A historico-ethical perspective on engineering education: from use and convenience to policy engagement

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Abstract

In the United States, professional ethics has become a standard part of engineering education. Such educational practice has an intellectual history that invites critical reflection. This article constitutes one such reflection, oriented not so much toward historical knowledge or the production of more engineers as toward developing a critical appreciation of engineering from a broad historico-ethical perspective. The argument advances through three main sections. After an untitled introduction, one section provides a partial narrative overview of the historical emergence of and debates about codes of professional conduct in engineering ethics, highlighting the mid-twentieth-century articulation of engineers as having a paramount responsibility to protect public safety, health, and welfare. Another considers some of the ways engineering ethics so construed and associated codes have been introduced into engineering curricula through textbooks. A third section and conclusion consider contemporary discussions of potential transformations in engineering ethics, especially the idea of a policy turn, and in the process challenge the future of engineering ethics while raising the possibility of a discipline that might be called 'post-engineering.'

The aim of this essay is to review the role of professional ethics in engineering education in the United States from a historical and philosophical perspective. More specifically, the goal is to provide a retrospective on the last one hundred years of engineering ethics development, and the place it now occupies in engineering education, in order to promote reflection on what role it might play in the future. Given the prominence of codes in engineering ethics education, section one constructs an interpretative overview of the historical emergence of and debates about codes of professional conduct in engineering, leading to the mid-twentieth-century formulation of the notion that engineers have a primary responsibility to protect public safety, health, and welfare. Section two then shifts to the ways such codes have, especially during the last third of the twentieth-century, been introduced into engineering curricula. Against this background, section three considers contemporary discussions of the place of professional ethics in the context of new interests in policy and in relation to recent studies by the US National Academy of Engineering on the future of engineering.Footnote1

An emergent argument is that although the engineering curriculum has progressively enhanced the professional ethics component, critical intellectual history – including the critical histories of ideas about engineering and engineering ethics – would be of added benefit. It is remarkable, for instance, that engineers are said to be responsible for the protection of public safety, health, and welfare, but in fact seldom take, and are certainly not required to take, courses dealing with the historical and social character of public safety, public health, or societal welfare. It is apparently assumed that such notions are non-problematic common knowledge, although there is good reason to doubt this is the case – as is revealed especially by policy studies.

Before proceeding, a comment on the approach to be taken here: Historico-philosophical reflection is neither history nor philosophy, strictly speaking, but closely related to intellectual history. According to one scholar in the field, intellectual history can be of three types: trying to figure out who had which idea when, mapping historical interrelations between ideas (also known as the history of ideas), or struggling to understand relations between what human beings think or say and how they act.Footnote2 The present essay incorporates elements from all the three, with a slight stress on the second and the addition of a modestly normative argument concerning ideas that might be appropriate to engineering ethics in the future. In another sense, the essay could be described as an extended bibliographic essay. The historical or social science base is admittedly selective, insofar as it is limited to published texts, but this would seem sufficient for the purposes at hand.Footnote3

The historical development of engineering ethics

The emergence of professional engineering ethics as a clearly defined component of engineering practice and education may be framed as a four-phase process. This framework rejects a belief common among engineers that engineering history can be traced back to the Romans and EgyptiansFootnote4 or is coeval with humanity.Footnote5 The conceptualization of engineering occupies contested terrain, with different approaches having been taken by engineers, historians, sociologists, philosophers, and others. One engineer-historian, Henry Petroski, seeks to split the difference by declaring, 'Engineering is as old as civilization, but the concept of the engineer as distinct from architect or master builder is relatively modern,' claiming at the same time that there were 'in ancient times individuals whom today we would call engineers.'Footnote6 The historiographic position adopted here, however, would deny the latter and, in sympathy with philosopher Michael Davis's combination of conceptual analysis and social science,Footnote7 but complemented with epistemological and ontological criticism, argue that engineering 'constitutes a distinctive way of turning making into thinking, engendering not only a special kind of making but also a special kind of thinking.'Footnote8 In support, it may be noted that the terms 'engineer' and 'engineering' are of post-1500 provenance and appeared in order to name a post-1500 activity. This post-1500 activity was given classic definition by Thomas Tredgold, in conjunction with the 1828 institutionalization of the British Institution of Civil Engineering (ICE), as the systematic skill 'of directing the great sources of power in nature for the use and convenience of [humans].'Footnote9 What follows is a narrative overview of discourse about codes of engineering ethics in a historical trajectory that emerged from this context, with an emphasis on engineering as manifested in what is perhaps the premier engineered society, that is, the United States of America.

