Day 20: Engineering & Social Justice Ch 2

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Engineering and Social...

CHAPTER 2

Mindsets in Engineering

"The technical rationality that is the engineer's stock-in-trade requires the calculation of means for the realization of given ends. But it requires no broad insight into those ends or their consequences. Engineers are aware of, are trained to be aware of, these limitations; insofar as they do consider ends, they cease to act as engineers."

Robert Zussman [1: 122–123]

This chapter uses engineering humor to draw out some mindsets commonly found in engineering and relates them to the intersection of engineering and social justice. Some mindsets are so much a part of mainstream engineering culture (or mainstream culture) that we may be unaware of alternative perspectives. The intent of this chapter is to separate the worldviews from the profession of engineering itself.

2.1 AN ENGINEERING MINDSET?

The last chapter dealt with developing a definition of social justice. Engineering may be somewhat easier to define than social justice, but it too has a contested and changing definition. The earliest uses of the word engineer in the English language (fourteenth century) were used to describe "a constructor of military engines" or "one who designs and constructs military works for attack or defense" [2]. In the nineteenth and most of the twentieth century, engineering was, in the words of Thomas Tredgold [3], "the art of directing the great sources of Power in Nature for the use and convenience of man." As the field sought to move away from its identity as a trade into that of a profession, it emphasized its theoretical underpinnings in science and became thought of as the application of math and science toward useful ends—typically commercial, industrial, or military: "The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems" [4]. Emphasis is often placed on problem solving as the primary activity of engineers or on invention and creativity. More recently, the exploitation of natural resources has been dropped as a defining element of engineering in favor of definitions such as "the science and art of applying scientific and mathematical principles, experience, judgment, and common sense to design things that benefit society" [5]. To some degree, these shifting definitions of engineering reflect changing views about the profession and its role in society as well as the changing values within the profession. Thus, the profession itself and its meaning in society can and do change, reminding us that we can shape what engineering is in order to make it more responsive to social justice concerns.

Before examining the relationship between engineering and social justice, I want to distinguish the profession of engineering from some common mindsets one finds within the profession, particularly those mindsets that, as we will see in Chapter 3, often stand in the way of engineering's intersection with social justice. While I recognize that, of course, the profession currently and historically reinforces and helps create the mindsets within it, I believe it is only through recognizing the underlying mindsets and changing them that the profession can truly be transformed. The profession has a central role to play in bringing about this change in mindset, and so I begin by seeking to characterize the worldviews which are held so commonly in engineering and throughout many parts of our society that one may not even recognize that there are alternatives. I carefully and intentionally do not refer to "the engineering mindset" because I seek to drive a separation between engineering and common mindsets in engineering in order to create change; I believe the mindsets I discuss here do not have to be the mindsets of engineers or of engineering. Indeed, engineering would be quite different if different worldviews were more common, and that is exactly the point.

Thus, we may not yet have a common understanding of what engineering is, or could be. I assume that the reader is sufficiently familiar with the profession of engineering and I do not seek to answer the question "what is engineering" in its naive sense, or in its totality, as many books, magazines, and websites do in order to recruit students. Rather, I seek to highlight certain mindsets relevant to the intersection of engineering and social justice. I seek to help engineers see ourselves with a new awareness of some of the things we often take as given in our profession and education. Some of these characteristics equip us to work on social justice issues, while others, as we will see more fully in the next chapter, keep us from working on—and sometimes even from recognizing or fully understanding the complexities of—social justice issues.

2.2 PROFESSIONAL HUMOR: DRAWING ON STEREOTYPE

Every profession has a series of jokes about itself, generally told within the group and drawing on some stereotypes about the profession. Clearly, not all engineers fit the stereotype, and some stereotypes are largely false. However, the jokes make some important contrasts between engineering and other professions, which reveal something about common mindsets in engineering which are less prevalent in other professions. If we look at these with an eye to cultural analysis, we can draw out some characteristics of these mindsets that are relevant to the intersection of engineering and social justice. These jokes may draw some strong reactions from readers; I ask that you remember these are stereotypes. We have the power to challenge and resist any of these stereotypes in our own lives, to develop new mindsets, and to change both the perceptions and the realities of the profession. These jokes are part of an oral tradition and are related here as I recall them, although most can be found in any number of online archives (see, e.g., http://www.inflection-point.com/jokes.php).

