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Engineering Ethics: Integrating STS and Practical Ethics

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Introduction

With some exceptions, STS scholarship seems largely to avoid taking explicit normative stances. While rarely if ever stated, it is not uncommon to hear STS scholars trained in the social sciences claim that their job is to illuminate the social processes by which arguments achieve legitimacy, rather than use their understanding of those processes to establish the legitimacy of their own arguments or positions. This reluctance to take a normative stance has been noted by several STS scholars. Most prominently, Bijker (1993) argues that STS began on the path of critical studies, took a break from being proscriptive in order to build a firm base of knowledge, and now needs to get back to the original path. "Seen in this perspective," he writes, "the science and technology studies of the 1980s are an academic detour to collect ammunition for the struggles with political, scientific, and technological authorities" (Bijker, 1993, p. 116). In the same year, Winner published his "Upon Opening the Black Box and Finding It Empty" in which he critiques STS theory on several grounds including "its lack of and, indeed, disdain for anything resembling an evaluative stance or any particular moral or political principles that might help people judge the possibilities that technologies present" (Winner, 1993, p. 371). Despite these promptings, little has changed in the STS community in the past decade.

Avoidance of the normative has the consequence of holding STS scholars and the field back from making recommendations for change that will improve the institutions of science and engineering. As well, it runs the risk of hiding the normativity that is often implicit in STS analysis. Despite the reluctance to take normative stances, most scholars, inside and outside STS, generally acknowledge that new ways of understanding often allow us to see new ways of acting. New ways of understanding reveal new possibilities for institutional arrangements, new approaches to decision-making, new forms of intervention, and so on. Thus, it would seem that STS concepts and theories have the potential to inform the institutions and practices of science and engineering and, thereby, to contribute to positive change.

Of course, ‘the proof is in the pudding.’ The aim of this chapter is to see whether STS concepts and theories can be used for normative analysis. We will focus on the fairly young but explicitly normative field of engineering ethics. Engineering ethics is normative insofar as it: critically examines the behavior of engineers and engineering institutions; identifies behavior, practices, and policies that seem unethical; and makes recommendations as to what engineers should do individually or collectively in a wide range of situations. In this chapter we will consider how STS insights can inform and improve the field.

To be clear, our aim in this chapter is not to convince STS scholars to take normative stances; nor is our aim to convince STS scholars to acknowledge the normative stances they implicitly take. Rather, we want to point to resources that STS can provide to scholars who work on engineering ethics, and to demonstrate the potential of STS to transform normative analysis of engineering. The analysis can be beneficial to both communities. On the one hand, it will facilitate engineering ethicists in utilizing the lessons of STS, and on the other hand, it will encourage STS scholars to recognize the potential of their work to help engineers and others build a better world. We acknowledge that we are not the first to attempt to do this. We have benefited enormously from the work of Kline and Lynch (2000), Brey (1997), and a few others.

The Development of Engineering Ethics

While we cannot provide a complete history of the field of engineering ethics, it will be helpful to sketch some of the key elements in the development of the field. In particular we want to emphasize that the field has developed on the basis of two presumptions: 1) that ethical concepts and theories are useful in informing engineers about how to behave; and 2) that the technical and social are separable. We have less to say about the first presumption though it is essential to understanding the current state of the art in engineering ethics. STS provides a critique and alternative to the second presumption.

It seems fair to say that the field of engineering ethics developed in the U.S. in large part during the second half of the 20th century in response to increasing concern about the dangers of technology. A sequence of events, starting with the shock of World War II and the use of the atomic bomb, continuing with the unfolding revelation of the effects of DDT, and persisting with the occurrence of the Three Mile Island disaster, the Ford Pinto case, and the explosion at Bhopal, generated a significant amount of concern in the media and the public about the effects of technology on human well-being. After decades of seemingly unmitigated praise, many Americans began to wonder if technology wasn't going to 'bite-back' and make us 'pay' (in negative consequences) for the improvements it had provided.

