Chapter 11
Integrity and the Ethical Responsibilities of Engineers

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Abstract Engineering is a unique profession in many ways. It is the oldest professional activities whose practitioners can be held to account for their failures, according to publicly promulgated standards. This is partly because engineering is such a pervasive profession, but also because engineering "failures" are usually highly visible and sometimes spectacular. Engineers go to enormous lengths to avoid "failure". However, the public has little understanding of what engineers do, because they do not understand the nature of risk or the limited extent to which individual engineers are responsible for the construction, use and maintenance of their designs. Integrity is explained in this chapter as not so much a virtue but rather as a coherence or synthesis of the virtues, including an unwillingness to compromise ones values for gain. Professional integrity requires a commitment to the goals and values of the profession, and a person of integrity will not take up such a profession unless they can do so without compromising their personal values and ideals. Because of the complex nature of engineering as a profession, engineering integrity is also complex, and engineering education should emphasize this.

> A person of integrity lurks somewhere inside each of us: a person we feel we can trust to do right, to play by the rules, to keep commitments. (Carter 1996, p. 8)

11.1 Introduction

Integrity is often considered to be a virtue. As Cox et al. (2005) note, "Integrity is one of the most important and oft-cited of virtue terms. It is also perhaps the most puzzling." In the popular literature, lack of integrity is sometimes identified with

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generally unethical behaviour, especially financial dishonesty and misuse of organizational facilities (e.g. Kay 2005). However, if having integrity means no more than acting virtuously, for instance displaying courage, loyalty, commitment, honesty etc., then there seems little point in discussing it as a separate topic. In this section, I examine a number of different accounts of integrity. I am sympathetic to the idea that it is in fact a "cluster concept" (Cox et al. 2005).

If integrity is indeed a virtue, then it is a special one. It seems to me that it is not so much a way of behaving as what holds together the commitment one has to certain ways of behaving. Everyone should have integrity. For engineers, this presents a particular challenge, because of the very nature of the profession.

11.2 Engineers and How They are Perceived

Engineering is the oldest profession. As an activity practiced for gain – a job or business – it may not be older than what is commonly referred to as "the oldest profession" – there is no way to know. However, it is the oldest skilled and paid activity for which there are publicly promulgated standards: the Code of Hammurabi. This is often referred to as a Code of Ethics, and admired for predating the earliest document on medical ethics, the Hippocratic Oath by about a thousand years. The relevant sections of the Code deal with structural engineering: they require competence and ascribe responsibility (and penalties) for failure.

The Code is an astonishingly modern document for its time. The predominant world view of the day was what we would call supernatural – events happened because that was what the gods decided. Thus was especially true in the case of crucial events such as rainfall (a matter of life or death in Babylon), the fortunes of war, and disease. The Greeks are usually held to have invented secular explanations of phenomena (i.e. science) and philosophy around the time of Thales, some 2600 years ago. However, the Code implies a basically mechanistic world view. It requires structural engineers to behave in a responsible way towards both clients and members of the public. This is taken for granted today but I imagine was not in 1750 BCE. The Hippocratic Oath, in contrast, discusses only responsibilities to clients and fellow doctors and even modern medical codes are oriented predominantly towards clients.

Engineering is the most pervasive profession. Engineers transform the environment. They drain swamps, create dams and divert watercourses; they create infrastructure such as roads, ports, railroads and airports; they devise ways of extracting resources such as minerals and energy sources, and they develop ways of generating, transmitting and using energy. They provide us with transport and communications and technology in every area from weaponry to cooking, video games to space travel. All of this is totally obvious to every engineer, but not to the public.

Engineering is the most interdisciplinary or multidisciplinary profession. At least in universities in the Western tradition, including former European colonies and countries such as Japan, an engineering education is characterized by teamwork and cooperation, with students working together to design and build projects as a team.