Phase one: implicit ethics

The first explicitly denominated engineers were members of a military corps, those who designed and operated fortifications and various 'engines of war' such as battering rams and catapults. In the plays of Shakespeare, for example, the word 'engineer' is synonymous with 'soldier.'Footnote10 The first institutions of engineering education were created by national governments and closely associated with the military, as illustrated by the Academy of Military Engineering established at Moscow in 1698 by Czar Peter the Great; the Estates School of Engineering at Prague in 1707 by Emperor Joseph I; the Bureaux des Dessinateurs du Roi in 1744, which became the Ecole des Ponts et Chaussées at Paris in 1747 by act of the King's Council under Louis XV; the Ecole Polytechnique at Paris in 1794 by the National Convention of the French Revolution; and the United States Military Academy at West Point in 1802 during the administration of President Thomas Jefferson.

Only as engineers began to function outside military fields were professional associations of non-military or civilian engineers created. John Smeaton, during the Industrial Revolution in Great Britain, was among the first to denominate himself as a 'civil engineer.'Footnote11 In addition, it was he who established in 1771 the informal Society of Civil Engineers, which after his death came to be called the 'Smeatonians,' and which eventually influenced the establishment of the ICE, the first officially recognized professional engineering society. It was not until the 1900s, however, that the ICE adopted a formal code of ethics.

Following the ICE model, professional engineering societies arose in the United States in the mid- to late-1800s, during the period of the American Industrial Revolution. These societies typified what Alexis de Tocqueville, the great French observer of Democracy in America termed intermediate associations.Footnote12 That is, in highly decentralized, individualist nations such as the United States, persons tend to band together in multiple and diverse associations intermediate between themselves and the state. Such voluntary associations are exemplified by churches, political parties, fraternal lodges, clubs – and professional associations such as those of physicians, lawyers, scientists, and engineers. In North America, particularly, these intermediate associations were forerunners of what are today known as non-governmental organizations (NGOs).

In the initial phase of their development, engineering NGOs – fragmented by technical (and social) boundaries into civil, mechanical, electrical, and other forms of engineering – included ethics only implicitly. Like the British counterparts, in their early years neither the American Society of Civil Engineers (ASCE, founded in 1852), the American Society of Mechanical Engineers (ASME, founded in 1880), nor the American Institute of Electrical Engineers (AIEE, founded in 1884) had any explicit codes of ethics. Instead, each society promoted an ethos of professional behavior as a mixture of technical knowledge and expectations concerning professional etiquette, all communicated primarily through apprenticeship and example.

The early minutes and transactions of these various engineering associations nevertheless reveal that key to this emergent ethos was a commitment to professional solidarity and a responsibility to those for whom they worked. Such an ethos might reasonably be described as manifesting two forms of loyalty: loyalty to each other and loyalty to clients or employers. In the military, engineer soldiers had similar primary obligations to their commanders and comrades in arms in an authoritarian hierarchy. Even though not technically members of the military, the motto of graduates of the Ecole Polytechnique, for instance, retains distinctive militaristic connotations transposed into civilian terms: Pour la Patrie, les Sciences et la Gloire. The implicit ethics of engineers who undertook to exercise their skills outside a formal military context can easily be interpreted as practicing a respect for and obedience to social hierarchy – in a world where social hierarchy was more prominent (if not more powerful) than is common in twenty-first century social orders.

Phase two: ethics as loyalty

Historically, as technical knowledge became increasingly rationalized in its various semi-autonomous spheres – following what sociologists have identified as a key element in the logic of modernity, structural differentiationFootnote13 – ethics too became an issue for differentiation. During this second phase of professional engineering development, occupying the initial third of the twentieth-century, professional ethics codes became subject to explicit formulation, commonly as a means to promote professional development and prestige. This process, naturally enough, tended simply to make explicit what had previously been implicit.

Primary examples are the codes of ethics of the AIEE, adopted in 1912, of the ASME and of the ASCE, both of which were adopted in 1914. Each of these three codes was less than a page in length and stressed that 'the engineer should consider the protection of a client's or employer's interests his first professional obligation' (to quote the AIEE code) or required the engineer to act simply 'as a faithful agent or trustee' (ASCE language).

With regard specifically to the ASCE, Sarah Pfatteicher has been especially diligent in uncovering the conflicting influences active in the emergence of its code and the particular language used in internal discussions that extended from the 1870s to the early 1900s. As she argues,

the first code of ethics adopted by the ASCE was intended to describe, rather than guide, the behavior of ASCE members … . Early codes of ethics were intended to document and publicize existing standards of behavior (largely for the benefit of potential employers), not to establish ideals toward which ASCE members might strive.Footnote14

As she further observes, this descriptive code also admonished members to be true to existing practice and 'to be loyal to their clients, their fellow engineers, and their profession.'Footnote15 Paradoxically, although one goal of this early code making was to enhance public recognition and a degree of autonomy, because of the pride of place given to business interests and company loyalty, the practical effect was to undermine independence as much as promote it. In other words, professional engineering – insofar as it articulated loyalty as a primary value – tended to promote a kind of self-imposed tutelage to its most immediate employers.