Fingers were pointed in a number of directions. Corporations and governments received a fair amount of blame. For instance, the U.S. government was denounced for its promotion of DDT, and Ford Motor Company and Union Carbide were the target of substantial criticism as well as lawsuits for the fatalities linked to their products. But a number of social critics, engineering professional associations, and the popular media also began to question why engineers—those professional heroic, trustworthy, progress-bringing engineers who were presumably dedicated to the public good—let such catastrophes occur on their watch. They contended that there must be something wrong with engineers as well and that perhaps one of the best ways of fixing the problem of technology was to fix engineers—to make them more ethical.

A number of scholars—borrowing from progress that had been made in medical- and bio-ethics—argued that a key to making engineers more ethical was to introduce them to the principles and tools of philosophical ethics [See Hastings Center volumes (1980)]; a strategy or approach that came to be known as 'applied' ethics. Ethical concepts and theories could be used in thinking through the circumstances of engineers; ethical theory and training in ethics would allow engineers to decipher the right choice with rigor and justification, rather than with 'gut' feeling or intuition. Ethical theory seemed to put ethics on a secure, rational platform when ethics otherwise seemed to be so subjective.

An important project in this era illustrates the movement in this area and the strategy that was adopted. During a stint at the National Science Foundation, Robert J. Baum, a philosopher, started a new program focused on the Ethical and Value Implications of Science and Technology (EVIST). Upon returning to Rensselaer Polytechnic Institute he obtained a large grant from the National Endowment for the Humanities to fund engineer-ethicist pairs to work on ethical problems in engineering [citation]. The idea was that knowledge of ethics and knowledge of engineering were both needed to understand the ethical issues in engineering. Thus the project encouraged engineers and ethicists to join forces and learn from each other as they worked through a topic in engineering ethics.

By all measures, this project was highly successful in jumpstarting the field of engineering ethics.[1] By the 1980s, an academic field commonly referred to as engineering ethics—made up of philosophers, engineers, historians, and social scientists—had begun to form. These scholars generally agreed that ethical theories and concepts could be useful tools for addressing the ethically dilemmas facing engineers [citation?]. The history of engineering was also thought to be important, especially in providing case-study examples that could be used to explore the circumstances of engineers and what made them successful or unsuccessful at addressing ethical issues in their practice, individually or collectively. The underlying belief seemed to be that engineers were more likely to behave well if they were exposed to ethical theories and trained in using the theory on cases. A dose of ethical theory was seen as a promising antidote for the temptations and pressures that led to engineers behaving in unethical ways. Engineers and engineering students were thus introduced to philosophical concepts and theories like Kant's categorical imperative, utilitarianism, and ideas of rights and dutieswhich could then be applied when issues arose around obligations to employers, property rights, trade secrecy, conflicts of interest, and the temptation to lie.

As this new field laid out potential dilemmas and illustrative case studies, the boundaries between the two disciplines that engineering ethics sought to bring together—engineering and philosophy—could be seen. The manner in which engineering ethics problems were presented seemed to presume a fundamental separation between, on the one hand, technical expertise and, on the other hand, the context in which engineering is practiced. The context in which engineering is practiced was understood to be that of business. In other words, there was thought

[1] In addition to producing a large number of the first, ground-breaking papers in the field, Michael Martin and Roland Schinzinger began working together as part of this project. They later produced one of the most widely used textbooks in the field. Michael Pritchard, a co-author of another engineering ethics primer, also was involved in this project.

to be a distinction between engineering knowledge and the business environment in which that knowledge was used. The divide between the technical world of engineering and the world of business – a world in which engineers are employees responding to non-technical, externally imposed real-world ‘constraints’—was seen as problematic

In many of the cases and several of the engineering ethics textbooks, the situation of engineers is described as if during normal, technical activities, such as design, ethics is not necessary. But once the technical work is done, outside forces are exerted to change the direction of technical practice, and ethical considerations may come into play and ethical analysis might be needed. Evidence of this framework is seen in the emphasis often given in this period to doing social impact analysis or statements.

