Int. J. Engng Ed. Vol. 24, No. 2, pp. 314–327, 2008
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Living Up to the Code: Engineering as Political Judgment*

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Nearly every code of professional ethics used in engineering begins with an affirmation of the engineer's obligation to hold paramount the safety, health and welfare of the public in the performance of professional duties. Most of these also either explicitly or implicitly acknowledge that the achievement of these high standards depends on the judgments made by practitioners in designing structures, devices, systems and technologies. To date, almost all of the interpretation and analysis of this first canon has focused on situations in which an ethical failure will result in an immediate catastrophe such as a building's collapse or loss of lives, that is, on the safety and health terms. Indeed, very little attention has been given to the 'welfare of the public' aspect of the code. While the meaning of this key phrase is often presented as self-evident, the current approach to the principle often relieves engineers of the responsibility to engage actively in articulating their design choices with the full substance of the ethical commitment it entails. Engineering ethics demands that, as part of their professional practice, they ask themselves (and others): what is the public welfare and how might my design choices either serve or undermine it? This paper asks what it would mean for engineers to live up to a demanding interpretation of this fundamental ethical commitment, and explores the contribution engineering education might make to enabling them to do so.

Keywords: ethics; politics; technology and society; engineering education

INTRODUCTION

CODES OF PROFESSIONAL ETHICS reflect a variety of interests and circumstances, but in nearly every case they begin with a sense of 'higher purpose' for the profession. This is particularly true in engineering, where such codes almost always begin with an affirmation of the engineer's obligation to hold paramount the safety, health and welfare of the public in the performance of professional duties, notably design. To date, almost all of the interpretation and analysis of this 'first canon' has focused on situations in which an ethical failure will result in an immediate catastrophe such as a building's collapse or loss of lives, that is, on the safety and health terms. Indeed, very little attention has been given to the 'welfare of the public' aspect of the code. While the meaning of this key phrase is often taken to be self-evident, failure to explicitly consider it may either relieve engineers of the responsibility to engage actively in articulating their design choices with the full substance of the ethical commitment it entails, or it may leave them open to the charge of inadequately considering their own high standards. Engineering ethics demands that they ask themselves (and others), as part of their professional practice: what is the public welfare and how might my design choices either serve or undermine it? The current approach to teaching engineering ethics often reduces the welfare of the public to situations of extreme crisis (such as being ordered to design an unsafe structure) or a platitude to be ignored.

ENGINEERING CODES OF ETHICS IN THE US

The history of engineering in the US can be traced back to the earliest days of the republic [1]; the first engineers served as officers in the Continental army. As in Europe, engineers first responsibilities were military. The term 'civil engineer' was an umbrella term to distinguish a highly varied group of workers from their colleagues working on military projects. The first engineering school in the US was West Point, established in 1802, followed in the late 1840s by the first formal civil engineering school at Rensselaer Polytechnic Institute. Other military schools followed West Point's lead and established various engineering programmes during the first half of the nineteenth century.

The modern engineering profession emerged in the middle of the nineteenth century with the intensification of forces of industrialization brought about by the railroad. In the early nine-

* Accepted 25 December 2007.

teenth century it was still possible to carry out large-scale projects without the help of a formally trained engineer—as Davis [1] points out, the Erie Canal 'was begun about the same time West Point settled on a curriculum'. These new technologies, however, required an intimate knowledge of the system as a whole. Standardization across large distances and interoperability were necessary to the proper functioning of even the smallest parts of the system and required an entirely different level of centralization. Under these conditions, knowledge of the 'fundamental principles' of the technology was essential. In many respects, the emergence of the engineer as a professional parallels the emergence of the large-scale industrialized operations in which they are 'held captive'.

While the American Society of Civil Engineers (ASCE) was established in 1867, engineering cannot be considered a profession in the modern sense of the word until the twentieth century. Professions distinguish themselves from other 'skilled occupations' by establishing formalized, standardized codes of conduct for their members [1]. By the turn of the twentieth century, the numbers of engineers working in the United States had mushroomed. Many of these engineers were young; committees were established by most of the major engineering professional societies as a way of passing down those accepted standards of conduct to their younger colleagues. In many ways, the codification of ethical standards had never been attempted before because the societies' members simply had not seen a need for it. Another important feature of the process of professionalization is the concerted effort made to distinguish the 'elite' engineer from the draftsman, technician or craftsman. The professional sees himself or herself as a 'prestigious, learned, responsible individual whose superior qualities entitled him to high public esteem and position (and, implicitly, material reward)' [2].

The first serious debates suggesting that ASCE should adopt a code of ethics took place in 1893 when the code's proponents changed their language from a question of 'rules' for members to follow to that of a common 'etiquette' to guide professional behaviour [3]. Ultimately, board members decided a code of ethics was not necessary to protect the reputation of the profession—after all, attorneys had no code of ethics but were considered a *bona fide* profession in the eyes of the public.

Passed largely in response to several states beginning to regulate the role of the engineer, ASCE's first ethics code was adopted in 1914 and reflected the preeminent importance of the profession's 'honour' and 'dignity'. Preferring to regulate from within rather than to submit to conditions imposed on a state-by-state basis, the code included six articles that dealt solely with the relationship between the engineer and the client, the professional reputation of members and behaviour required to maintain it, and how members may advertise their services [4]. Licensing of engineers had become a reality in two states (with nineteen more to follow over the following decade) [3]; the code of ethics was seen as a way to assert the autonomy of civil engineers on their own terms.

The 1961 revisions to the code resulted in a much larger, comprehensive account of the professional duties of the engineer. Yet while the expanded version introduced specific explanations of the kinds of activities prohibited on ethical grounds and a reference to the 'public interest' in the preamble, the scope of the code remained essentially the same. The overarching concern continued to be the professional relationships of engineers to their clients and amongst themselves [5].

It was not until the 1970s that a broader discussion of the role of the engineer in society took place, resulting in the integration of several 'fundamental principles' and 'fundamental canons' into the code itself. In 1974 a task force assembled by ASCE reported [6] that 'professional engineers have always been aware of their obligations to serve society, and this has been implicit in the Code. But the obligation has not been spelled out.'