One criticism of this historical narrative deserves acknowledgment. Davis has challenged the idea that engineers initially took loyalty as their primary obligation.Footnote16 Such a view, he argues, ignores historical context and the role of interpretation required by any law or code of conduct. Without rejecting Davis's argument – which, as a whole, makes important and valid points – it is nevertheless possible to reply that considerations of historical context can also support the loyalty narrative. Repeatedly in various early twentieth-century engineering society proceedings there is an emphasis on some form of loyalty as primary. For instance, in a proposal leading up to adoption of the AIEE code, it is clearly stated that ‘the electrical engineer should consider the protection of his client's interests as his first obligation’Footnote17 ; and in a discussion preparatory to the ASME code, it is proposed that ‘the engineer should consider the protection of a client's or employer's interests his first obligation, and he should avoid every act contrary to this duty.’Footnote18 The fact that loyalty was considered as a special problem to be confronted in engineering ethics education even as late as the 1980s is further confirmation of the important role this notion has played.Footnote19 Davis is clearly correct, however, that engineers also thought such loyalty was in the public interest and the promotion of some level of commitment to the public good was a necessary manifestation of company loyalty, that is, was for the good of the company as well. One need only recall in this regard President Calvin Coolidge's statement that ‘the chief business of the American people is business’Footnote20 and General Motors President Charles E. Wilson's that ‘What is good for General Motors is good for the country and vice versa.’Footnote21

Phase three: the ethics of efficiency

Orthogonal to both the implicit code of obedience and the closely related explicit code of loyalty, but developing in parallel, was an ideology of leadership in technological progress through pursuit of an ideal of technical perfection or efficiency. In 1895, in an ASCE presidential address, George S. Morison, one of the premier North American bridge-builders, spelled out this moral ideal in a bold vision of the engineer as the primary agent of technical change and the main force in human progress. In Morison's words:

> We are the priests of material development, of the work which enables other men to enjoy the fruits of the great sources of power in Nature, and of the power of mind over matter. We are the priests of the new epoch, without superstitions.Footnote22

During the early part of the twentieth-century, this vision of engineering activity, one quite common among engineers, was closely associated with the technocracy movement – and the idea that engineers should be given political and economic power. Economist Thorstein Veblen, for example, argued in two influential books that if engineers were freed from subservience to business interests, then their own higher standards of good and bad, right and wrong, would lead to the creation of a more sound economy and better consumer products.Footnote23

There is no doubt that there is some truth to this position. Certainly the subordination of production to short-term money making, with little concern for the good of any commodities produced, is not desirable in the long run, and inefficiency or waste – especially insofar as external costs fail to be internalized – may benefit the bottom line only at the expense of the common good. Moreover, in a highly complex technological world it is often difficult for average consumer citizens to know what might be in their own best interests. It remains an open question whether efficiency can be adequately promoted by the consumer pull of imperfect markets or requires a push from either technical professionals or government regulatory agencies.Footnote24

Nevertheless, when technical decision making becomes an end, it is also easily decoupled from general human welfare. The pursuit of technical perfection for its own sake is not always the best use of limited societal resources – as when, for example, cars are designed to go faster than a socially defined speed limit engineered into the roadbed. The ideal of efficiency also virtually requires the assumptions of clearly defined boundary conditions that perforce can exclude important and relevant factors, including legitimate psychological and human concerns, so that it readily takes on the ideological cast of a justification for special interests. Then there is the tension between technology and democracy. Coupled with the problematics of an ethics of loyalty, such objections contributed to the development of a third distinct ideal for engineering ethics, that of public responsibility.

Phase four: public safety, health, and welfare

Phase four of engineering ethics code development began after World War II, as engineers became increasingly aware of the social impact of their work and of corresponding social responsibilities. The key characteristic of this period was the rise to codified prominence of a new principle recognizing the importance of public safety, health, and welfare.

One precursor experience in this emergence was a case involving a couple of ASCE members in California during the 1930s. Two civil engineers and ASCE members publicly reported the illegal actions of a contractor working for the Los Angeles Water Department, an exposure that actually led to convictions for taking bribes. But the exposing engineers were then expelled from the ASCE for professional disloyalty and thus breaking the code of ethics, an action that stimulated serious questioning within the engineering community about the status of loyalty as an ethical principle.Footnote25 Indeed, Bernhard Jakobsen, one of the principals expelled from the ASCE for violating "professional ethics and [injuring] the reputation of a 'brother engineer'," self-published a pamphlet to inform ASCE "members of what actually happened … and to help the society provide a code of ethics that will encourage members to expose graft, no matter whom it involves.Footnote26 More generally, however, the re-codification of engineering ethics to emphasize public responsibility can be documented by developments in three acronym-denominated professional organizations: Engineers Council for Professional Development–Accreditation Board for Engineering and Technology–American Association of Engineering Societies (ECPD–ABET–AAES), National Society of Professional Engineers (NSPE), and Institute of Electrical and Electronics Engineers (IEEE).