As already mentioned, a key thrust of this early work was to emphasize and come to grips with the fact that engineering often takes place in the context of business. While practicing engineers did not have to be told this—they knew it first-hand—it wasn’t clear to engineering ethicists that academic engineers and undergraduate engineering curriculum acknowledged it. The reality they thought needed to be stressed was that practicing engineers cannot study a problem forever; resources and the marketplace do not allow engineers to build the safest or most efficient product; complexities and uncertainties pervade the work of engineers; and communication is an essential tool. All of this, engineering ethicists maintained, is essential to engineering and to the understanding of engineering ethics.

In the 1980s and well into the 1990s, the bulk of literature on engineering ethics can be seen as digesting the implications of engineering being practiced in the context of business. Much of the scholarship framed the ethical issues in engineering as arising from a structural conflict between the duties of engineers, as professionals, and the duties of engineers, as employees (Johnson, 1991). This analysis can be seen most clearly in the amount of attention given to whistleblowing. Starting with the analysis of the BART case, moving through the DC-10 crash, the Pinto case, and culminating with the Challenger disaster, accounts emphasized the tension between engineers (who had certain responsibilities qua being engineers), and managers (who might be engineers but were acting as representatives of the interests of the company). Because of this tension, engineers had to decide whether or not to blow the whistle. A litany of issues concerning whistleblowing were addressed including what constituted blowing the whistle, when such behavior is justified, whether it was ever obligatory, how to do it without getting fired, and so on. [See, for example, De George, 1981.].

In hindsight it seems clear that the presumption that there is a separation between the technical and social (business) became embedded in thinking about engineering ethics. We can speculate about the causes—the ideology of engineering emphasizing the neutrality of technology and the special authority of engineers; the fact that non-engineers were trying to understand something they had neither been trained in or had experience with—but whatever the causes, the presumption was that engineers have a kind of knowledge about the way 'things' work and that their expertise is often at odds with the way the business (social) world wants it to be. Johnson (1991) argued, for example, that engineers had to act as professionals and that the profession needed to be stronger to protect engineering from the pressures in the workplace. Davis made parallel arguments in several pieces (citations). Layton called for engineers to be the 'loyal opposition' (Layton, 1971). And Kipnis (1981) argued that engineers should hold public safety and welfare paramount implying that if the 'paramountcy of this obligation weren't emphasized, engineers might defer to other interests. In framing the issues in this way, engineering ethicists perpetuated the idea that engineering knowledge is not just esoteric but isolated; it is a special kind of knowledge that is free from social, political, cultural, and business values. This special knowledge is what makes engineering a profession and means that engineers have the responsibility to ensure the safe application of the knowledge. The engineering ethics literature argued, in effect, that engineers should be loyal employees and work for the good of their company until a certain line is crossed when good engineering judgment is compromised and the public good might be significantly jeopardized. In these cases, the engineer should work through the chain of command to avoid the problem, but if this fails, blow the whistle on his or her company in an attempt to prevent a catastrophe. Most of the literature argued that in order that engineers continue to be trusted to use their specialized skills and expertise for the public good, they must adhere to the codes and principles of professional ethics and resist being misled by the interests of business.

This emphasis on the business context of engineering can be seen in Kline's (2001/2, p. 16) summary of the major issues that form the core of engineering ethics texts in the U.S.:

1. *Public Safety and Welfare* – What is the responsibility of the engineer toward public safety and welfare? How safe must a safe design be?
2. *Risk and the principle of informed consent* – Should engineers assess risk from the point of view of technical experts, the public, or from some other perspective? Should engineers strive for the ideal of informed consent with users of a technology?
3. *Conflict of interest* – What is a conflict of interest and what is wrong with it?
4. *Whistleblowing* – Should engineers be expected to 'blow the whistle' on their employer if there is wrong doing of a design is unsafe? What if lives are at stake?
5. *Trade Secrets* – Should engineers be expected to keep trade secrets, which are legal in the Untied States, when moving from one job to another if that might prevent them from using their technical expertise to make a living?
6. *Accepting gifts* – What guidelines should engineers follow in accepting gifts from sales representatives and governments?