2.2.1 Joke 1: The Guillotine

> A lawyer, a priest, and an engineer are scheduled to be executed by guillotine. The lawyer goes first, the executioner pulls the cord, but nothing happens. "Double Jeopardy! You have to let me go!," cries the lawyer. And the executioner does. The priest is next, the same thing happens. "Divine Intervention! You have to let me go!," cries the priest. And the executioner does. The engineer is next. As the executioner gets ready to pull the cord, the engineer cries, "Wait! I think I see your problem . . . " (Figure 2.1).

This joke is rich, revealing multiple perspectives and values. First, there is a valuing of problem-solving abilities and a celebration that engineers can solve problems others cannot—in this case, to a fault. Part of this ability is credited to another value—exclusive technical focus—in this case, to the exclusion of everything else going on in the world around us, even in our own lives. Third, this joke draws on the value of loyalty—an unthinking willingness to accept the authority of the state, such

FIGURE 2.1: "Wait, I think I see your problem. . . . " Engineers solving problems even if it kills us. Accessed January 18, 2008, from http://etc.usf.edu/clipart/15200/15229/guillotine_15229_lg.gif.

that an engineer would fix a guillotine even when it is the engineer's own neck on the line. There is altruism here as well, a willingness to help other people and to solve their problems, even if it kills us and even if it betrays a social justice value like opposition to the death penalty.

2.2.2 Joke 2: The Church Steeple

> An engineer and a sociologist were tasked with finding the height of a church steeple. The engineer measured the angle to the top of the steeple and calculated the height using trigonometry. Then, to check the estimate, the engineer climbed to the top of the steeple, lowered a string until it touched the ground, climbed back down and measured the length of the string. The engineer compared the measurement to the estimate, calculated the standard error, and drafted a report documenting the methods and results. The sociologist bought the sexton a beer in the local pub and he told her how high the church steeple was.

This joke emphasizes the engineer's tendency toward "brute force" methods of problem solving and an exclusive focus on the calculated and measured solution, even if it takes much longer… Perhaps it does not occur to the engineer to simply ask someone; perhaps it does but a certain social awkwardness gets in the way.

This joke also says something about *epistemology*, or how we know what we know. While the sociologist derives knowledge through human interaction, the engineer might not trust the veracity of this type of knowledge. Instead, the engineer relies on the scientific method, using mathematics to create an estimate and then designing and conducting an experiment to make a measurement. This exclusive reliance on the scientific method to reveal knowledge is known to philosophers as *positivism*. Positivist epistemology is a common mindset in engineering (certainly, our education trains us in this way). Without an awareness of alternative epistemologies, one adhering to this mindset might simply characterize scientific knowledge as "true" or "factual" and view other kinds of knowledge as "less reliable" or as "opinion."

2.2.3 Joke 3: You Might Be an Engineer If . . .

> You might be an engineer if . . . in college you thought Spring Break was metal fatigue failure.
> You might be an engineer if . . . you say "It's 77 degrees Fahrenheit, 25 degrees Celsius, and 298 Kelvin," and all they say is "Isn't it a nice day?"

Here, engineers are characterized as being solely focused on work and too busy to have fun, or too focused on technical details to relate socially or just enjoy the day. Whether engineers are not interested in the traditional Spring Break activities involving the opposite sex and drinking, or whether their engineering education is so overloaded with technical courses and grunt work that they have no time to even think about Spring Break is up to interpretation; that is, the joke plays on both stereotypes. The engineer apparently does not know when to turn off the technological approach, when to stop analyzing/working and just have fun. The values here could be characterized as a strong work ethic, and a strong and narrow technical focus, perhaps including as well a denial or devaluing of relationships and enjoyment.

2.2.4 Joke 4: The Golf Course

> A pastor (rabbi/imam/priest), a doctor, and an engineer were waiting one morning for a particularly slow group of golfers. Annoyed, they decide to ask the greens keeper, who explains that they are a group of blind firefighters who lost their sight fighting a fire in the clubhouse years ago, and they play for free whenever they want. The pastor remarked, "That's so sad. I'll pray for them." The doctor said, "I know an ophthalmologist who might be able to do something for them." The engineer said, "Why can't they play at night?"

This joke reveals a mindset focused completely on the practical side, in the interest of problem solving, to the exclusion of human relationships and even basic compassion. Interestingly, engineering is cast as a profession that is *not* a helping profession in contrast to medicine and ministry.