The ECPD–ABET–AAES case

In 1947, the ECPD – founded in 1932 as an organization of organizations (rather than individuals), and charged in part to develop an ethics code acceptable to its constituent engineering societies – adopted an ethics code that made it a leading duty for engineers 'to interest [themselves] in public welfare' and to 'have due regard for the safety of life and health of the public.' Revised in 1963, 1974, and 1977, this code eventually formulated the first of seven 'fundamental canons' as follows: 'Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duty.'

In 1980, the education function of the ECPD was restructured into the Accreditation Board for Engineering and Technology, today simply named ABET, to certify engineering degree programs in the United States. Initially ABET assumed the final ECPD revision of its code, along with an extended 'Suggested Guidelines for Use with the Fundamental Canons of Ethics.' In this form the ABET code had some influence on engineering education, insofar as ABET slowly began to stress the importance of engineering ethics in the engineering curriculum. Then at the turn of the century, as part of a broad overhaul of the accreditation process, a new set of accreditation criteria (ABET EC 2000) listed 11 outcomes for graduate engineers, one of which (criterion 3f) explicitly called for 'an understanding of professional and ethical responsibility.' At least one and perhaps two other outcomes may also be interpreted as ethics-related. This made professional ethics, at least nominally, a substantial component of engineering education. At the same time, ABET shied away from any explicit recommendations about the specific content or pedagogy of engineering ethics instruction, even dropping its endorsement of the old ECPD code, leaving these questions instead to the faculty of specific programs.

The restructuring of ECPD educational activities into ABET took place parallel with the restructuring of ECPD interdisciplinary professional development activities into a new AAES. One of the perennial problems of professional engineering in the United States has been fragmentation in the professional engineering community, a dispersal of social power that dilutes public influence. Unlike ABET, however, the new AAES did not assume the ECPD code, but in 1984 officially adopted its own 'Model Guide for Professional Conduct,' which sought to provide a unifying framework for all existing disciplinary codes. This AAES guide, in revision, likewise progressively stressed the importance of safety, health, and public welfare.

The NSPE case

A second illustration of the post-World War II appearance of social responsibility in engineering ethics was a code developed by the NSPE. Like the EPCD, one of the original objectives of the trans-disciplinary NSPE, founded 1934, was 'the establishment and maintenance of high ethical standards and practices.' Unlike the ECPD, which was an organization of organizations, the NSPE is an NGO of some

50,000 individuals, all of whom are professional engineers. According to its mission statement, the NSPE ‘promotes the ethical and competent practice of engineering, advocates licensure, and enhances the image and well-being of its members.’

Although an ethics code was proposed as early as 1935, none was formally adopted until 1946, when the NSPE endorsed the new EPCD code even before the EPCD formally did so. With the 1963 revision of the EPCD code, however, the NSPE moved to create its own code. The evolution of a distinctly NSPE code led in 1981 to the adoption of a short list of ‘Fundamental Canons,’ the first of which is to ‘Hold paramount the safety, health and welfare of the public.’

The IEEE case

Still a third example of the rise in social responsibility characteristic of US engineering ethics codes in the second half of the twentieth-century can be found in the IEEE – which emerged in 1963 from the unification of the AIEE and the Institute of Radio Engineers (IRE, founded 1912) and is today the largest professional engineering NGO in the world, with more than 300,000 members.

In the early 1970s, the IEEE undertook to write a new code of ethics, stimulated in part by an experience of three engineers working on the design and construction of the new Bay Area Rapid Transit (BART) system in metropolitan San Francisco. In a situation similar to that of the ASCE engineers earlier in the century in southern California, these engineers exposed malfeasance on the part of their employer contractors and were subsequently fired. The difference is that as a result in part of their appeal for support to the IEEE, and a subsequent IEEE report that supported their actions, they were not disciplined by any professional engineering society. Instead, they actually received some compensation from the contractors, and were given public recognition for their efforts to protect public safety. Reflecting this commitment to support engineers who undertook such actions, in the preamble to its code of 1974, the IEEE declared that

Engineers affect the quality of life for all people in our complex technological society. In the pursuit of their profession, therefore, it is vital that engineers conduct their work in an ethical manner so that they merit the confidence of colleagues, employers, clients and the public.