Except for (1) and (2) they each explicitly or implicitly have to do with the business context and (1) and (2) have to do with the effects of technology not with engineering practice.

Engineering ethics literature has succeeded in illuminating an array of situations in which engineers often find themselves and has provided concepts, terms, and frameworks with which to think through these situations. It has worked in parallel with STS in recognizing and making salient the business context of engineering. However, the engineering ethics literature has largely neglected other social factors shaping technology and the work of engineers. In this respect the field seems impeded both by the presumption of separation between the technical and social and by a fairly restricted view of how social factors come into play with technology. In the next two sections of this chapter we associate the separation of technical and social with technological determinism and we argue that engineering ethics can be enriched by taking up the STS critique of technological determinism and by drawing on the alternative model that STS offers.

Technological Determinism and the STS Alternative

STS scholarship is far from monolithic and can be framed and explicated in any number of ways. But it seems non-controversial to claim that a major thrust of STS literature aims to dispel the idea of technological determinism. Generally STS scholars argue that technological determinism is a poor representation of the world and that it can be a dangerous model because it leads to thinking that technologies are the inevitable outcome of uncovering nature's resources, and, hence, humans (whether they be managers, engineers, or users) do not have the power or the responsibility for these technologies or their effects. Instead STS has advocated the more complicated view that technology and society are inextricably intertwined and co-shape one another.

Before we explore how STS can enrich engineering ethics, it will be helpful to articulate the idea of technological determinism and the STS critique of it. What is technological determinism? What is wrong with it? What is the alternative?

While multiple definitions and forms of technological determinism have been offered, at the core of the concept seem to be two basic tenets and a number of possible corollaries.[2] The first tenet is that technology develops independently from society. The second is that when a technology is taken up and used, it has powerful effects on the character of society. According to the first tenet, technological development either follows scientific discoveries—as inventors and engineers 'apply' science—or it follows a logic of its own, with new invention deriving directly from previous inventions. Either way, technological development is understood to be an independent activity separate from social forces; engineers and inventors do their work in an isolated domain in which all that matters is discovering and manipulating the workings of nature.

The second tenet of technological determinism is the claim that when technologies are adopted by societies or particular social groups, the adoption brings about—determines—social change and patterns of social behavior. The famous example is the claim made by historian Lynn White (1978) that from the invention of the stirrup came feudal society. Another example is Langdon Winner's (1986) claim that you can't have nuclear power without hierarchical organization; that technologies necessitate particular forms of political organization. This tenet of technological determinism leads to the commonly held view that technology determines society; that is, when technologies are adopted and used, they change the character of society.

[2] For a more thorough account of technological determinism, see Bimber (1994).

STS literature generally denies the first tenet entirely but has a more complicated response to the second tenet. In denying the first tenet—the claim that technology develops independently from society and follows science or its own logic of development—STS scholars argue that technological development is shaped by a wide variety of social, cultural, economic, and political factors. Nature does not reveal itself in some logical order. Scientists and engineers look at nature through a lens of human interests and human theories and concepts; engineers invent and build things that fit into particular social and cultural contexts. Technologies are successful not by some objective measure of their goodness or efficiency; rather, technologies are taken up and used because they are perceived to achieve particular human purposes and to improve a particular social world or to further the interests of individuals and social groups.

The same claim is made in response to the second tenet of technological determinism, that it misses the fact that technology is being shaped by social factors and forces. Here STS scholars do not deny the technological determinist claim that technology affects society; rather, they argue that forces move in both directions. Technology shapes society *and* society shapes technology. STS literature shows that the theory of technological determinism gives an inadequate and misleading picture of the technology-society relationship by leaving out the powerful social forces at work in shaping the development, adoption, use, and meanings associated with technology. STS scholars claim that shaping works in both directions; technology and society are mutually constitutive; they co-create one another.

In place of technological determinism STS scholarship offers a number of theoretical approaches that help us to understand how technologies are socially shaped. Most notable are the social construction of technology or SCOT approach (Pinch & Bijker, 1987) and actor-network theory (ANT) (Law & Hassard, 1999). Both theories seek to explain why and how particular technologies are adopted while others are rejected or never developed; the theories explain how technological designs are created through social practices by social institutions and become embedded in social practices and social institutions.

