A Philosophical Inadequacy of Engineering

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A Philosophical Inadequacy of Engineering

Engineering is a philosophically inadequate profession. This is not to claim that engineering is inadequate insofar as engineers fail to do philosophy. Such a claim would be true but trivial. Why should engineers be philosophers? Instead, the argument is that engineering is caught in a fundamental difficulty that is revealed by philosophical inquiry and thus may be described as philosophical in character. Reflective or critical analysis of engineering reveals that the profession is committed to an end that is not in fact integral to it. This philosophical inadequacy or deficiency leads to misunderstandings and false expectations both within and without the profession.

The flaw in engineering as a profession can be succinctly stated. Engineering is commonly defined as the art or science of "directing the great sources of power in nature for the use and the convenience of humans" (*McGraw-Hill Encyclopedia of Science and Technology*, 2008). This definition is but little changed from an 1828 formulation by Thomas Tredgold used in the Royal Charter of the Institution of Civil Engineers: "Engineering is the art of directing the great sources of power in nature for the use and convenience of man." But there is nothing in engineering education or knowledge that contributes to any distinct competence in making judgments about what constitutes "human use and convenience." Engineering as a profession is analogous to what medicine might be if physicians had no expert knowledge of health or to law if attorneys knew nothing special about justice.

The following argument for the philosophical inadequacy of engineering will proceed in three steps. It will review the conceptualization of engineering as a profession defined by two key features: technical knowledge and commitment to a service ideal. It then explicates in more detail the engineering service ideal. Finally, it argues there is something fundamentally deficient with regard to how this service ideal is or could be enacted, and concludes briefly with some implications.

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Before proceeding, two qualifications: First, the argument, as is often the case in philosophy, takes place at a certain level of abstraction if not naïveté. It will, for instance, ignore an increasing body of literature, both sociological and philosophical, on the professions *tout court*. Indicative of a growing interest in a philosophical engagement with the professions is the fact that the first edition of the *Encyclopedia of Philosophy* (1967) had no entry on or index mention of the professions or professionalism, whereas the *Encyclopedia of Philosophy Supplement* (1996) and *Routledge Encyclopedia of Philosophy* (1998) both include relevant articles and cross-references. Most philosophical debates regarding the concept and meaning of professions and professionalism will nevertheless be ignored here in order to concentrate more narrowly on a single issue with regard to engineering.

Second, in the present instance, all references to engineering will be to the profession as it has developed and is practiced in the English-speaking world—especially in the United States. Despite this limitation, there are good reasons for believing that the argument applies in some form to engineering as a profession in other socio-cultural contexts. The profession has not emerged in the U.S. in isolation from developments elsewhere.

1. Engineering Defined

Prescinding from the definition originated by Tredgold, the most comprehensive and careful analysis of engineering as a profession is found in the work of Michael Davis. According to Davis, who is summarizing standard views,

> An engineer is a person who has at least one of the following qualifications: (1) a college or university B.S. from an accredited engineering program or an advanced degree from such a program, (2) membership in a recognized engineering society at a professional level, (3) registration or licensure as an engineer by a government agency, or (4) current or recent employment in a job classification requiring engineering work at a professional level. (Davis, 1998, p. 32)

As Davis rightly notes, each of these four qualifications or criteria is philosophically deficient because each includes some form of the definiendum (engineer) in the definiens (engineering or engineer).

One effort to escape this inadequacy would be to take criterion (1) and consider the requirements for accrediting an engineering program. Do these requirements include reference to the definiendum? According to

ABET—"ABET" is the acronym of a former name, U.S. Accreditation Board for Engineering and Technology—all engineering programs are required to demonstrate the following outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering;

(b) an ability to design and conduct experiments, as well as to analyze and interpret data;

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

(d) an ability to function on multidisciplinary teams;

(e) an ability to identify, formulate, and solve engineering problems;

(f) an understanding of professional and ethical responsibility;

(g) an ability to communicate effectively;

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

(i) a recognition of the need for, and an ability to engage in life-long learning;

(j) a knowledge of contemporary issues;

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (ABET, 2007, p. 2)

Since four of these eleven outcomes—(a), (e), (h), and (k)—again reference the definiendum, this approach fails to escape definitional inadequacy.