The fourth article of the code itself specified that IEEE members have a responsibility to ‘protect the safety, health and welfare of the public’ and even to ‘speak out against abuses in those areas affecting the public interest.’

In 1990, following significant debate in the late 1980s about the way properly to amend it, the code was simplified and public responsibility was elevated to the first of 10 principles. IEEE members committed themselves ‘to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment.’

Engineering ethics in engineering education

During phase four, engineering ethics began both independently and through ABET to have an influence in engineering education. It is, for instance, a mistake to think that only with EC 2000 did ABET require professional ethics be included as part of accredited engineering programs. EC 2000 criterion 3f simply replaced a previous criterion IV, C, 3j, which stated:

An understanding of the ethical, social, economic, and safety consideration in engineering practice is essential for a successful engineering career. Course work may be provided for this purpose, but as a minimum it should be the responsibility of the engineering faculty to infuse professional concepts into all engineering course work.

Indeed, in a study done before EC 2000, engineering educator Karl Stephan had conducted a survey of ethics-related instruction in US engineering programs. Although he concluded that ethics had relatively low visibility, he was able to identify a number of examples that could serve as models for the teaching of engineering ethics.Footnote27 At the same time, as indicated by Stephan and others, engineering ethics had become a field of sustained scholarly publication.Footnote28 But the educational dimension of phase four deserves independent examination, and has certainly been enhanced by EC 2000.Footnote29

During its first three phases, engineering ethics – and, in consequence, engineering ethics education – was primarily an issue for professional societies and learning through apprenticeship. There was little by way of explicit promotion of engineering ethics at the college level, certainly nothing by way of required courses, and virtually no reflection on the social dimensions of engineering practice or its philosophical assumptions. Mostly there was just implicit acceptance of the ideology of engineering as the unappreciated foundation of civilizational progress throughout history. Two widely used volumes from the first third of the twentieth-centuryFootnote30 included chapters on personal ethics in the context of conducting engineering business. Yet as the author of one of the most widely used texts candidly admitted, what was included in his book was ‘inadequately treated,’ and did little more than advocate ‘the ‘square deal’ in the relations of the engineer and architect with the contractor and with all others with whom they have relations.’Footnote31 North American developments up until the period after World War II were at best piecemeal and pragmatic, in accord with the larger character of US intellectual culture.

Beginning in the 1970s, however, individual engineers, especially professors of engineering, became more involved, often working in tandem with academic philosophers. This new phase was stimulated by a series of widely publicized cases perceived as examples of engineering negligence or improper subordination to economic interests, and by federal funding for engineering ethics research. Among the leading cases were a series of catastrophic DC-10 airliner disasters traceable to questionable engineering designs, the previously mentioned instance of whistle blowing concerning safety issues associated with the BART system, and poor design on the Ford Pinto automobile that contributed to a number of fatal accidents.Footnote32 The nuclear meltdown at Three-Mile Island, the rise of the environmental and consumer protection movements, general protests against authority stimulated by the Vietnam War and the political corruption associated with Watergate were other factors promoting a perceived need to take ethics into the classroom. Indeed, such factors contributed not just to the emergence of engineering ethics but of a more general ethics of technology – including especially biomedical and environmental ethics as two major components of a broad applied ethics movement.

The publication of three major engineering ethics textbooks between 1980 and 1983 marked this new phase. All were supported, in different ways, by new federal governmental grant programs that in turn reflected a social sense of urgency and questioning of science and technology.

The first was a two-volume collection co-edited by Albert Flores and Robert J. Baum.Footnote33 This work was part of a 'National Project on Philosophy and Engineering Ethics,' directed by Baum at the Center for the Study of Human Dimensions in Science and Technology of Rensselaer Polytechnic Institute (from which developed the RPI Department of Science and Technology Studies).Footnote34 The project was a 3-year effort that sought to broaden the discussion of engineering ethics. Funded by a grant from the National Endowment for the Humanities, the project supported just over a dozen two-person teams of philosophers and engineers to examine value issues of engineering skills and activities. Team projects included the preparation of case studies on selected ethics problems, curricular development, and the drafting of recommendations for professional engineering societies. For the next decade, the Flores–Baum collection was the single best source of materials; indeed, it remains an important historical reference.

The second textbook was by computer engineer Stephen H. Unger.Footnote35 Unger had participated in the Baum project, and received further funding from the new Ethics and Values in Science and Technology (EVIST) program at the National Science Foundation. (The creation of EVIST in 1972, with Baum as its first director, is further witness to the critical spirit of the times.) Additionally, Unger led the IEEE investigation of the BART whistle blowers and helped to create the IEEE Society for the Social Implications of Technology, which publishes the important IEEE Technology and Society Magazine (1982 to present), activities that made him an influential presence in the profession. Unger's book, which surveys cases, argues the importance of professional ethics and for more vigorous ethics activities on the part of professional societies in support of practicing engineers, and puts forth its own model ethics code, appeared in a second edition in 1994 and remains in print.