The Spiro Agnew affair—in which the Vice President accepted kickbacks from engineers—served as a catalyst for the rapid adoption of the revised ethics proposed by the Engineers Council for Professional Development [6]. In September 1976, ASCE's Code of Ethics spelled out the responsibility of engineers to use 'their knowledge and skill for the enhancement of human welfare' [7] as a fundamental principle of the profession. The so-called first canon of engineering was also added, asserting that 'Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties'. While the earlier provisions respecting professional conduct and business relationships still constitute the largest part of the Code of Ethics, the recognition of the engineer's broader social responsibility is a significant shift from earlier conceptualizations of what it means to be a professional engineer. Over the course of this decade, the paramountcy of the public welfare was also codified in the ethics codes of most—if not all—other professional engineering societies in the United States [8–10]. While authors such as Vesilind argue that this new code had as much to do with public relations as with a genuine, association-wide concern for an expanded definition of the social responsibilities of the engineer, by the 1980s the paramountcy principle had been enshrined as the guiding force behind engineering decisions [6].

The *Guidelines to Practice under the Fundamental Canons of Ethics* [11] describe in further detail the demands placed upon the engineer when questions of the public welfare arise. Specifically, the 'Guidelines' require engineers to 'recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgments, decisions and practices incorporated into structures, machines, products, processes and devices'.

Engineers are expected to inform their clients or employers of the consequences of their work on the safety, health, and welfare of the public and are even expected to act in a whistleblower capacity when their concerns are ignored. The final two sections under the first canon—those that suggest an engineer's role in civic affairs and improving the environment proactively—shift in their language use from the prescriptive 'shall' to the suggestive 'should'.

What does the addition of this newfound concern for public welfare and the environment mean for engineering professors and those considering the problems of engineering? Davis's definition of the code of ethics is useful here [12]; primarily, a code of ethics is a 'convention between professionals'. Thus we can assume that professional engineers, generally speaking, agree that it is not their personal conscience that guides their professional decisions, but those agreed upon to protect the common values and interests of the profession as a whole. Regardless of the engineer's individual outlook on sustainability or the public welfare, their actions must be guided by the consensus of the whole.

Yet all this attention to the supposed paramountcy of the public welfare seems to have been overshadowed by the other provisions of the first canon, namely those calling attention to the more tangible concepts of health and safety. In a survey of the literature on engineering ethics, the vast majority of texts interpret the concept of 'public welfare' narrowly, making this potentially broad and wide-reaching concern one that is essentially coterminous with health and safety [13].

It is interesting and noteworthy that ASCE nearly added an additional canon, dealing with sustainable development and the environment, in 1983. The proposed amendment read:

> Engineers shall perform service in such a manner as to husband the world's resources and the natural and cultured environment for the benefit of present and future generations.

The guidelines accompanying the so-called 'eighth canon' used prescriptive language (i.e. 'shall') requiring engineers to consider and 'be concerned with' the protection of natural and cultural environments—it also included the obligation to 'oppose or correct' any actions detrimental to those systems [14]. In the end, the eighth canon was abandoned [11], and replaced in 1997 by an (unenforceable) addition to the first canon that required engineers to 'strive to comply with the principles of sustainable development'.

NON-US PERSPECTIVES ON ENGINEERING CODES

As noted above, the development of engineering as a profession and the associated codes of ethics are strongly dependent on the particular historical situations in which practicing engineers find themselves. Not surprisingly, then, there are a great number and variety of professional societies and associated codes of ethics around the world. These groups range from what are essentially marketing groupings to organizations that act with the force of law. For many of the societies, the codes of ethics are similar to those in the US (The Canadian and US codes, for example, are quite similar.) Of more interest, however, are those cases where the professional society has traced a different path, or where the code reflects substantially different cultural and professional traditions. In this section, we examine several such examples.

European perspectives: France and Germany

The development of the engineering profession in France shared few of the features of its American counterpart. In France, engineering was—and remains today—the most respected occupation within society. Because of this, French engineers were never forced to go through the same self-interested process of professionalization in order to secure their place in society and recognition from the public. As Lucena [15] points out, it is assumed that anyone who has made it through the rigorous selection process of the state educational system has the ethical knowledge and is duty bound to perform in the name of the republic.

Furthermore, it has always been claimed in France that engineering is carried out in the public interest. The *Corps des ponts et chausées*, composed of state engineers and established in the eighteenth century, was charged from the beginning with promoting 'the complementary notions of rational public administration in the general interest and planning on a national scale' [Smith, quoted in 15].

Nevertheless, and perhaps in response to codes of ethics in American engineering, the *Conseil national des ingénieurs et des scientifiques de France* (CNISF) introduced a Charter of Engineering Ethics in 1997. The Charter is broken into four sections: 'The Engineer in Society', 'The Engineer and his Competencies', 'The Engineer and his Profession', and 'The Engineer and his Callings *(mission)'*. It explicitly recognizes service and responsibility to the public, an awareness of the impact of technology on the environment, and principles of sustainable development. While the CNISF is less influential than its North American counterparts, its Charter indicates a common understanding of the increasingly interconnected relationship between the engineer and the society he or she serves.

The experience of professional engineers in Germany, like that of most of the professions, was profoundly and irrevocably shaped by Nazism, the Second World War and the Holocaust. After having been successfully co-opted into assisting and even supporting National Socialism in the 1930s, the engineering profession needed to be reformed and rebuilt in the postwar era. The

Verein Deutscher Ingenieure (VDI), or Association of German Engineers, began its post-Nazi incarnation at an international conference on Technology as an Ethical and Cultural Task. This initiated an extensive collaboration between the VDI and (anti-Nazi) philosophers which continues to this day. One of the key documents of this effort was the Engineer's Confessions, which used spiritual and religious rhetoric to describe engineering as a vocation. Specifically, the engineer 'should place professional work at the service of humanity . . . [and] should work with respect for the dignity of human life and so as to fulfil his service to his fellow men without regard for distinctions of origin, social rank and worldview' (quoted in [15]). Lucena has written a history of the German experience, showing how it has culminated in what must be considered among the most politically and socially engaging codes of ethics in the world [15].