An STS Critique of Engineering Ethics

The STS critique of technological determinism and accounts of the social shaping of technology have a good deal to offer engineering ethics. Much of the engineering ethics literature seems to rely on a technologically deterministic view of technology—a view that STS has shown to be incomplete and often misleading. Engineering ethics scholars never explicitly argue for technological determinism. In fact they hardly ever note that such a theory or viewpoint exists. But shades of technological determinism can be seen in how they present problems, in the areas they choose to explore, and the topics and viewpoints they ignore. The most salient technologically deterministic aspect of the engineering ethics literature is found in the way technical decisions making is treated as abstract and separate from the social and ethical. The technical and social are seen as connected only after the technology has been developed, and begins to be used; it then has effects or impacts that are social and ethical.

The idea that the technical and the social are separated seems to be consistent with the idea that a large part of engineering is the unproblematic (neutral) application of scientific laws or natural features and principles. On this view, there is no room for the social or the ethical to get involved. Many engineering ethicists have designated much of engineering work as a technical practice and viewed technical practice as activity in which right answers and proper practice are necessitated by the subject matter. Many engineering ethics scholars see this technical realm not as a context for engineering ethics, but as a distinct and unquestionable part of engineering. Indeed, it is often seen as the part of engineering that must be protected from corruption. The engineering ethics literature takes it for granted that technical decisions in and of themselves have no ethical problems; it is only when the interests of non-engineers interfere that ethical issues arise.

The best way to see the technical/social divide is to examine the way that case studies are commonly presented in engineering ethics. The following case study is representative of many cases in the field and is drawn directly from a popular textbook: *Engineering Ethics: Concepts and Cases* by Harris, Pritchard, and Rabins (2000, pp. 324-325). It illustrates the way in which ethical dilemmas are presented as arising from the intersection between engineering and business.

An Example: the Case of "Shortcuts"

> Your first job after completing your undergraduate engineering degree is with the Kitchen Shortcuts Company. Shortcuts manufacturers microwave ovens and other time-saving kitchen equipment. You are hired into a low-level engineering position. Your first task is to test a series of microwave ovens to determine their defrosting capabilities. You proceed to your lab where you find a few dozen microwave ovens in their boxes waiting for you to start your testing. You notice that virtually every brand of microwave oven is here, including all of Shortcut's competitors' brands.
>
> You unpack all the microwave ovens and begin your tests. The process is rather slow. So while you are waiting for test items to defrost, you begin to dig through the cabinets in your lab to see what is there. You discover that this used to be the lab where they tested microwave oven doors for radiation permeability (the amount of radiation that could escape through the glass door of microwave ovens). You also find an intriguing little piece of hand-held equipment that apparently was used to measure radiation levels. Because you are an engineer, you cannot resist trying it out.
>
> You switch on the meter and point it around the room and out the window. You notice that when you point the meter at some of the microwave ovens, it gives a very high reading. You turn off all the other microwave ovens and discover that the reading is not a fluke. The ovens you are standing in front of are emitting much higher-than-average levels of radiation. You discover that one of the ovens is from Shortcuts and the other is from Home Helpers, Shortcuts'

> archrival. These microwave ovens are currently the two best selling ovens on the market, primarily because they are the least expensive. It seems that these bargain ovens may not be as safe as they seem.
>
> You decide to look around a little more. You find the test report that discusses the radiation emissions from all of Shortcuts' models of microwaves. You learn that only the top of the line and the midlevel microwaves were thoroughly tested. The bargain ovens' results apparently were extrapolated from the test results from the other ovens.
>
> Discuss at least two possibly conflicting obligations you have as an engineer in this case…

In this case study, the dilemma is fairly well defined. At the beginning of the story it seems as though the engineer is finding a technical problem, perhaps caused by lack of awareness, negligence, or the incompetence of another engineer. Especially because of the way the question is asked at the end, focusing attention on conflicting obligations, it seems relatively clear that the problem arises from something more than a technical mistake. There is the possibility, at least, that an attempt has been made by the corporation to deliberately mislead the public. The engineering methods used in the first sets of tests were so sloppy it is difficult to conceive of them being a mistake. After all, our heroic engineer seems to be able to determine the problem in spare moments while conducting another test, using an instrument he or she had never seen before. It seems that "Shortcuts" has been proudly living up to its name.