Still a third important textbook creation from this period was the result of collaboration between philosopher Mike Martin and engineer Roland Schinzinger.Footnote36 The Martin and Schinzinger volume – the popularity of which is indicated by the fact that in 2005 it went into its fourth edition – takes an approach representative of the Anglo-American analytic tradition in philosophy; that is, it adopts a mixed utilitarian and rights-based ethical perspective and presents ethics as dependent on critical moral reasoning. At the same time, it makes a provocative argument for engineering as social experimentation, and seeks to draw out some of the implications, although in a non-radical manner. It is one of the most widely used texts in the field.

Finally, a decade later, another important text that grew out of NSF engineering ethics grant support – this time, for the creation of a series of ethics education scenario cases – is by Charles E. Harris, Jr., Michael S. Pritchard, and Michael J. Rabins (the first two being philosophers, the third an engineer).Footnote37 Its subtitle, 'Concepts and Cases,' indicates the adoption of a pedagogical strategy that has become influential and of continuing popularity – as indicated by the fact that this volume in 2008 went into its fourth edition.

Although there have been other additions to the engineering ethics textbook literature supplementing the work of Flores–Baum, Unger, Martin–Schinzinger, and Harris–Pritchard–Rabins, the last two of these have become the most widely used. Among supplementary volumes, for instance, there is a well-used anthology edited by Deborah JohnsonFootnote38 and an advanced textbook–monograph by Caroline Whitbeck.Footnote39 Throughout, however, teaching has remained to a significant degree focused on what may be described as a largely internalist and individualist emphasis – that is, on individual professional responsibility to promote public safety, health, and welfare – using a mix of analytic ethics and case studies with some modest introduction of social implications, always with explicit reference to the ethical codes of various professional engineering societies.Footnote40 Indeed, all of the textbooks mentioned include reprints of some select set of professional engineering ethics codes.

Just at the third stage of this federally funded engineering ethics research – that is, the stage represented by Harris–Pritchard–Rabins (Flores–Baum being stage one, and Unger and Martin–Schinzinger stage two) – there occurred a historical event that became a case study of major pedagogical impact. This was the space shuttle Challenger disaster of January 1986 – to be followed 3 months later by the nuclear accident at Chernobyl, Ukraine. The Challenger disaster, personified by mechanical engineer Roger Boisjoly, who – after being invited by Caroline Whitbeck's engineering ethics students at MIT in January 1987 to give an account his experiences – became a traveling missionary for engineering ethics education.Footnote41 Having made this pitch first at MIT, he began to do so across the US to anyone who would listen. His talk at the American Society for Engineering Education meeting in June 1988, for instance, was a moving argument that surely influenced the formulation of ABET EC 2000 standards. The need for take engineering ethics into the classroom was being forced by historical circumstances and media attention in ways that only reinforced previous intellectual arguments.

Contemporary possibilities: a policy turn?

With the creation of ABET EC 2000 standards, however, phase four reached a kind of plateau, thus setting the stage for a possible phase five. It is always risky to attempt to characterize the phase in which one lives, but venturing such a risk, this might be called a ‘policy turn’ in engineering ethics. The policy turn is defined by a growing dissatisfaction with individualist or personal professional ethics. Increasingly, the sense is that personal responsibility is necessary but not sufficient. That is, there is an emerging (if still a minority) consensus in the professional engineering and the philosophical communities that personal ethics is not enough, that ethics – including professional ethics – must include analysis of and on occasion action to transform institutional arrangements and policy directives as they set contexts for the pursuit and practice of engineering. In turn, engineering ethics education is called upon to take these new dimensions into account.

A few nodal events in support such a claim might include the following:

1.
When a detailed reconstruction of the Challenger disaster was finally published, its analysis reduced the importance of personal decisions in favor of institutional policies.Footnote42

2.
When engineering educators in Europe undertook to write their own first engineering ethics textbook they chose to distinguish their approach from that of their North American colleagues by including major sections on institutional ethics and public policy.Footnote43

3.
Other publications pointing in this direction have been Richard Devon's argument for a ‘social ethics of technology’Footnote44 and Joseph Herkert's for a new focus on ‘macro-ethics’ in engineering education.Footnote45 Devons' social ethics and Herkert's macro-ethics have a lot in common with notions of policy.

4.
William Wulf's keynote address, as President of the National Academy of Engineering, at a 2003 National Academy of Engineering (NAE) workshop, gave a kind of official recognition to the interests of Devon and Herkert when he too called for complementing micro- with macro-ethics.