Fundamentals of Engineering Ethics [16], adopted in 2002, begins by acknowledging that engineers are 'responsible for their professional actions *and the resulting outcomes*', and goes on to say that '[e]ngineers are responsible for their actions to the engineering community, *to political and social institutions* as well as to their employers, customers, and technology users' (italics added). These, in themselves, constitute a remarkably direct appropriation of responsibility by the VDI, but the next statement in the code goes further than any other we have seen. Section 1.3 states:

> Engineers know the relevant laws and regulations of their countries. They honour them insofar as they do not contradict universal ethical principles. They are committed to applying them in their professional environment. Beyond such application they invest their professional and critical competencies into improving and developing further these laws and regulations.

Notice that the VDI is not merely calling for its member engineers to follow the law, but to recognize that the law may be in conflict with 'universal ethical principles'. Further, the engineer is specifically tasked to work to improve and develop laws and regulations.

The second section of the *Fundamentals* addresses the disposition which the engineer must bring to bear in resolving conflicts and making decisions. This section of the code speaks, among other things, to the need to consider 'the impact on the lives of future generations', including the need to maintain for them 'the options of acting in freedom and responsibility'. The VDI calls on its members to resist constraints and pressures, including 'the forces of short-term profitability', and to 'consider the values of individual freedom and their corresponding societal, economic, and ecological conditions the main prerequisites to the welfare of all citizens within modern society'. In the resolution of conflicts, the VDI code offers the following guidance:

In cases of conflicting values, engineers give priority:

- to the values of humanity over the dynamics of nature,
- to the issues of human rights over technological implementation and exploitation,
- to the public welfare over private interests,
- to the safety and security over functionality of their technical solutions.

Engineers, however, are careful not to adopt such criteria or indicators in any dogmatic manner. They seek public dialogue in order to find acceptable balance and consensus concerning these conflicting values [16].

Finally, in a third section, the code of ethics addresses the conflicts which may arise between matters of law and conscience, including public disclosure.

What is perhaps most striking about this code of ethics is how much the overall structure seems to address explicitly what is offered implicitly in the first canon. Perhaps it is because the authors recognize from their own national experience that technology applied in the service of evil leads to catastrophe, but for whatever reason, the *VDI Fundamentals of Engineering Ethics* is a unique document in the Western world.

The developing world: Zimbabwe and Pakistan

Professional life in much of the developing world has its roots in the former colonial powers, and, as such, the codes of ethics found usually take their cue from those countries and the United States. Thus the Code of Ethics of the Board of Engineers of Trinidad and Tobago [17] reads more like a legal document from an earlier time than a philosophical statement. There are, however, interesting examples of how the professional engineering societies have shaped their codes to their own concerns.

The Zimbabwe Institution of Engineers (ZIE) acts with the force of law in regulating its members' professional activity. The Code of Conduct [18], as modified in 1998, includes as its first rule, 'A member, in the course of his employment and in pursuance of his profession, shall have due regard for the public interest'. The remainder of the code generally consists of the traditional obligations to clients and other practitioners, including honesty, competency, and appropriate decorum, except for an addition to the first canon. Rule 1.1 states that 'A member . . . shall have due regard to the Environmental Code of Professional Practice approved by the Council of the Institution'.

The Environmental Code of Professional Practice [19] (ECPP) was adopted in 1997, and carries regulatory authority in law. While the ECPP was drafted in a manner which allows for considerable interpretation and professional judgment, it specifically holds engineers accountable for following sound and 'effective management of environmental issues'. For example, it states that, 'Members should be aware that non-compliance with the provisions of this code may be relevant when considering disciplinary matters' and goes on that 'failure to adhere to the provisions of this Code . . . may evidence an infringement of the ZIE's Rules of Conduct which could lead to disciplinary proceedings'.

The ECPP offers a definition of the environment that, in addition to flora and fauna, includes 'all cultural, social and economic conditions that influence the life of a community'. It also calls upon engineers to 'recognize that your duty to the community takes precedence over personal and other partisan interests'. In terms of specific actions, the ECPP calls on members to 'discuss environmental issues, developing technology and regulatory requirements with others', 'bring major potential environmental damage to the attention of those in authority in a responsible manner', and 'to join debate over drafting and implementation of legislation'.

The current political climate in Zimbabwe, however, reminds us that an engineer's ability to live up to principles such as these depends heavily upon the possibilities and constraints established by the political system more generally. Under fundamentally undemocratic conditions such as those that persist in Zimbabwe, meeting ethical obligations such as these could place the engineer in conflict with the existing regime. Under such circumstances the stakes and ethical complexity of living up to the code escalate considerably. Similar concerns can be raised to the practice of engineering in any country subject to authoritarian rule.

As both an Islamic country and a culture in which English is widely spoken and used professionally, Pakistan provides a possible window into engineering ethics in the Islamic world. The ethical guidelines of the Pakistani Engineering Council, the legally constituted body for the regulation of engineering in that country, are organized into two sections. The first, the Code of Ethics, is unlike any code of ethics found in the West. It begins

> Whereas Allah enjoineth upon his men faithfully to observe their trusts and their convenience; that the practice and profession of engineering is a sacred trust entrusted to those whom Nature in its magnificent bounty has endowed with this skill and knowledge; that every member of the profession shall appreciate and shall have knowledge as to what constitutes this trust and covenant, and; that a set of dynamic principles derived from the Holy Quran shall guide his conduct in applying his knowledge for the benefit of society [20].

The Code of Ethics then includes a series of precepts and commands taken from the Quran, such as 'Allah commands you to render back your trust to those to whom they are, and that when you judge between people, you judge with justice. Allah admonishes you with what is excellent'. And 'Fulfil the obligations'.

This approach to a code of ethics appears to contradict Western ideas about the secular, scientific and independent nature of engineering practice. The standard approach to the grounding of ethical codes in the Islamic world, however, is to begin with religious belief and values, and only extend guidance from these. In an analysis of journalistic ethics and Islam, Mohamed [21] highlights that any code of ethics begins with the principle of piety (*taqwa*), then looks to central pillars or concepts, such as oneness (*tahwid)* and justice (*'adl*). It is only in the light of these principles that specific actions have moral or ethical meaning. Thus by basing the code of ethics on the Quran, the Pakistani Engineering Council is providing a basis intended to make ethical decisions consistent with the other aspects of the practitioner's life. (It goes without saying that there is an inherent tension for non-Islamic engineers who practice the profession in Pakistan.)