2.2.5 Joke 5: Mechanical vs. Civil

> What's the difference between a mechanical engineer and a civil engineer?
> Mechanical engineers build weapons, civil engineers build targets.

This is a joke about the military orientation of engineering. It is both a slight against civil engineers (as in, ha, ha! You just build things so we mechanical engineers can blow them up) and a commentary on militarism in engineering. In one reading, this joke takes the work that civil engineers do out of the context of helping people have clean water, sanitation, transportation, etc., and diminishes it by placing it in the military context, in which it is seen as a "target," destroyed by mechanical engineers. This reveals a distinct militaristic mindset. In another reading, this is a comment on the futility of militarism, or simply a matter-of-fact recognition of engineering's military focus. This reveals a mindset critical of militarism in engineering. I have heard the joke told in both contexts, revealing both mindsets in engineering.

2.2.6 Joke 6: 'I Are an Engineer'

> *Real* engineers . . . have a non-technical vocabulary of 800 words.

This joke (and the joke I snuck in the section header) communicates a devaluation of written and oral communication skills, as they celebrate engineers' difficulty in this area.

2.2.7 Joke 7: Real Engineers . . .

> *Real* engineers . . . have politics that run toward a corner office and a parking space with their name on it.

This joke emphasizes the corporate context in which engineers often work and a mindset of managerialism in which organizational bureaucracy is an end in itself. The popularity of Dilbert reinforces the centrality of corporate life for engineers. This joke reveals a mindset that is careerist, politically inactive, disinterested, or uninformed.

2.2.8 Joke 8: The Glass

> To the optimist, the glass is half-full. To the pessimist, the glass is half-empty. To the engineer, the glass is twice as big as it needs to be (Figure 2.2).

This joke is overtly about engineers' worldview. Some would praise this mindset as creative thinking outside the box (or the glass). Certainly, it challenges some things that are conventionally assumed. At the same time, this joke reveals a mindset that will not *evaluate* a situation and refuses to make a subjective judgment. Is this a sign of uncompromising objectivity, or just bad design? Drinking water will continually require redesign of the glass.

2.3 WHAT DO THESE JOKES TELL US ABOUT MINDSETS IN ENGINEERING?

It is too simple to say that these jokes tell us nothing about engineering because they are based on stereotypes, for which we can find many counterexamples. The fact that these are the jokes that

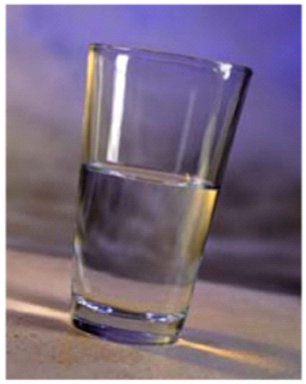

FIGURE 2.2: Half-full, half-empty, or wrong-sized? Accessed January 18, 2008, from http://bp2.blogger.com/_tqCXEUMzxCk/RqVHzNrXBGI/AAAAAAAAAOI/IZp5UWPHjQ0/s320/Half+Full+Glass.jpg.

are told about engineering by engineers and that these are the stereotypes our community draws on, and not other ones, demands our notice and our interpretation. How do they acculturate us as members of the profession? There is a combination of self-deprecation and celebration of these characteristics in the engineering jokes, an acknowledgement that many possess these mindsets and a recognition that they may not always produce desirable outcomes. Within each joke lies not only the presentation of a mindset but also some discontent with it and desire for change. Let us examine each characteristic more carefully.

2.3.1 A Desire to Help . . . and the Persistence to Do It

There is something in the spirit of the engineer that wants to help. Some engineering deans call for a public relations and/or recruitment campaign that presents engineering as a profession that serves humanity [6,7]. They can cite examples, whether it is bringing clean water and sanitation to a community or developing new drugs, designing renewable energy solutions to address climate change, or connecting people with wireless networks. Engineers are known for our work ethic; we are committed to getting the job done and will slog through hours of grunt work to make it happen. We serve and serve well. The helping spirit and strong work ethic of engineers are important traits for engaging in social justice work. There is a certain amount of overlap between the kinds of problems engineers solve and social justice problems, although the engineering approach may not define the problem to be solved in terms of social justice.

2.3.2 Centrality of Military and Corporate Organizations

This raises a question: who does engineering serve? We want to help, but who are we actually helping? Alice Pawley [8], assistant professor of engineering education at Purdue, analyzes the narratives of engineering faculty members with an eye to the establishment and reinforcement of gendered boundaries in engineering. She uses three tools in analyzing the way engineers define and delimit the boundaries of our profession: space, time, and actors.