These nodal points in engineering ethics are enhanced by increasing interest in science policy, in research on science policy, and in the establishment of science policy centers such as the Consortium for Science, Policy, and Outcomes (initially in 1999 as a Center at Columbia University and subsequently at Arizona State University) and the Center for Science, and Technology Policy Research (from 2001 at the University of Colorado, Boulder). Reflective of this interest is an emerging discourse associated with the philosophy of science policy,Footnote46 which raises questions that could often just as well be applied to engineering. Indeed, there is also an emergent field of discourse in philosophy and engineering that is helping to broaden scholarly work in engineering ethics.Footnote47 Finally, there now exists a nascent movement in philosophy, especially in certain fields of applied ethics, that has been referred to as the policy turn in philosophy.Footnote48 As in engineering ethics, the policy turn in applied philosophy generally argues that individualist ethics is not enough – and that philosophy has an obligation to become more involved with and willing to learn from public policy concerns and activities.

What might the implications of this potential policy turn be for engineering ethics and engineering education in general? This is a difficult question, and can only begin to be speculated on here. In the form of speculation, then, consider three comments.

First, as suggested at the beginning of this essay, the ideals of public safety, health, and welfare – the paramount values of professional engineering today – have histories in multiple senses. Safety, health, and welfare have been and will continue to be conceived differently by different people. To have knowledge of such differences cannot help but will increase intelligence in trying to live up to such values. In this sense, ethics always benefits from the history of ideas, because any ethical good has a history. But in the present case, one might state as a lemma to historian of technology Melvin Kranzberg's fifth law: 'All history of technology is important, but the social history of engineering ethics and its ideals is more important – at least to engineering ethics.'Footnote49 It might even be added that there is very little in the way of such a history of ideas, which thus marks out a challenge and responsibility that could take engineering ethics – along with engineering studies – into modestly new areas.

Second, policy and policy initiatives also have intellectual histories and social contexts. Indeed, like engineering, the very word 'policy' has a conceptual and social history that is not without relevance to the theory and practice of the policy turn. The origins of the concept have some parallels with that of engineering itself, and a case can be made that policy is peculiarly allied with the theory and practice of social engineering.Footnote50 Additionally, over the course of time and in multiple human situations, it is arguable that more policies run themselves out to failure than turn out to be successes. For anyone contributing to the policy turn in engineering ethics, to become acquainted with how policies have been formulated and worked out would seem to be crucial. Thus, we could propose a second lemma on Kranzberg's fifth law: 'All policy history is important, but the intellectual and social history of engineering policy is more important.'

Third, any assumption in regard to engineering ethics that the policy of affirming responsibility for the protection of safely, health, and welfare is non-problematic is almost guaranteed to subject one to direct experience of the deeply problematic character of such a professional engineering ethics and policy ideal. Additionally, it may well be that an appreciation of the contingencies involved with the enactment and pursuit of such ideals could lead to rethinking the character of engineering itself. Ultimately, it might even be worth considering the possibility that the age of engineering as we have known it is coming to an end.

Conclusion: post-engineering

The idea that the age of engineering as we have known it may be coming to a close is on the intellectual agenda in a number of serious discussions related to engineering ethics broadly construed. Two examples are reports, alluded to at the beginning, from the NAE. In late 2001, the NAE undertook to envision the likely character of engineering in 2020 and then to assess engineering education in light of this vision. The first step was released in 2004 as a report on The Engineer of 2020: Visions of Engineering for the New Century. The second appeared in 2005 as Educating the Engineer of 2020: Adapting Engineering Education to the New Century.

The 2004 report began with two chapters outlining the technical and societal changes of the next decade as disclosed through reflection on four possible scenarios – the future as dominated by scientific revolution, or biotechnological revolution and social reaction, or natural disasters, or global conflict between civilizations. It then argued, to quote from the executive summary, for developing a new cadre of 'engineers who are broadly educated, who see themselves as global citizens, who can be leaders in business and public service, and who are ethically grounded.' This would entail enhancing 'analytical skills, creativity, ingenuity, professionalism, and leadership.'Footnote51

An assessment of this assessment may begin with three not wholly unrelated observations. First, engineers are among the most self-reflective of the professionals. Seldom do other academic disciplines or professions analyze their possible futures with such zeal. Only rarely do chemists or physicists or biologists examine the future of these disciplinary professions. Slightly more common is such discussion among physicians and lawyers. But at least two observers have independently documented how over the course of the twentieth-century the engineering community issued more than 20 significant self-assessments (some of which made at least passing reference to engineering ethics).Footnote52 Although salutary, such determined self-reflection no doubt also reflects a measure of professional insecurity.