Specific governance of professional behaviour is set forth in an associated Code of Conduct [22]. This document reads in much the same way as the codes of ethics adopted by the engineering societies in the West in the 1970s, when the code was adopted. Focused primarily on individual behavior and interaction with the client, the code also contains a version of the paramountcy principle, albeit in a later canon. Codes of conduct such as these are arguably a reflection of the secular character of the profession as it has developed in the West. By subordinating the Code of Conduct to the Code of Ethics, the Pakistani Council of Engineering appears to be confirming that, within their tradition, ethical standards derived from religious principles are prior to, and the necessary context of, standards of conduct.

The subject of codes of ethics and cross-cultural relationships has recently been the subject of a workshop sponsored by the United States National Research Council, the Academy of Sciences of the Islamic Republic of Iran, and the Academy of Medical Sciences of the Islamic Republic of Iran [23]. The participants took part as private citizens and did not necessarily represent either their governments or their professional societies. In addition to supporting calls for more interaction, the group examined the bases of ethics and ethical codes in their cultures. Their report reinforces Mohamed's point regarding the religious foundation of professional ethics in Islamic societies.

POLITICS AND ENGINEERING

It is a safe bet that relatively few young men and women embark on a career in engineering because they want to do politics. Similarly, it is unlikely that many practicing engineers understand their work as political. To be sure, working engineers regularly experience the frustration of something called 'politics' standing in the way of getting the real the job done. In this instance, politics is understood pejoratively, in the sense of rivals seeking competitive advantage, or winners placating losers either following or in advance of their loss. In this sense, when a practicing engineer is forced by circumstance to do politics, it is understood to be doing something other than engineering, something that must be tolerated but which is not intrinsic to the practice. Engineering is engineering, but *that* is 'just politics'. Engineers today are well-trained to integrate into their practice at least some degree of concern for the rectitude of their professional decisions and conduct, to act responsibly and to tell the truth. This is the customary domain of professional engineering ethics. However, as Winner has pointed out [24], there is a point 'where ethics finds its limits and politics begins . . . when we move beyond questions of individual conduct to consider the nature of human collectivities and our membership in them'. It is precisely beyond this point, the point where ethics ends and politics begins, that most professional engineers understand their practice as not requiring them to venture.

This attitude toward the relationship between the technical and the political is not peculiar to engineers. It agrees with a more general cultural orientation in technological and scientific societies, in which the technical and the political are held to be separate and distinct: politics is one thing; technology is another. This separation accomplishes a great deal for science, engineering and technology. On the one hand, it serves as the basis for the relative prestige, privilege and power of science and scientists, technology and engineers. For, in distinction to the subjectivity, irrationality and contingency that rules in most social domains, here is thought to be a realm in which disinterest, objectivity, neutrality, efficiency and method are the currencies of truth. On the other hand, separating the political and the technical serves to insulate the latter from the former, and to circumscribe the social and political responsibilities borne by practitioners of science and technology, leaving them free to seek out the one best way. No matter that design criteria such as efficiency, effectiveness and economy are, in fact, deeply subjective, historically situated, and socially constructed standards. To conflate the political and the technical is to risk undermining the status of science and technology as central legitimating principles in our society, and it is also to ask too much of engineers and scientists.

Or is it? Consider the first canon and its invocation of 'engineering judgements, decisions and practices'. Judgement, decision and practice are all political words, and they signify far more than merely technical or scientific considerations. In the first place, the context in which engineers practice is always political, in the sense that it is formed by political judgements about desirable ends, and by relationships in which power is differentially distributed. Second, as this canon recognizes, the judgements, decisions and practices of engineers become embodied in the structures, machines, processes and devices they make and these, in turn, are implicated in the well-being of society more generally. Thus, the judgements and decisions engineers make in practicing their vocation are never "just technical." This implies both that engineering is not different from a range of other social practices, and that engineers bear a special responsibility to engage in their practice, at least partially, as if they were doing politics.

As suggested above, one reason why engineers might be reluctant to recognize their practice as inherently and necessarily political is the diminished and pejorative sense in which 'politics' has come to be regarded in contemporary culture. In this context, politics is typically understood as a cynical, strategic conflict between self-interested actors with competing agendas, whose only apparent motivation is private advantage, or the perverse satisfaction that comes with victory over others. On a small scale, we see politics of this sort in the incessant jockeying for position by people and groups we encounter daily in our professional and personal lives. On a larger scale, we are subjected to this version of politics in the dispiriting media spectacle of partisan competition for the seat of government, a game whose incentives recommend that one should never say what one means, or mean what one says.

Fortunately, our imagination need not be limited to the impoverished meaning attached to politics in the current climate. A more robust conception might more readily suggest to engineers the positive ways in which their work can be understood as political. At its core, politics concerns judgement, in particular judgement about good ends, and about just means for reaching towards them [25]. Politics is about making judgements about what we ought to do, and how we ought to do it. In making these judgements, we set out what we think we should be and, in carrying them out, we become what we are. Judgment of this sort is also political by virtue of its public character: political judgement is carried out *in* public, *by* public persons, in a manner that takes into account or addresses the public nature and implications of the things under consideration. As public judgement about public things that have public implications, politics is the very opposite of the sort of private calculation of private interests for private advantage that characterizes so much of what we mistakenly label 'politics' today. This is not to say that politics has nothing to do with competing interests. To the contrary, political judgement about what is good and what is just is not some abstract, formal practice. Rather, it is precisely because competing interests, relationships and distributions of power are at stake in judgements about the good and the just that politics has a substance that elevates it above the status of a mere game.

The form with which political judgement is most readily identified is dialogue, in which people give their reasons and take those of others, and together deliberate upon an outcome that all can accept, even if they do not all agree [26.] It is not by accident that this sounds conspicuously like what goes on in a design studio [27]. Political judgement usually results in some sort of action, and the actions arising from it can take many forms. We are accustomed to think of actions such as votes, legislation, resource allocation, letters to the editor, civil disobedience and even art as expressions of political judgement, but we need not stop there. Bridges, solar arrays, mobile telephones and missile guidance systems—these things, too, are the outcomes of judgements about good ends and the best means to realize them, judgements in which engineers participate in a variety of roles. Such things are also deeply implicated in the fortunes of competing social interests, in social relationships and in the distribution of resources and power. If what goes on in a design studio looks a lot like political judgement, then it stands to reason that what comes *out* of a design studio, as the expression of those judgements, can be understood in a political light. In order to make things, engineers make, or participate in making, political judgments, and the things that result from these judgements are political things.