The case presents proper engineering practice as blatantly obvious—even to non-engineers. The dilemma for the engineer in the story is not in determining the problem, but whether to be a professional engineer and take steps to ensure public safety (and perhaps lose his or her first job) or to "be a faithful employee" (although that is sometimes problematized in the literature) and go along with the party line and be able to provide for his or her family.

No doubt there are cases in "the real world" where an engineer is confronted with a dilemma in which he or she must decide whether to practice ethical engineering or submit to a decision made by unscrupulous business interests. Thus, our point is not that the engineering ethics literature has been wrong about the context of engineering. Courses on engineering ethics should prepare engineers for such situations. The problem is, rather, that the vast majority of attention is spent on distinguishing business from engineering and not enough attention is paid to engineering. As it is in this case, the practice of engineering is often marginalized and left unexplored. The dilemma as presented in this case is based on the idea that engineering knowledge provides one authoritative answer to the question of whether the microwave is unsafe; an answer that any competent engineer should arrive at. What constitutes "proper engineering practice" is not questioned or even discussed.. It is simply assumed. All of the factors that go into testing and engineering decision-making have been black boxed and glossed over.

If, however, the presumption were shifted and engineering ethicists recognized that the technical and social are intimately intertwined and cannot be completely separated, more attention would be given to engineering practice, and not just to its context. The field of STS has developed a number of techniques, theories, and questions that reveal the complexity of engineering practice and engineering decisions. They reveal the social and ethical issues 'in' the technical. For example, in the case study just described, the following set of questions can be asked—questions that begin to penetrate the technical in addition to the context. Consider the following:

1. Is a handheld radiation gauge an accurate tool for measuring exposure?
2. Is it wise for an engineer with no training on a particular piece of equipment to make broad conclusions using it?
3. Is it really a good idea to measure radiation levels in a room with large windows?
4. What levels of radiation exposure should be of concern to humans?

5. If the only way to make microwaves affordable to low-income families is to build them with slightly higher levels of radiation, are the benefits worth the risks?
6. If a particular microwave model releases more radiation than others, but does not pose any increased amount of risk, should radiation data be released to the public?

If one were to begin analyzing the decision-making process of engineers with questions like these, two things happen. First, such an exploration may help engineers come to an understanding that helps resolve the dilemma. After thinking through the first three questions, for instance, an engineer may find that he or she does not understand the technical side of things. Answering those questions may in and of itself resolve the ethical dilemma. Even if they do not completely resolve the dilemma, they may suggest a different strategy or give the engineer extra resources and arguments to make his or her case to management.

Second, these questions help to uncover a number of new ethical issues that engineering ethics could grapple with. For instance, the final three questions are examples of important ethical questions that get to the heart of many important issues in technology. Accuracy and measurement or proper use of equipment are complex socially negotiated concepts. They are never completely settled, but rather, continually negotiated. Engineers have the ability and even the duty to influence the way these questions are formulated and answered both as individuals and as active members of institutions; engineering ethicists need to recognize and address them.

The case as presented does not encourage readers to ask any of these questions. Some may argue that this is as it should be; that these are questions which should be addressed in technical courses. But that is to miss the point. Each of them, and many others like them, are not simply technical questions with obvious answers. They are complex ethical questions which, depending on how they are answered, could have profound effects. To ignore these questions in a study of ethics is to ignore a majority of what an engineer does and to deny that technical practice has any ethical import. Because they are complex ethical questions they should be analyzed and critiqued with the tools of ethics rather than just left to the mistaken assumption that engineering teaches the one best way. [We've lost the argument that STS is part of our argument? Do we want to flag that at some point or not?]