Second, engineering exhibits an ambiguous social role. Not only engineers but also economists sometimes present engineering as the motor of progress and necessary tool for international competitiveness. This position is argued at length by a U.S. National Academy Committee on Prospering in the Global Economy of the 21st Century chaired by Norman Augustine.Footnote53 In fear, for instance, it is often noted that the political leaders in China – with its rapidly expanding economy and rapid economic growth – tend to have been educated as engineers. But this evocation of the ideal of technocracy also points up how engineering has readily been captured by various authoritarian social or cultural interests – and the historical insensitivity of engineers to issues of social justice or human rights.Footnote54

Third, the methodological base of the engineering of 2020 report is scenario planning. Scenario planning is creative and useful, within limits. In the present case there is an insufficiently questioned assumption: engineering is an unquestionable good and should be advanced. The attempt to identify challenges is done only to adopt engineering to these challenges, not to consider the possibility that the age of engineering may be coming to a close – that the engineering profession does not in fact have the unquestionable social value that engineers would like to be the case. Critical reflection on the core analysis of the NAE study can be argued to point toward the following possibility: that engineering is just not as important as it used to be, that the profession is properly waning – at least in the United States. To give this prospect positive form, consider that the 2020 future scenarios indicate much than the need for a reformed conception of engineering, what might well be called 'post-engineering.'

Two indicators of what this post-engineering might be like – neither of which invokes the term – come from the two North American coasts. One of these is contained in a personal reflection by a former MIT Dean of Undergraduate Education, Rosalind Williams. In her insightful memoir, Williams explores the self-contradictions in engineering, especially how engineering has undermined if not destroyed the ways of life on which engineering and engineers have from the 1500s depended. The phenomenon of post-engineering is the paradox of an 'expansive disintegration':

There is no "end of engineering" in the sense that it is disappearing. If anything, engineering-like activities are expanding. What is disappearing is engineering as a coherent and independent profession that is defined by well-understood relationships with industrial and other social organizations, with the material world, and with guiding principles such as functionality … . Engineering emerged in a world in which its mission was the control of non-human nature and in which that mission was defined by strong institutional authorities. Now it exists in a hybrid world in which there is no longer a clear boundary between autonomous, non-human nature and human-generated processes.Footnote55

Surely this is the reality on which a new engineering ethics, enhanced by an alliance with policy, is called upon to reflect.

The second indicator can be found in a meditative reflection on his life's work by a professor of electrical engineering at San Jose State University in the heart of Silicon Valley, Gene Moriarty. Drawing on the philosophical work of some leading figures in the philosophy of technology, but especially that of Albert Borgmann, Moriarty undertakes to distinguish different types of ethical engagement appropriate to engineering projects, technological systems, and the human lifeworld. Although human beings in North America live increasingly in an engineered world that disburdens from unwanted tasks that once consumed much time and effort, this same disburdenment often leaves people disengaged from the natural and even human surroundings. In such a world, Moriarty argues for what he calls 'focal engineering.'

Focal engineering incorporates the know-how of premodern engineering and know-what stressed in modern engineering into an attitude that seeks to also know why … . Focal engineering focuses on the public role of the practicing engineer. Public policy is made in the lifeworld, and the focal engineer plays an active role in the process of making policy about technological advances.Footnote56

Yet the focal engineer does not so much contribute to policy making by attempting to engineer it as by working to reduce the role of the strictly engineering approach. For Moriarty, the goal is to take ‘engineering to a new level,’Footnote57 but one that is more accurately described as lower than higher, because it is subordinate to efforts to advance a deeper human understanding of the Good. ‘Although ten people might have ten different notions of the nature of the Good, the conversation of the lifeworld could open up whatever common ground comes to light’Footnote58 – and then strive to be true to that non-technological enlightenment.

Independent of Williams and Moriarty, the argument for a post-engineering ethics and policy may be outlined as follows: A world transformed by the possibilities of continuing scientific revolution, or biotechnological revolution and social reaction, or concatenations of natural disasters, or global conflict between civilizations is indeed one in which – to quote from the main body of The Engineer of 2020 report – ‘engineering schools may have to create new engineering degree programs to attract a new pool of students interested in a less rigorous engineering program as a ‘liberal’ education’Footnote59 and engineers must be ‘educated to understand and appreciate history, philosophy, culture, and the arts.’Footnote60 But the obvious question is: Why should such a liberal arts-based program or a program focused on history, philosophy, culture, and the arts continue to be called engineering? Is this not like insisting that when alchemy was transformed into chemistry it should still be called alchemy? Or when natural philosophy was transformed into science, it should still be called natural philosophy? What is the justification for such a rhetorical ploy? Quo vadis engineering? Is this not the question on which engineering ethics should be focused on infusing into engineering?Footnote61

Acknowledgments
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