Pawley's construct of space helps us understand where engineers work. Drawing on National Science Foundation data as well as her interviews with engineering faculty, Pawley establishes that engineers work overwhelmingly in private profit-oriented organizations and on industrial, commercial, and military problems. Problems tend to be at a larger scale, with small-scale problems relegated to areas outside of engineering. There are few opportunities for engineering employment outside of government, industrial, and commercial settings. The centrality of managerialism in engineering may not be surprising, given that engineers are embedded in corporate organizations. Managerialism takes a systems approach to organizational management, viewing human relationships within the organization through a lens of inputs and outputs and increasing organizational efficiencies by minimizing inputs and maximizing outputs [9].

Turning to actors, Pawley asks who defines engineering problems, who benefits from the solutions to the problems, and who actually does the work of engineering. She further asks who is left out of the picture; while her analysis specifically examines how these boundaries are drawn along gender lines, the questions are equally relevant for examining other questions of social justice. Applying Pawley's construct of time to her data reveals that engineers typically rely on tradition and precedent in determining what they should do in the present and future. This makes the profession resistant to change.

Pawley's constructs cited above and the research she draws upon in her work provide some insight into why engineering retains a narrow focus that excludes and precludes a great deal of social justice work. Clearly, broadening the settings in which engineers work and the actors involved is necessary to create opportunities for engineers to work on social justice issues.

2.3.3 Engineers Have a Narrow Technical Focus and Therefore Lack a Number of Other Skills

Engineering's embedding in military and corporate applications can explain the narrow sense of career path many students experience. There are few alternatives to a military or corporate career in engineering and to the development of a culture within engineering that does not question authority in preparation for performance in hierarchical military and corporate organizations.

Bruce Seely [10], a historian who studies engineering education, has documented the reform efforts in engineering education over the last century; one of the things they have in common is the recurring debate about how broad or narrowly focused an engineering degree should be and how much (and what specific) content from the liberal arts is appropriate. In 2000, the Accreditation Board on Engineering and Technology [11] changed the program outcomes criteria (standards) to include a number of nontechnical capacities engineering students must develop including communication, teamwork, global and local context, and professional responsibility. The extent to which these are addressed varies from program to program, as engineering curricula continue to be packed heavily with required courses.

Generally, engineering students learn to think *analytically* only in certain ways appropriate to technical analysis. For example, we learn to break problems down into small parts, solve the individual parts, and then work back up to a solution. We typically do not come away with the ability to think *critically*, to question what is given, or question the validity of our assumptions, because we are too busy learning the essentials of problem solving. For this reason, we often cannot see the larger context of the problem we are working. We lose sight of the big picture, especially if we are sleep-deprived from too many hours in the lab and doing problem sets. We do not learn, with any depth, critical approaches from the humanities and social sciences, and we do not learn many communication skills beyond writing technical reports and giving PowerPoint presentations. Thus, it is no wonder that some engineers may come across as apolitical or clued out about contemporary issues outside of technology.

2.3.4 Positivism and the Myth of Objectivity

A positivist mindset often relates to two other perspectives that are commonly held in engineering: reductionism and technological determinism. Reductionism is the notion that phenomena (or problems) can be broken down into smaller components for analysis and that analysis of the components can fully explain the system as a whole. A reductionist perspective is evident in the engineering problem solving and engineering design processes. Technological determinism holds that technology develops on its own in a self-propelling fashion (i.e., without regard to social forces) and that its innovations, in turn, impact society and drive political, cultural, and economic developments. This perspective is found in engineering when concern is placed on the impacts of technology on society without consideration for how society also constructs technology. Positivism and technological determinism lead many engineers to believe that their work is objective and that science itself is objective.

As Foucault [12] points out, however, science is subject to the same vicissitudes of power that other forms of truth face from institutions in society. It is easy to recognize power at work in what questions are considered fundable, what research is pursued and later published, and how entire fields of inquiry are established and supported or left unfunded and floundering. For example, in the Bush Administration's Climate Change Science Program begun in 2002, 13 federal agencies' funding directed toward climate research has been coordinated to answer questions determined to be of high priority. Unfortunately, many of the most critical questions around the human and economic dimensions of global change have been given short shrift, while the anthropogenic causes of climate change (which were already well established by 2002) are now extremely well studied [13]. It should also be noted that in the Bush administration, even more extreme measures were taken to control information related to climate change. Science journalist Seth Shulman [14] documents several cases of government suppression of scientific studies that differed from the administration's position and other efforts to undermine the work of government scientists. Cases include censorship of government reports on climate change.