The idea that science and technology are political practices with political outcomes is one that has received thorough treatment in the field of science and technology studies. Scholars in this field have worked to unsettle established notions about the progress of science and technological development, in which disinterested scientists and engineers, motivated only by a pure desire for knowledge or efficiency, using wholly objective methods, produce facts and artifacts that are, in themselves, neutral. Social studies of science and technology paint a different picture. In this picture, scientists and engineers embody and respond to the diverse social, political and economic interests of the societies and communities in which their work is situated, they absorb and reproduce epistemologies and discourses that reflect those interests, and work in settings that are shot through with power, negotiation and accommodation. Finally, their work yields facts and artifacts that are political both because they materialize the politics that generated them and because their appearance in the world always has implications that can properly be described as political [24] [27–30]. This account departs radically from the one that prevails in our culture, in which science and technology are more often presented so as to remove deeply political judgments from public, political consideration and relegate them to the private spaces of boardrooms, laboratories and design studios, all in the name of efficiency, progress and prosperity. In this manner, science and technology are converted from disinterested, neutral forms and fruits of inquiry into ideology in the strict sense of an operation that obscures and denies the fact of politics [31].

On the account being advanced here, the political character of engineering arises before, during and after the design of technological devices, processes and systems. The contexts and patterns from which decisions to invent, design and build emerge are political insofar as they reflect judgements—sometimes established, sometimes contested—about good ends and the preferred means to realize them, and insofar as they comprise complex configurations of interests, social relationships and distributions of power. These patterns and contexts are a significant determinant of when, why and how technology comes into the world. Thus, among the ethical obligations of engineers who understand their work as political is an ongoing critical engagement with the relationship between her professional practice and the institutionalized patterns and contexts in which it is situated [24]. This demands extension of the engineer's ethical attention significantly beyond that which is typically encompassed by the conceptual phase of engineering design. As mentioned above, social studies of science and technology have taught us that design outcomes are rarely, if ever, a necessary, straightforward, objective accommodation of facts and efficiency. Decisions about how to build, or how not to, reflect judgments about what is good and the best means to achieve it, and these judgements are made in an environment that is as political as it is clinical or technical, an environment saturated with competing interests, complicated relationships, and power differentials. This suggests that an engineer's ethical attention must also be exercised within the preliminary, detailed and final phases of design. Politics does not just *precede* the engineer's work as a designer of devices and systems, it defines a significant portion of the work of design itself.

Engineers must exercise political judgement before, and during, design because of the politics that arise afte*r* design, once a device, system or thing is released into the world. Technological societies are culturally disposed to view technology either as completely neutral or, where some substantive character is assigned to technology, as primarily orientated towards the goods of progress, prosperity, variety and convenience. However, the argument that technologies are simply neutral or primarily progressive is difficult to sustain: one can drive a car here or there, or not at all, but a city organized to prioritize automobile traffic is radically different than a city made for walkers, and it closes down as many options as it opens up; and, standing in the middle of a parking lot beside a street with eight lanes but no sidewalks, it is not always clear how, why, or in relation to which alternative, this represents progress. Technologies are not neutral in their outcomes, even if there is a tremendous degree of contingency in the manner in which individual technologies are appropriated and used. In this respect, technology is much like other fundamental principles: an American would never say that the principle of freedom of expression is 'neutral', or devoid of substantive content that distinguishes it from its opposite, simply because people can 'use' freedom of expression to say they hate their government as easily as they can use it to say they love it. Despite the fact that freedom of expression can be exercised in a variety of ways, it is far from neutral: it embodies and structures a particular way of life in distinction to others; it establishes political relationships, permission and prohibitions; and it is bound up with the distribution of political power. The same can be said of technology. Despite (or, perhaps, because of) the contingencies of its use in any given context, technology is implicated in particular possibilities for social organization and relationships, in the establishment and enforcement of permissions and prohibitions, and in the distribution of economic, social and political power. Arguably, this is precisely what is affirmed in first canon of ASCE Code of Ethics when it calls upon engineers to recognize that public health, safety and well-being, 'are dependant upon engineering judgements, decisions and practices incorporated into structures, machines, processes and devices'. This does not indicate merely that someone could get hurt if a system or structure is poorly designed; it recognizes that design itself can do good, or do ill, in the world.

The ethical codes to which professional engineers already subscribe would thus seem to confirm the insight of science and technology studies that technology is a political matter in the most demanding sense of that term. This insight has been expressed most clearly by Feenberg, in his book *Questioning Technology*:

> Technology is power in modern societies, a greater power in many domains than the political system itself. The masters of technical systems, corporate and military leaders, physicians and engineers, have far more control over patterns of urban growth, the design of dwellings and transportation systems, the selection of innovations, our experience as employees, patients and consumers, than all the electoral institutions of our society put together. But, if this is true, technology should be considered as a new kind of legislation, not so very different from other public decisions. The technical codes that shape our lives reflect particular social interests to which we have delegated the power to decide where and how we live, what kinds of food we eat, how we communicate, are entertained, healed and so on [28].

In a similar vein, Verbeek observes [32], '[w]hen technologies are inherently moral entities, this implies that designers are doing "ethics by other means": they materialize morality'. If this is true, it would seem to have radical implications for the practice of engineers who seek to adhere to the ethical standards of their own professional codes. For while this commitment itself appears to be native to the ethical self-understanding of the engineering profession, the ethos necessary to live up to it demands the sort of consistent cultivation for which little room is currently made within the actual practice of the profession. Living up to the code in this respect would require that, alongside technical and scientific creativity and rigor, engineers integrate into their practice what Winner has described as 'political savvy and the capacity of political imagination'. This requires that, in their practice, engineers routinely ask a range of questions which are perhaps more foreign to the profession than the ethical commitment whose observation necessitates them [24]: 'For the sake of what deeply meaningful ends are our technologies well suited or ill suited? In response to what central human needs are our techniques and instruments developed and applied? On the basis of what fundamental orienting principles do our technology-based practices and institutions find their uses and their limits? In selecting a particular engineering project, what kind of world do we affirm and seek to create?' It might seem that to ask this of an engineer is to ask her/him to be a philosopher before he/she is an engineer, but these are political questions, not philosophical ones. They involve deliberation upon ends and purposes, means and alternatives, reasons and arguments about needs and limits, and the substance of the goods to which we are committed, in common with others, in public encounters where such matters are only ever provisionally settled, and demand constant revisiting. This is the price of citizenship, and so too the price of being an ethical engineer.