Engineers see themselves as pragmatic, inventive, creative problem solvers: Samuel Florman's famous *The Existential Pleasures of Engineering* (1976) is still the best account of why engineers love their work. They are primarily interested in making the world a materially better place and therefore tend to be utilitarians. They tend not to be closely involved in politics (Beder 1998; Wiewiora 2005) – according to one of the many jokes about engineers, "Real Engineers' politics run towards acquiring a parking space with their name on it and an office with a window" (Professions Jokes website). Only one of member of the US House of Representatives, and no senator, is an engineer, whereas 170 representatives are lawyers (Greenberg 2008). There is also evidence that they are more conservative and religious than average (Gambetta and Hertog 2007).

Engineers believe, correctly, that of all the professions they are both the most useful and the most misunderstood. According to one US government study, "Despite decades of social change, the general perception remains that IT workers, scientists and engineers are unusually intelligent, socially inept and absent-minded 'geeks' or 'nerds'" (Kowalenko 2000). A 2005 AAES Harris poll documented that "most of the public see engineers as creating economic growth (69% vs. 25% for scientists); preserving national security (59% vs. 29%); and making strong leaders (56% vs. 32%). However, scientists are seen more prominently as discovering the natural world (92% vs. 6%); saving lives (82% vs. 14%); and protecting the natural environment (77% vs. 17%). Science is seen as improving the quality of life more than engineering (71% vs. 22%); as caring more about the community than engineers (51% vs. 37%); and as being more inclusive of women and minorities (54% vs. 26%)" (McCarter 2005). Some of these figures are quite bizarre, especially those on "saving lives" and "improving the quality of life".

The comparison on "caring about the community" is interesting because I suspect that engineers are probably more concerned with what engineers usually call "social responsibility" than scientists. While there was much debate in the 1970 s and into the 1980 s about whether engineers have any responsibilities at all other than technical excellence and doing the best for one's client the engineering literature tends to reflect a recognition that technical and social considerations are inseparable, because technology both shapes society and is shaped by it; indeed, it is sometimes argued that, because of their expertise and knowledge of risks, engineers have a duty to be "moral heroes" (Alpert 1982). Moreover, especially in Australia and New Zealand, engineers are increasingly aware of their environmental responsibilities (Gunn and Vesilind 2005).

Perhaps one reason why the public is so ignorant about what engineers do is that it has very limited knowledge of risk. In relation to transportation, for instance, most people probably consider that flying is probably the most inherently risky. However, consider these figures: In 2005, 45 636 people died in transportation accidents in the US, almost all (43 443) on the nation's highways. Of the 616 aviation fatalities, only 22 were on airlines. Rail accidents claimed 789 deaths and 769 died in marine accidents (almost all in recreational boating incidents); 785 cyclists were killed in accidents (National Transportation Safety Board 2008, Bicycle Helmet Safety Institute 2007). It would be interesting to survey the public perception of the relative

safety of these modes of transport. Media coverage is probably largely to blame. Incidents where a number (even quite a small number) of people die, such as the Minneapolis bridge collapse on 1 August 2007 (13 deaths) are treated as "disasters". Moreover, they are also treated as engineering failures, even though the engineers who designed and built the bridge had absolutely no control over its use and maintenance.

11.3 Engineering: The Unique Profession

The thesis of this section is that engineering is a uniquely demanding profession, for three reasons.

First, it is the most public profession and all engineering projects are supposed to be 100% successful. Anything that goes wrong is perceived as a "failure". Of course, all engineering structures will fail eventually but they should not fail when in I ot. trolled by engineers, which t arely is. ail eventually but they should not fail when i use, and they rarely do if their use and maintenance is controlled by engineers, which it often is not. If a plane crashes or a ship sinks, a bridge or building collapses, a life support system stops working, a brownout occurs, or, horrors, a nuclear meltdown occurs, everyone knows about it, and everyone knows who to blame. In contrast,

- Lawyers negotiate in secret, and of the cases that go to trial, on average they lose half of them.
- Doctors are expected to "lose" some patients and can bury their mistakes.
- The "helping professions" – social workers, priests, counselors, psychologists and psychiatrists operate under confidentiality and "the client has to want to change" so if s/he doesn't, it's not the professional's fault.