To a large extent, engineering ethics has been reduced to business ethics. The decisions that engineers make as technical practitioners are rarely explored except perhaps in the case of determining acceptable risk and her some have argued the decision is not one for engineers to make. The idea that engineering is complicated by things other than business pressures does not receive nearly enough attention. By reducing engineering ethics to business ethics, engineering ethicists fail to comprehend the power engineers have in shaping the world. They have made the basic tasks of engineers appear routine and deterministic. Engineers would quickly build the best of all possible worlds if they did not have to contend with the world of business.

To be fair, scholarship in engineering ethics has been evolving and there has been some movement in the direction we are proposing. Nissenbaum's work on values in design is one example of work that addresses the ethical in the technical. Another is found in a chart presented by Schinzinger and Martin in *Introduction to Engineering Ethics* (2000, p. 6):

Tasks	**A selection of possible problems**
Conceptual design	Blind to new concepts. Violation of patents or trade secrets. Product to be used illegally.
Goals; performance specifications	Unrealistic assumptions. Design depends on unavailable or untested materials.
Preliminary analysis	Uneven: Overly detailed in designer's area of expertise, marginal elsewhere
Detailed analysis	Uncritical use of handbook data and computer programs based on unidentified methodologies.
Simulation, prototyping	Testing of prototype done only under most favorable conditions or not completed.
Design specifications	Too tight for adjustments during manufacture and use. Design changes

	not carefully checked.
Scheduling of tasks	Promise of unrealistic completion date based on insufficient allowance for unexpected events.
Purchasing	Specifications written to favor one vendor. Bribes, kickbacks. Inadequate testing of purchased parts.
Fabrication of parts	Variable quality of materials and workmanship. Bogus materials and components not detected.
Assembly/construction	Workplace safety. Disregard of repetitive-motion stress on workers. Poor control of toxic wastes.
Quality control/testing	Not independent, but controlled by production manager. Hence, tests rushed or results falsified.
Advertising and sales	False advertising (availability, quality). Product oversold beyond client's needs or means.
Shipping, Installation, training	Product too large to ship by land. Installation and training subcontracted out, inadequately supervised.
Safety measurers and devices	Reliance on overly complex, failure-prone safety devices. Lack of a simple 'safety exit.'
Use	Used inappropriately or for illegal applications. Overloaded. Operations manuals not ready.
Maintenance, parts, repairs	Inadequate supply of spare parts. Hesitation to recall the product when found to be faulty.
Monitoring effects of production	No formal procedure for following life cycle of product, its effects on society and environment.
Recycling/disposal	Lack of attention to ultimate dismantling, disposal of product, public notification of hazards.

Martin and Schinzinger have taken a number of steps toward teasing out the complexities in the technical. As can be seen from this chart they attempt to analyze the entire process of engineering from initial conception of a product through its use and reevaluation and redesign. At each point of a product's life cycle, they point out possible technical oversights and business ethics issues that could give rise to problems if not dealt with appropriately. This list of possible problems is intended to get engineers to continually ponder the question: "What is the best technical practice."

Even when engineering practice is analyzed, however, the idea that every decision has both technical and social aspects is often overlooked. Arguably, the key point to influence the design of technology is in the early stages of its development before specifications are settled.

Certain designs promote or inhibit certain values; different designs constrain and facilitate different interest groups and their interests. Engineering ethicists are beginning to address this gap as in the work of Nissenbaum and Brey but such work has not traditionally been seen as part of engineering ethics. Consequently, justice, equality, privacy, and other social values are not seen to be embedded in technical decision making.