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The call to engineers to engage in their practice politically echoes the obligation to attend to the public welfare that is explicitly stated in most of the ethical codes that govern the contemporary profession. Among the more challenging questions facing engineers who would answer this call is: 'Who, or what, is the public?' There is no easy answer to this question. As Warner has written [33], 'Publics are queer creatures. You cannot point to them, count them, or look them in the eye. You also cannot easily avoid them'. Arguably, the whole of Western political philosophy can be described as a two-thousand year history of trying to come to terms with these queer creatures, these curious abstractions that can be neither seen nor ignored, leastwise in a democratic context [34].

In the modern context, the term *public* came to be associated with the assembly of otherwise private (i.e. non-titled) persons gathered, whether in-person or through various media, to express and debate their common interests, and especially to affirm or contest the legitimacy of established political authority [35]. Modern public spheres have never been completely inclusive, or free from structural conditions of class and gender domination and subordination that seriously undermine images of the 'generality' of publics from the Enlightenment onward [36]. Still, it is during this period that the word public comes to be associated, at least normatively, with notions of inclusivity, equality, and commonality, and with shared spaces, resources, interests and modes of discourse. More recently, postmodern critics have sought to problematize the public/private binary, arguing not only that its deployment serves to reproduce and naturalize the relations of domination and exclusion that have characterized its history, but also that the distinction between public and private is increasingly difficult to discern and that, in any case, to speak of *the* public as a unified singularity in an age of multiple, nested, networks of diverse publics is to enact an untenable reduction [37].

When an engineer begins a project to design a water treatment facility, should a previous requirement be immersion in the history of western political thought concerning the nature of the public, publicity and the public sphere? Certainly not, (though having this experience somewhere in the engineer's educational background probably would not hurt). Does the engineer need to be attentive to the complexity of the public whose well-being is part and parcel of the commitment to serve by ascribing to the ethical obligations that define the profession? Absolutely. Engineers can go a long way towards satisfying this need simply by taking it seriously, and by questioning the ways in which the public and its interest are often mischaracterized. The public and its interest cannot be taken for granted: the public is not simply an object out there waiting to be served or observed, it is comprised of real people who must be recognized and activated through ongoing engagement. Given the considerable diversity of location, circumstance and identity with which contemporary North American society is blessed, this means that attending to the public interest really means integrating into engineering practice an ongoing, good-faith effort to engage the interests of multiple *publics*. With some notable exceptions (such as, for example, engineering and design projects that have direct environmental or health implications), the current institutional and professional organization of engineering practice does not provide for this sort of engagement in its most robust forms. However, rather than serving to excuse engineers from making such engagement part of their customary practice, this institutional and professional failure should constitute a reason to try to do better.

In seeking to engage publics and their interests, engineers must also resist the temptation to accept the various surrogates that stand-in for publics in contemporary discourse. The public sphere is not simply a market, and publics are not the same as shareholders or stakeholders, audiences, clients, or consumers. A market is a mechanism for self-interested exchange of commodities and the calculation of price, not a forum for publicly-interested political deliberation concerning human goods that may be priceless. Shareholders are those who have something to gain in a transaction, and stakeholders are those who have something to lose. In other words, they have interests, but their interests are typically private, not public. Audiences watch and listen, typically quite passively; publics engage, act, and express themselves. Clients make demands, and consumers make choices from among the alternatives they are offered; publics express their interests by making claims, telling stories, asking questions, and the citizens that comprise them don't just choose between available alternatives, but also imagine alternatives to the choices they have been afforded. In each of these examples, what distinguishes the public sphere as a space of encounter and a public as a social form, is a characteristic mode of address that is necessarily intersubjective. In other words, publics are not simply aggregations of isolated, individual subjects and their private interests and preferences. They are, instead, social bodies whose identity and interests are constructed through deliberate and dynamic encounters that take a variety of forms, including dialogue, debate, narrative, celebration and conflict, to name but a few, via a variety of media. It is for this reason that the complexity of a given public's interest cannot be reduced to, or even registered by, that monstrous artifice we have come to identify with the public itself in the modern age—public opinion, as generated by techniques designed to isolate members from the very encounters and modes of address that constitute a public as something more than mass of private interests.

All this means that taking the public good seriously, by engaging publics in all their diversity and complexity, will be a difficult task for engineers. Our suggestion is not that this will be easy, but rather that it is a challenge that engineers should rise to, rather than shrink from, at least if they take seriously the ethical commitments of their profession. One thing that might assist engineers to imagine ways in which they might engage publics is the realization that their work already does this in a decisive way. Publics are not born, they are made. As Warner has put it [33], a public 'exists by virtue of being addressed'. To use the example mentioned above, opinion polls do not simply reflect or register the opinions of a public that exists independently of the poll. In an important sense, the public is constituted by the technique of the poll itself, created by virtue of its being addressed in this way [38]. One of the implications of this insight is that there are many ways of addressing and, therefore, initiating a public. Laws, literature, speeches, the drawing of political boundaries, and architecture are obvious examples. Each of these modes of address initiates a public, which then goes about the work of shaping and expressing itself, to itself, as well as to others and, in so doing, achieves its definition and independence [33]. Recent work in science and technology studies suggests that, among the modes of address that initiate publics, we should include those elements of the designed and built environment—technologies, artifacts, systems, structures—that might properly called 'things'. In his recent call for an 'object-orientated democracy', Latour [39] has drawn attention to 'the *matters* that matter, the *res* [thing] that creates a *public* around it'. Drawing on the philosophy of Martin Heidegger, Latour reminds us that things are gatherings (of materials, forms, relationships, etc), and that things gather (people, concerns, locations, etc). In short, in designing and making things, engineers are also making publics. When a bridge, or a weapon, a windmill or a computer network is designed, the engineer is enacting an address that initiates the self-organization of a public. Obviously, the characteristics of the thing's design—both what is present and what is absent; options taken and rejected—will have an important influence on the shape and concerns of the public that is initiated. The engineer's attention to the public and its welfare, then, must start right here, in imagining, thinking about, and ultimately engaging with the potentially multiple publics arising out of the thing she is making. This is a daunting prospect. In the contemporary context especially, the things engineers are called to design and build traverse spatial and temporal boundaries that will require engineers to imagine and engage publics in places they have never been, and futures they will never see. This, arguably, is a burden that engineers have always faced. The only question is whether they have been, or now are, prepared to face up to it.