Secondly, professionals such as lawyers, doctors, dentists, architects and the "helping" professions":

- Mostly operate one on one, which engineers rarely do.
- Have far fewer constraints on their practice than do engineers.
- Do not run a high risk of "indirect" harm, i.e. harm to third parties as a result of their professional services to their clients, unlike engineers.
- Are therefore expected to devote themselves entirely to their clients' interests, whereas engineers have to take account of the interests of others likely to be affected.

Thirdly, the attribution of responsibility in other professions is often relatively straightforward, because those professionals are often in control of the whole process (the client's cooperation excepted). Paradigm cases include the dentist who fills your teeth, the accountant who files your tax return, the doctor or midwife who delivers your child, the surgeon who locates and removes your diseased appendix

and sews you up, the lawyer who takes your case. Note that these professional services are carried out in isolation; their providers do not form a "team" and nothing that, say, the accountant does for a client has any impact on the services provided by the dentist. The attribution of responsibility in engineering is much more difficult, because, as noted, engineers, whether operating individually or as a team, are responsible for whole projects. Moreover,

- Engineering failures often have multiple and/or unknown causes.
- Engineers operate under financial and institutional constraints. All engineers are familiar with the story of the astronaut who was asked how he felt about his first flight and replied, "How would you feel if you if you were out in space and sitting on 20 000 parts each of which was purchased from the lowest bidder?"
- Engineers who design structures don't build them, nor, as noted, do they have any control over the use and maintenance of those structures.

Thus, whatever professional integrity might turn out to be, it will likely be more complicated in engineering than in other professions.

11.4 What is Integrity?

> By "integrated life" I mean a life in which various aspects are in harmony; for example, one's plans and policies cohere with one's values and ideals, one's deeds cohere with one's words, and the whole pattern of one's "inner" and "outer" choices cohere over time not only with each other but with others' in a larger moral community. (Hill 1991, pp. 77–78)

As Cox et al. (2005) note, "Integrity is one of the most important and oft-cited of virtue terms. It is also perhaps the most puzzling." In the popular literature, lack of integrity is sometimes identified with generally unethical behaviour, especially financial dishonesty and misuse of organizational facilities (e.g. Kay 2005). However, if having integrity means no more than acting virtuously, for instance displaying courage, loyalty, commitment, honesty etc, then there seems little point in discussing it as a separate topic. In this section, I examine a number of different accounts of integrity. I am sympathetic to the idea that it is in fact a "cluster concept" (Cox et al. 2005).

While this chapter is not primarily concerned with ethical theory, it is worth noting that virtue ethics theorists disagree on what exactly integrity is, or indeed on whether it is a virtue at all. Robert Solomon, a professor at the University of Texas who specializes in virtue ethics in business states,

> Integrity is not itself a virtue so much as it is a synthesis of the virtues, working together to form a coherent whole. This is what we call, in the real sense, *character*. (Solomon 1999)

In many contexts, integrity refers to a wholeness, with the implication that an object, organization, natural or human made system is intact and not damaged or corrupted, and is thus functioning properly. Integral parts or features are those that are necessary to proper functioning. Typically, the term has strong normative

overtones, as is evident from the contrast with damage and corruption. Obviously, everything constructed by engineers has to have integrity in this sense.

Analogous to this is the idea of the integrated self:

> [I]ntegrity is seen as a matter of persons integrating various parts of their personality into a harmonious, intact whole. Understood in this way, the integrity of persons is analogous to the intactness of things: integrity is primarily a matter of keeping the self intact and uncorrupted. (Cox et al. 2005)

One may also speak of a whole person in a psychological sense, as if a person who is suffering from a mental illness or personality disorder, or lacks cognitive abilities, is incomplete. In another chapter at this conference, it was noted that cluster bombs are often weapons in pursuit of a policy of encouraging depopulation of a strategically important area. A proportion of the bomblets that make up a cluster bomb are deliberately designed to "fail", that is, not to explode on impact. They are also small and brightly coloured and thus attractive to children, who tend to pick them up and have their arms blown off. When this happens, whole communities will move away. An otherwise normal engineer who works on such projects would need to be able to compartmentalize his or her life to the point of not being a "whole person".

