consequential tradeoff to be made.

It is conceivable that there may perhaps come a time when you perceive a major ethical problem with the way that things are being done in your organization—whether that be a dangerous design flaw, a troubling safety record or some other problem—that you are unable to satisfactorily resolve within your organization's official processes. If this should occur, many larger organizations today offer one additional channel: an ethics office. In fact, even Northwestern University operates one (see www.northwestern.edu/ethics). The purpose of an ethics office, among other roles including education and regulatory compliance verification, is to serve as a confidential venue for reporting ethical concerns. If you feel the need to, you should not hesitate to take advantage of this important avenue, particularly if you believe you have exhausted conventional channels and that the problem poses substantial risks.

Of course, in extreme cases, it is possible that even the ethics office, assuming it exists, will not be able or willing to do enough to address the problem. In these cases, you may be forced to consider becoming a “whistle-blower.” The term simply refers to someone who publicly “blows the whistle” to call attention to problems as a last resort to getting them addressed. The “whistle-blow” may take the form of contacting the media, the government, or even a lawyer. The intent in each case is to apply pressure from outside the organization to force it to address the problem. While some of the most important cases in recent history have been initiated by conscientious whistle-blowers (including, for example, cigarette dangers), it is also true that whistle-blowing can be personally a very risky thing to do, threatening relationships as well as employment and even resulting in lawsuits. However, if the issue is important enough, potentially affecting many people or threatening serious injury, you may have no ethical choice but to go public. Fortunately, such cases are not common. In addition, federal law today exists to protect and even reward whistle-blowers.

11.4.4 Regulatory compliance

Engineers, and even entire engineering companies, do not operate in a social vacuum. Because of the large impact of engineering and engineered products on society, there are a plethora of laws, regulations and codes that govern its practice and products. Regulations are part of the social compact between industry and society. Society desires the products of industry—whether they be iPods, automobiles or new drugs—but not at any cost. Regulations, abstractly speaking, exist to mediate the quality of and the means by which these products are developed and sold. Complying with these regulations is thus also an ethical, as well as legal, responsibility.

We cannot hope to cover all or even many regulations here. But you should be aware that they exist, and of the important role they play, so a rough overview of our regulatory system is in order. The regulatory environment is very different for the different phases of a product lifecycle described above. Different federal agencies, for example, will have jurisdiction over different kinds of activities. Below are a few of the more prominent ones in the U.S., and a basic idea of their purviews.

Environmental Protection Agency (EPA). The agency most responsible for preventing the pollution of air, water and land, the EPA has rules which may influence all phases of the product's lifecycle, from mining for raw materials to production waste products to the energy efficiency of the final product itself.

Occupational Safety and Health Administration (OSHA). OSHA is responsible for establishing and enforcing safety standards for the workplace, including industrial sites. Their rules may influence manufacturing aspects in order to protect factory workers.

Food and Drug Administration (FDA). The FDA is charged with protecting the safety and efficacy of all medical products (drugs and devices) as well as the safety of many foods. If your product is a medical device or a drug, you must have FDA approval to market it in the US. This often requires clinical studies demonstrating both safety and efficacy. The FDA also regulates promotion and marketing claims for the products it has jurisdiction over. It shares its jurisdiction over food products with the United States Department of Agriculture, USDA.

Federal Trade Commission (FTC), including their Bureau of Consumer Protection (BCP). The FTC's mission is to promote fair and honest competition across all sectors of industry. To this end they regulate advertising and product claims, among other things. Their rules may influence sales policies and product marketing. For food, drugs and cosmetics, FDA has primary jurisdiction.

Consumer Product Safety Commission (CPSC). The CPSC is a small agency, but it has a large job. It is responsible for policing the safety of any product not regulated by FDA or other agencies. For example, it has rules around lead content in children's toys. The CPSC can mandate recalls of products it determines are toxic or otherwise unsafe.

Local regulations. There are of course an unlimited variety of local laws. Building codes are one important example. Codes are set by states and municipalities and govern in detail the construction standards of new buildings. There may also be local regulations around many other activities relevant to engineering.

This list is just a sampling of some of the more prominent sources of regulation in this country. Other countries will often have comparable agencies. The point is that the engineer, or someone in his or her company, must be fully aware of the relevant regulations. Ignorance of the law is never considered a valid defense and unfortunately some of the regulations can be complex. If you are doing business internationally, you must comply with the local laws everywhere you operate, which adds to the complexity. Many organizations have entire offices, called compliance departments, dedicated to understanding, keeping up with, and ensuring compliance with applicable regulations.

But smaller companies lacking such departments are often equally subject to the laws, and must find a way to become aware of and comply with them.

11.5 CONCLUSION

It should be clear by now that ethics in engineering is not any one skill. It is not confined to any one area or stage of engineering. Nor is it a skill that is ever fully mastered. Rather, it is suffused throughout engineering practice, in ways large and small. And it is a skill that you will continue to hone and grow in throughout your career. The main premise of engineering ethics is to always keep in mind the potentially profound impact your work may have—and which engineering, collectively, certainly has—both locally and globally, on your users as well as on society.