IMPLICATIONS FOR ENGINEERING PRACTICE AND EDUCATION

If we accept that engineering design is an inherently social and political activity, the natural questions we confront are how this might change our practice of engineering and, by inference, how we teach engineering.

The first question we might turn to is whether these ideas require any change at all in our professional relationships and behaviour. The broader society which we engage is, after all, quite capable of placing demands and constraints on engineering practice when political will becomes manifest. Consider, for example, the rapid development of environmental impact assessments in response to the enactment of the Clean Air and Clean Water Acts in the 1970s. In a relatively short period of time, society modified engineering practice with respect to almost all civil engineering design activities in the United States. Can responsible engineers simply accede to the demand to follow environmental laws and consider their ethical obligation satisfied? To do so assumes that the political processes are sufficient—in limiting oneself to this, one is claiming that the public interest is always, only, and adequately served by the current legal system. This should worry us. Engineers had a role to play in the adoption and implementation of the environmental review process before its adoption. As such, they were sitting at a place at the table where policy is set, not merely followed. Essentially, the first canon is not reducible to 'obey the law', a necessary but not sufficient condition for most practice, any more than the presumption of safe designs are satisfied by legally permissible but clearly dangerous elements.

The extreme form of the alternative, however, in which the engineer deeply considers the social, political and environmental effects of each and every design decision, is equally problematic. Designers often do not and cannot know all the potential inputs or possible outcomes of their designs [40]. Consider the manner in which inventions are quickly and significantly appropriated by users for new purposes [41]. The telephone, for example, was originally invented and developed as a business tool, placed in the homes of executives to increase their availability to their companies. Use by homemakers was neither intended nor desired in the initial design and marketing of the device. Yet the device was rapidly appropriated by women in the home, who ultimately redefined its purpose and functionality into a wide range of social circles [42]. The Internet was initially conceived as a pipeline for data transfer within the research community, and its capture by the public was resisted by some of the original designers. If the trajectory of technology is not predictable or knowable, how can the engineer be expected to take responsibility for the effect on public welfare? Even developing first predictions of the use and effects of technology can be time consuming and wrong. This concern is made worse when one considers that much of contemporary practice is done in the employ of large organizations that are likely to be unwelcoming to such apparent inefficiency, to say nothing of attitudes which might challenge current practice. In addition, contemporary design processes often decompose systems to small enough elements that designers may not know the final design configurations in which their work will appear. Few engineers want to heroically place themselves in the path of the client, consumers, or the market. If every engineering decision risks 'paralysis by analysis' and then places the practitioner in a position of professional danger with employer, partners and the public, then implementation appears daunting, if not impossible.

One of the key lessons of the historical review of the ethics codes is that these systems served to enhance and clarify the work processes of the engineer. In essence, by clarifying what activities and behaviours were expected or prohibited of all engineers, they simplified the situation for each engineer. A thoughtful examination of engineering practice through the lens of the first canon may give us a way through this seeming dilemma.

Feenberg's analysis of technology [28] offers several important insights that can help us in determining when and how the engineering community and the individual designer can and should act. These insights include a method for distinguishing between what is characterized as 'primary and secondary instrumentalizations', and also the recognition that social, political and economic values are made concrete to technology primarily in the form of technical codes and rules of practice.

By 'primary instrumentalization', or 'functionalization', Feenberg means that designers generally follow a practice of abstracting from the immediate problem, characterizing it as generally as possible at the outset, and then looking to a wide variety of solutions that might accomplish the desired function. (Engineering designers use phrases such as 'opening up the design space' for the beginning stages of this activity.) The result is either a technology, or, more often, a building block toward a technology that is available for use, but which has not been put into the ultimate system. The products of primary instrumentalization are as close to neutral as technologies get. As he has stated in lectures, 'It's hard to distinguish a capitalist gear from a communist gear, or a Christian lever from an Islamic one'. This is primary instrumentalization, pure and simple. 'Secondary instrumentalization', or 'realization', is where these building blocks are put together into systems with specific ends in mind, and with direct impacts on social, economic and political systems.

How does this help us with respect to engineering practice? Primarily in allowing engineers to filter out, and possibly even exempt, substantial areas of practice from intense scrutiny. Put simply, the engineer must make a judgment about whether or not her practice is about the production of gears, or the use of those gears in a more political way.

Feenberg's second insight is that the critical place where the social and political are embedded into technical decision-making is in the formulation of technical codes which define and constrain acceptable engineering practice. He gives the example of the changes which followed upon the American with Disabilities Act (ADA). Initially, designing transportation and civil structures to allow access to persons with disabilities was resisted as inefficient. Once set in concrete (literally, in the case of curb cuts and ramps) in the building codes, however, the political decision defined engineering practice. This relationship can be shown to go both ways—if the technical code indicates that particular technical decisions are 'necessary', it is very difficult to generate the political will to 'change nature'. This is not to deny that good technical analysis often underlies engineering technical codes, but simply notes that the drawing of boundaries and limits on practice never occurs in a vacuum. Recognizing this, a particularly fertile area for exploration by engineers and designers would be to review the technical code with an eye to those items which reflect contingent historical circumstances (i.e, politics, broadly defined), and revisit their appropriateness. Similarly, a key role that could be played by the professional societies is in asking what changes to the code would increase the ability of their members to live up to the first canon more fully.