In a moral sense, a person is said to have integrity if they are true to their values and refuse to compromise them. Consider the following case:

> Chris is Chief Engineer for a local authority. He is required to represent the authority at an Environment Court hearing on a proposed expressway. Chris is not in favour of the routing of the expressway, because it will cut in half a low income housing area and destroy a local park; this conflicts with his strong personal commitment to social justice and equity.

If Chris is to be true to his personal values, it is difficult to see how he can advocate for the expressway.

There is a sense in which only I can know whether I am acting with integrity, because only I know what standards I strive to meet. As Eugene Torisky (Undated) puts it,

> There is no set of necessary and sufficient conditions accessible from outside, from a third person perspective, determining whether a person is living with integrity.

However, if a person has publicly committed herself or himself to a set of values, their reputation will suffer if they are perceived to act contrary to those values. Consider the following example, based on a real case from New Zealand:

> Kiri (name changed), a consulting engineer, is asked by the Minister of Conservation to be a member of a panel that is hearing an application under the Resource Management Act 1991 from a meat works to continue to discharge wastes into the ocean via a pipline; she believes that she will be able to persuade the rest of the panel that pre-treatment of the effluent must be improved, thus reducing the degree of water pollution, but for cultural reasons she is strongly opposed to any marine disposal of organic wastes

Kiri was (and is) a prominent member of the Maori community and advocate for traditional Maori values being incorporated into decision making and policy. Maori believe that human waste must never be discharged directly into waterways.

As well as being a sound public health policy, this practice has a spiritual basis: wastes can be purified only by being first passed through the body of the Earth-Mother, Papatuanuku.

It is often noted that we can greatly admire people with whom we disagree because they have integrity, even if we disagree with them. University of San Diego philosopher Lawrence Hinman (Undated), who calls this "personal integrity" gives the example of former Arizona Senator and 1964 Republican presidential nominee Barry Goldwater (1909–1998).

> Personally, I disagree with almost everything that Goldwater has said over the years. However, I always trusted Barry Goldwater to be Barry Goldwater, to stick by his beliefs, no matter how unpopular they were at any given moment. Goldwater didn't change his beliefs in order to gain votes ... he always stood for something ... he fought hard for what he believed in, but he also fought fairly. And we admired him for it . . .

However,

> Because we find ourselves with so many commitments, of so many different kinds, and because commitments inevitably clash and change over time, it will not do to define integrity merely in terms of remaining steadfastly true to one's commitments. It matters which commitments we expect a person of integrity to remain steadfastly true to. (Cox et al. 2005)

Hinman (Undated) compares Goldwater with the Unabomber, whose terrorist activities were, he claimed, designed to draw attention to his views about the dangers of modern technology, "He has certainly remained steadfast in his commitments, and has backed up his words with actions." However, Hinman believes that the Unabomber lacked integrity, for two reasons. First, of all the virtues, courage is most directly related to integrity. This is because "integrity involves standing up for what we believe in – and that takes courage." The Unabomber, however, was a coward, sending parcel bombs through the mail (killing three and wounding 29) and demanding that his manifesto (Kaczynski, Undated) be published but anonymously. Secondly, Hinman states (though he doesn't argue for it) that a person's acting on his values is not consistent with integrity if those values are not within "the range of core values which reasonable human beings can accept".

Many writers also refer to professional integrity, which is associated with voluntarily assumed roles. As Hinman (Undated) notes, this can be seen, and expected, at many levels, from the firefighter who risks his or her life to rescue someone from a blazing building to a parent remembering to be the Tooth Fairy.