An STS informed Engineering Ethics

Although many engineering ethics scholars have been hesitant to open the black box of technology and technical practice, the field of STS offers a variety of approaches and tools designed to open up the previously unquestionable. To fully realize the potential of STS insights to inform and transform the field of engineering ethics will, however, require a good deal of work. At this point we can only offer a rough start in the form of an incomplete list of some of the ways that engineering ethics can be enriched and redirected. The overarching idea that can shape a re-configuration is explicit recognition that engineers (together with other actors) develop things that are not merely material objects, as well as recognition that engineers develop these things using skills that are not limited to the logical application of science and technique. Engineers are an important part of a socio-technical system which produces other socio-technical systems. That is, they are part of and produce systems that consist of artifacts, social relationships, social practices, and systems of knowledge. None of these parts can exist without the other. An engineering ethics that rejects technological determinism and is informed by STS would have as its unit of analysis something that is a combination of things and people (organized in various ways). We call this unit a socio-technical system but it could just as well be an actor network in which actants are encompassed. Whatever it is called or however it is conceptualized, it must allow scholars to address systems of social practices, social relationships, and material objects together.

This shift in the unit of analysis would have at least two significant implications. First, it means that evaluation of the work of engineers must take into account the full system. We can't say here are the technical specifications and here are the business demands. These are all part of a socio-technical system of which the engineer is more than simply a cog in the wheel. Engineers must recognize that their work is not contaminated by outside forces, it is constantly shaping and reshaping what constitutes "proper engineering practice." Engineering in the modern world cannot exist separate from business, government, and public opinion. For example, what constitutes acceptable risk is probably decided more by non-engineers than engineers. Rather than fight against this situation and deny the expertise of others, engineers need to learn how to balance and draw upon the benefits of supposedly non-technical input. Engineers do not build technologies by themselves. Many other actors are complicit in producing the socio-technical systems that take hold and become part of the world. Another way of saying this is to say that engineers with others are making the social world (as the social world is making engineers). Some scholars have made some headway on this [citation?].

Second, once you take socio-technical systems as the unit of analysis, engineering ethics would have to look far beyond material artifacts to achieve its goal of examining the outcomes of engineering,. We can't say "here" is the technology and "here" is the social and cultural changes it causes. Engineers would need to be encouraged to examine artifacts and the way they are integrated in the world at the same time. By taking this approach, engineers can no longer dismiss ethics as something that happens after they are done. Instead, it forces them to realize that their assumptions about the world, about the user, and about what constitutes a social good, are all bound up in the way they design an artifact and the way they promote that artifact to society, or at least their managers. Through being introduced to STS ideas, engineers can be conscious of the way values are bound up in their day to day practice.

An STS informed engineering ethics would need to give much more attention to the design process and the design process will have to be seen as an ongoing process, far from complete when the artifact is given to the marketing department or sold to consumers. The design process would become an object of normative analysis and would facilitate engineers in designing with a broader or a different set of values in mind. Acknowledging the ways in which values direct design allows engineers and others to envision alternative values, alternative technologies, and alternative futures. Instead of technologies being evaluated after they have already been developed and gained momentum, analyzing the process of design while it is in process would be put on the radar screens of engineers and engineering ethicists. Who is involved? In what decision making framework?

An STS informed engineering ethics would have to consider all stages of a technology's life cycle including development, production, distribution, marketing, and disposal. It must include what it takes to design, build, maintain, distribute, and dismantle the system including institutions, corporations, relationships, communities and so on. This again would require engineering ethics to address a significant number of new factors that it currently does not take directly into account.

Conclusion

As you can see, phasing out technological determinism and phasing in STS theories will challenge the status quo by arguing that things need not be the way they are and by offering suggestions for alternative paths. Many engineering ethics textbooks stress that an engineer should consider various alternatives when faced with an ethical dilemma. But all too often, they fail to remind engineers that they also have alternative technologies and alternative methods of design upon which they can draw. This is a critical step in the process of encouraging engineers to be reflective and active. As STS assists engineers and engineering ethicists to envision a world that is complicated by an intermingling of the technical and the social, it also helps them to imagine solutions that draw upon this knowledge.

The rejection of technological determinism opens up the possibility of directing and correcting technology at all its stages—from initial conception, through design and production, to use and subsequent reconception and redesign. Understanding the ways in which the technical and social are interrelated helps an engineer to envision ways in which a combination of social and technical changes can be a more effective solution than previously developed. We believe that acknowledging that he or she is just one of a number of individuals and organizations that will shape the way technologies are developed and used will allow the engineer to work with these other groups to enact positive change.

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