In terms of individual practitioners, however, there is a need for a set of guidelines to assist in determining which decisions most clearly come up against the challenge of the first canon. Winner [24] has argued (not entirely convincingly, in our view) that most of the important ethical implications come about at the conceptual design stage, and particularly in the build/no build decision. One can argue that he understates many of the decisions made during preliminary and detailed designs, but it is clear that the ability to distinguish which design activities are likely to have far reaching effects would be valuable. There is a role here for engineers and social scientists to collaborate to develop tools that would facilitate this. Among the guidelines we recommend are consideration of the anticipated market size and penetration, the extent of change/significance in the lives of users, the extent to which the designed artifact is related to social interaction, and the ability of the artifact to influence or mediate social and power relations. (In a sense, we are arguing that engineers should take their employers at their word when they argue that every product the company introduces will revolutionize the world.)

In those cases where the engineer wants to apply such criteria, it may seem that a new set of skills will need to be acquired, although an argument can be made that these topics in many ways are already incorporated into the conceptual design process as taught in most engineering programmes. Questions that need to be more sharply focused include:

- What are the communication skills that are required to hear perspectives not traditionally voiced in the design process?
- How can we recognize the publics that are likely to be initiated by our design choices and participate with them?
- What are the 'protections' that need to be built into our interpretations of the code if the first canon is to be lived up to? Note that an engineer can and indeed must decline certain actions under the prevailing interpretations. Should the societies be providing analogous protection and requirements for certain types of design? If so, how?

This leads us more broadly to consideration of engineering education. Most engineering ethics texts use the code of ethics as a foundation and organizing principle. Yet most are relatively quiet on the subject of this paper. Part of this is because it is easier and more convincing to students to focus on health and safety issues than a consideration of public welfare and the good life. Similarly, design texts, particularly ones with examples related to sustainability or the environment, offer insights and guidance in stakeholder identification and communications, but offer little instruction in how the topic under discussion relates to the welfare of the public. It is important to note that some engineering educators are introducing various flavors of the matters raised in this paper, albeit generally with materials they generate themselves, and usually as a result of individual efforts rather than a more general curricular design [43–45]. What is needed is a set of tools that will enable and encourage educators to raise these issues in a manner that cultivates an ethical disposition.

The case study is the tool most widely used to teach engineering ethics, and with good reason. Cases are particularly effective tools for engaging students by having them place themselves into a situation they have likely never experienced first hand. The cases are usually tailored to a single issue, and the students can wrestle with the complexity of the problem before being guided to a correct consensus—don't take or offer bribes, don't pencil-whip tests, don't harass your employees. These cases, useful as they are, offer us precious little in terms of how engineering decisions may either liberate publics or reinforce power relations over them. We are aware of no cases which teach students how to listen to the voices of those who are excluded from design decisions, even though they may be significantly impacted by them.

There are a variety of case studies which could be written in support of the first canon. These include:

- Cases where choices made by designers can affect the quality of life of publics either positively or negatively. These might include cases where economic development can occur, but with an affect on pre-existing cultures and value schemes.
- Cases which challenge students to identify publics in the design process more broadly than has been traditionally done, particularly those who are affected by the outcome who may not have an immediate economic role, or whose quality of life is affected in non-economic ways.
- Cases which call for development of methods of communicating the design process (both listening and speaking) to publics with a radically different world view or perspective.
- Cases in which the set of alternatives under consideration will result in the creation of significantly different publics.
- Cases which track the design process in a way that reveals some of the different possible points of intervention into the design process by the public (i.e. before, during and after the project).

The argument might once have made that this sort of educational activity is not properly the function of engineering educators, but more properly belongs in the humanities and social science faculty. While this is an appealing claim, given the already loaded curriculum of most engineering programmes, it is unconvincing for several reasons. This is particularly so in light of the renewed focus on ethics stemming from the ABET EC2000 guidelines. ABET, the accrediting agency for US engineering educational institutions, includes among the criteria for approving programmes the requirement [46] that students attain 'an understanding of professional and ethical responsibility'. Pfatteicher sums up the response of the educational community [47], noting that '[f]ew engineering faculty object, in principle, to these changes, but many struggle with the practical question of just how to instill this understanding of ethics in their graduates'. Regardless of accreditation issues, engineering students take their strongest affirmation of the profession from other engineers. It was members of the profession who adopted the challenging language of the codes of ethics. It is their responsibility to teach engineering students how to live up to the code.

Finally, we are left with the question of the role of codes of ethics in crossing boundaries of countries and cultures. While it seems clear that the codes are reflections of historical and local circumstances, it is noteworthy how similar they are in the various environments. Virtually all the codes of ethics (or their associated codes of conduct) have some version of the paramountcy principle. Almost every code recognizes that there is a need for engineers to consider the effect of their work on society. All the codes anticipate a tension between loyalties to the profession, the client, and the public. This commonality suggests that there may be core values and practices in the profession.

There are substantial local differences, however. We have noted the particular challenges engineers face under governments that are hostile to democratic ideals, such as that in Zimbabwe. Their own history has demanded that German engineers look deeply into their responsibility for the horrific application of technology during the Nazi period. Their response has led to a code that requires engineers to consider the effects of technology with a deep concern for others, even to the point of resisting the law. The Pakistani Code of Conduct has been elaborated in the context of a broader, religiously-inspired Code of Ethics that establishes both the limits and the meaning of its provisions. In each of these examples, the substance of the ethical is derived from a notion of the good life that is particular culturally, and historically, even as its adherents express this substance in universal terms.

The relationship between the universal aspirations of engineering ethics and their necessarily local embodiment is an opportunity for engineering practitioners, educators and students to reflect critically upon the substance of their own ethical commitments, and their reasons for holding them. This, too, is an intrinsic part of living up to the code. Just as there are many possible solutions for any given design problem, the relationship between the universalism of the paramountcy principle and the localism of its meaning and application is not straightforward. In all contexts, there is work to be done turning a foundational commitment to the public welfare into engineering practice. It is work that demands political judgment and public engagement. This, we have argued, is the ethical work of engineers.

Acknowledgments—The authors express their appreciation to the Mellon Foundation, which provided some of the resources to allow Patrick Little to spend an academic year at McGill for the purpose of this collaboration, and to the Canada Research Chairs programme.

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