> When we grant integrity to a person we need not approve of his or her principles or commitments, but we must at least recognize them as ones that a reasonable person might be tempted to sacrifice to some lesser yet still recognizable goods.

Professionals and other role players, unlike individuals acting in a private capacity, cannot just be guided by their private beliefs, and given the nature of their profession, engineers may be said to have special responsibilities, as the following case suggests:

> Students ("Aggies") at Texas A & M had a tradition, beginning in 1907, of building a bonfire associated at the time of their annual football game against traditional rivals the University of Texas. Originally it no more than a trash pile, gradually evolving

> into a 20 m complex "wedding cake" structure there is an impressive photograph at http://en.wikipedia.org/wiki/Aggie_Bonfire. In 1999, the bonfire collapsed during construction, leaving 12 dead and 27 injured. The bonfire was designed and supervised by engineering students but no professional engineers were involved.

It is unclear how responsibility for this disaster should be apportioned. It was an official university event, and the university lent tools and trucks to the students, but did not exercise any supervision. Despite the huge size and complexity of the structure, it does not appear that any professors from the College of Engineering made any attempt to advise on its design and construction. Somewhat belatedly, the Texas Board of Professional Engineers stated in 2000 that "the Aggie Bonfire met the requirements to be considered a complex construction project that should be regulated by state engineering laws" (Wikipedia 2008). It is submitted that a number of persons (not just engineers) failed to exercise their professional obligations in this case and, in this sense, did not observe the requirements of integrity.

Furthermore, and perhaps more so than any other profession, there is a sense in which an engineer is always "on duty", as the following 1995 case from New Zealand illustrates:

> Fourteen people, on a college trip, died when a Department of Conservation (DOC) scenic viewing platform 40 m over a small stream, Cave Creek, collapsed. This was not exactly an engineering failure because no qualified engineer (or even builder) was involved in design, approval or construction. The platform had significant design faults, exacerbated by the fact that some of the sound designed safety features were not actually built. The Commission of Enquiry into the disaster noted that DOC had acted illegally and negligently, but emphasized that it was under-resourced and forced to "cut corners" and "forced to accept poor quality standards"

Perhaps, though the Institution of Professional Engineers in New Zealand might consider taking on a watching brief for potentially dangerous structures especially where, as in this case, no building permit was ever sought. While, as noted, no engineers were involved in this project, no doubt a number had visited it but apparently did not notice its deficiencies as a structure. But, it might be said, an engineer on vacation is just a tourist and should not be expected to be constantly on the look out for risks.

In so far as we value integrity for its own sake, we do so because people who have it in a high degree are prepared to stick to their values regardless of whether it is in their interests to do so. If we ourselves have made sacrifices for what we believe in, we are entitled to feel a modicum of pride in ourselves. But as well as intrinsic value, integrity is important because it makes the difference between merely having a theoretical commitment to virtues and following them in practice.

Finally, lack of integrity is often seen as a major reason for organizational failure. It is not that those involved do not know what they ought to do, but that they don't have, in Britspeak, the bottle to speak up. From St Peter in the Bible, who denied that he was a follower of Jesus, to the engineers who kept silent about the Challengers' O-rings, people have failed to do what they knew to be right; have exhibited what

Aristotle termed *akrasia*, moral weakness. Carter (1996, p. 8), who believes it to be "the first among the virtues": puts it well:

> Indeed one reason to focus on integrity as perhaps the first among the virtues that makes for good character is that it is in some sense prior to everything else: the rest of what we think matters very little if we lack basic integrity, the courage of our convictions, the willingness to act and speak in behalf of what we know to be right.

For professionals, this ideal means that their professional and personal values and behaviour coincide. But professional life is immeasurably more complicated than personal life, and, as I have argued, engineering professional life is more complicated than that of other professions. Probably, it requires more compromises. It certainly requires more education.

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