When science is seen as objective, technology itself is seen as neutral (and often ahistorical), disregarding the social forces that demand certain forms of technology or pose certain questions. The consequences of technology are attributed entirely to the way the technology is ultimately used and not seen as part of the engineer's responsibility. Thus, the values that are embedded in technology are often those of the engineers' employers. Each engineered object brings with it a set of values and assumptions, which ought no longer to be taken for granted. I will examine these issues further in Chapter 3.

Waller [15] points out the predominance of positivism in engineering research, which carries over into engineering education research, to its detriment. Harding [16: 125] questions the use of positivist frameworks in engineering (and science) research, noting that "the ideal of one true science obscures the fact that any system of knowledge will generate systematic patterns of ignorance as well as of knowledge." Harding further notes how the myth of expertise can lead to authoritarian power structures. Science and technology studies scholar Langdon Winner [17] makes a similar point in noting how engineered systems, such as nuclear power plants, require centralized power structures in order to be created and maintained.

2.3.5 Uncritical Acceptance of Authority

A positivist mindset that sticks with the scientific method as the only way of knowing what we know, combined with a lack of exposure to other ways of knowing, or contexts in which those other ways of knowing are valued, can lead to a lack of questioning of certain types of information. When we do not learn to question the information given to us, we are unlikely to question authority. When the organizations who hire us operate in hierarchies and we are rewarded by following orders within those organizations, we are unlikely to question authority. Sociologist Diane Vaughan's [18] account of the events in National Aeronautics and Space Administration (NASA) leading up to the

Challenger accident document the ways in which power can construct knowledge in organizations, as outside pressures related to NASA's funding and productivity became internalized and began to affect thinking and behavior inside the organization. She documents the ways in which engineers conformed to organizational norms when raising concerns, following chains of command and deviating only at the behest of an authority. Vaughan's work suggests that the organizations in which engineers work may play a large role in setting these norms for engineers, as other employees may behave similarly regardless of their training or profession.

Sociologists Diego Gambeta and Steffen Hertog [19] present some unsettling data about the overrepresentation of engineers among radical Islamist groups (44% of those with college degrees where the major subject was known were engineers). Notably, engineers were not present among non-Islamic leftist groups, but were well represented among non-Islamist right-wing groups and overrepresented among U.S. white supremacists. In seeking to explain this overrepresentation, the authors found no evidence of engineers being selected by the radical groups because of their technical expertise. They rather offer two explanations: that engineers experienced particular social difficulties in Islamic society and that engineers, among others, are more likely to possess a certain mindset that increases their propensity to right-wing radicalism and violence. To support their argument, Gambeta and Hertog reference documents from radical Islamist groups and Western intelligence, noting recruiters look for a combination of intelligence and a willing acceptance of authority. Engineers were, in fact, recruited by some groups (and self-selected into others) more for their mindset than their technical ability.

This mindset exhibits three traits: *monism* (a belief in one right answer and an intolerance of uncertainty), *simplism* (locating a single cause for complex phenomena, a belief that rational behavior leads to simple solutions to social problems), and *preservatism* (a desire to restore a lost mythical order to society). Monism and simplism relate fairly clearly to positivism and reductionism as discussed above. Gambeta and Hertog cite additional evidence for the presence of this mindset in surveys of engineers around the world and ethnographic work with radical Islamist engineers. This mindset is distinctly right-wing in a political sense. It also prevents the acquisition of some critical analytical tools used in the social sciences and humanities to understand our world.

2.4 CONCLUSION

Engineers and the engineering profession have some characteristics that prepare us well to work on social justice issues: the strong desire to be helpful and the persistence of a strong work ethic. Yet some structural problems with the profession—its military and corporate focus and the narrowness of engineering education, which excludes a number of important skills—can present obstacles when we engage in social justice work. In addition, there is an engineering outlook that privileges scientific knowledge over other kinds of knowledge, prefers certainty to uncertainty, and seeks single, simplistic explanations for complex social phenomena, which creates a political tendency that eschews social justice and presents real roadblocks in acquiring skills outside of engineering that are needed for social justice work. In the next chapter, we begin to step outside the common mindsets in engineering by considering some critiques of engineering from a social justice perspective.

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