ENGINEERING ETHICS PART I – THE PLACE OF ETHICS IN ENGINEERING DESIGN

What is Engineering Ethics?

The first thing to realize about engineering ethics, and professional ethics in general, is that it is not a different form of ethics than you already know and practice – it is only a new context for your ethics. This means that your personal and professional ethics are not really separate things. Quite the opposite, in fact; nothing can replace your own personal moral grounding. Without this foundation, studying professional ethics would not mean anything. Our personal moral identity remains the source of our motivation to be ethical, and the core of our ethical instincts. But that alone is not always enough in professional situations.

What is different about ethics in the professional context? What you do professionally may impact many, many people in complicated ways. Personal integrity is essential. But having a conscience is not enough when you either don't know what you should do, or don't even realize there is an ethical dimension involved. Ethics in general is about taking responsibility for your actions and their consequences, both intended and unintended. As future engineers, your work may profoundly impact your users, your community, and society at large – perhaps in ways you did not anticipate.

In fact, this is true of professions generally – from doctors to lawyers to professors. What distinguishes engineering from all other professions is *design*: the development and creation of new products and systems which collectively have the capacity to profoundly affect society – for better or worse. Thus ethics in engineering means that you – the designer and the design team – must take responsibility for the impact of your design, both in its intended function and in its unintended consequences.[1] Only such an approach will allow you to manage those consequences, and help ensure that they are positive.

Ethical engineering – that is, engineering that hopes to maximize its positive effect on society – requires addressing complex design questions ranging from the selection of the problem to be solved by the design to the evaluation and selection of a design solution and its manufacture; from the testing of the design to the post-market life of the product. To do this, engineers must try to anticipate likely consequences – and even unlikely ones – as much as possible. It is crucial to recognize that 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 consequences, and thereby presents ethical risks and opportunities.

Ethics in design is not about having good intention, 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; it is not an optional specialty. It is also one of the more difficult skills to master.

[1] Of course, engineers do more than just design things, and there are other aspects of engineering ethics (professional ethics, conflicts of interest, confidentiality, teamwork, etc.). But as this is a course on the primary task of engineers – designing and building things – we'll focus on ethics in design. That actually turns out to have pretty broad implications.

Of course, there are reasonable limits to this principle. No one can be held personally responsible for everything that follows from every action they take 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.

What kinds of consequences – and where?

These impacts are not limited to the direct performance and safety of the product itself, as important as that is. Like engineering design, engineering ethics involves much more than safety. A safe design is not necessarily thereby a good design; however, an unsafe design is probably not a very good one. Likewise, an unsafe design is very probably not an ethical one, but a safe design is not all there is to an ethical one. Ethics and safety remain distinct.[2] An understanding of the full lifecycle of a design, and the many impacts it can make within each stage, is crucial. Let's consider the main areas in which a typical engineering design may make its impacts.

1. Development

First, a design must be developed and tested. This first means selecting a problem to be solved – ideally, if the option presents itself, one which will address a basic unmet need for many people rather than, say, another consumer good. Though fewer engineers are fortunate enough to have this opportunity, it is worth noting that this initial decision – what need will it fill? – is probably the most important determinate of just how much good the effort will yield. In any case, once an initial design has been arrived at, it must be tested – or in the case of medical products, undergo clinical trials. But this testing can carry inherent risk to the subjects.[3] The source of the subjects can also present ethical concerns, particularly in medical trials.

2. Manufacturing

Second, the engineered product will very likely involve the use of natural resources – for example, steel or petroleum-based plastics in the finished product or in the parts which 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

Third is the most obvious area: the direct impact of the design on the people who use it. 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

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[2] Note that this is relative – an unsafe design is a design that is not as safe as it could be given all constraints, not a design that has any risks at all.

[3] We will have a later discussion on ethics in user testing

or financial costs to the user. This area of impact is the most closely tied to the actual engineering design goals; but only if those goals encompass all aspects of the product's user impact will the design goals be the same as 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.

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. This is the fourth area of impact. Among the examples here are automotive emissions, which affect everyone, regardless of whether 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 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 are a range of potential positive and negative consequences. If the product contains valuable natural resources that can easily be recovered, its disposal presents an opportunity to prevent further resource consumption. If on the other hand it contains toxic elements which 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.

Note that while it is helpful to consider these various areas of impact individually, in practice all these areas are unified in the design process. After all, the nature of the design 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.

Lifecycle stage	Example areas
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

Too big a scale?

It may seem that many of these impacts, while real, 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 an engineer 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 on the margins 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 citizens. Second, if everyone on a project had such awareness, the changes possible become greatly magnified, just as they would if everyone in an industry attained such awareness. And thirdly, you may be in a position later in your career, as a team leader or 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 life of your users.

Good design and ethical design

Ethical consideration must be integrated into the design process because it is in design that consequences are best accounted for, and negative ones minimized or eliminated as possible. Can we say, then, that design ethics is 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 can have – are directly built into other ordinary engineering design goals. For example, 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 is likely to be an explicit engineering design goal; but this consideration does not reflect the true 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 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 needs remains central. But ethical, responsible design will consider other needs as well. Engineers, like all professionals, have a responsibility that extends beyond their users or customers. 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 seen – the impacts of engineering touch us all, directly and indirectly. Engineering ethics ultimately means expanding the metrics used to evaluate a design, taking into consideration aspects that include but might go beyond immediate and obvious user needs. Engineering ethics is a matter of *scope.*

This scope, as we saw above, may even extend beyond consideration of the product *per se*, and include the processes that necessarily surround it – from testing to manufacture to disposal.

Engineering design goals traditionally focus squarely on the product itself. They may address associated processes – for example, manufacturability – but they typically do so as they relate to the end result of the product itself (for example, keeping the unit cost low). Engineering ethics, as we have seen, 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.