Similar efforts with respect to the other three criteria likewise fail. With regard to criterion (2), the self-description of recognized professional engineering organizations, such as the Institution of Civil Engineers in the U.K. or the National Society of Professional Engineers in the U.S., include references to and assume knowledge of what constitutes engineering. With regard to criterion (3), registration or licensure as an engineer again rests on assumptions about or reference to engineering. Finally, with regard to criterion (4), it is unlikely that any job classification title of "engineer" would not also include an assumption about or reference to engineering.

Despite such philosophical weaknesses, Davis argues the common conception has pragmatic value insofar as the four criteria indicate the parameters within which the engineering profession exercises a certain degree of autonomy or self-determination, similar to that found in what are generally accepted as the two classic professions. Just as, practically speaking, physicians are those whom other physicians agree to recognize as physicians, and lawyers are those whom other lawyers accept as members of the bar, so engineers are those whom other engineers agree to recognize as such. Engineering is what people who call themselves engineers think and do—or attempt to think and do. As a conclusion of his analysis, Davis thus reduces the four criteria to two, one concerned with thinking and another with doing: "(1) specific [specialized or technical] knowledge and (2) commitment to use that knowledge in certain ways (that is, according to engineering's code of ethics)" (Davis, 1998, p. 37).

Davis's practical definition is confirmed by the ABET accreditation criteria, which can themselves be grouped in two types: those having to do with a specialized knowledge or skill and those having to do with ethics. The knowledge and skills criteria are specified by outcomes (a), (b), (c) at least in part, (d), (e), and (k). The ethics criteria are present in (c) designing to "meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;" (f) "understanding . . . professional and ethical responsibility;" and (h) ability "to understand the impact of engineering solutions in a global, economic, environmental, and societal context." Outcomes (g), (i), and (j) are more generic and characterize any profession or occupation. They are necessary for well-educated citizens, never mind the roles they might occupy in society.

On another occasion, Davis summarizes his position by rejecting the attempt to formulate a philosophical genus-and-species definition of engineering. According to Davis,

> There can be no philosophical definition . . . that captures the "essence" of engineering (because engineering no more has an essence than you or I do). All attempts at philosophical definition will: a) be circular (that is, use "engineering" or a synonym or equally troublesome term); b) be open to serious counter-examples (whether because they exclude from engineering activities clearly belonging or because they include activities clearly not belonging); c) be too abstract to be informative; or d) suffer a combination of these errors. (Davis, forthcoming)

Instead, as with other professions such as medicine or law, engineering should be understood as a self-perpetuating community of practitioners.

> There is a core, more or less fixed by history at any given time, which determines what is engineering and what is not. This historical core, a set of living practitioners who—by discipline, occupation, and profession—undoubtedly are engineers, constitutes the profession. They decide what is within their joint competence and what is not. (Davis, forthcoming)

In other words, it is engineers as a historically constituted group who determine what counts as engineering, in terms of both thinking and doing or of specialized knowledge and commitment to use.

Davis's conclusion, it may be noted, accords with generally accepted accounts of the constituent features of any profession. According to Michael Bayles (1989), for instance, the working concept of a profession includes extensive training with a significant intellectual component and the provision of an important service to society. Davis elsewhere also proposes: "A profession is a number of individuals in the same occupation voluntarily organized to earn a living by openly serving a certain moral ideal in a morally permissible way beyond what law, market, and morality would otherwise require" (Davis, 2002, p. 3).

2. Historical Emergence

In the present instance the concern is not so much with technical knowledge as commitment to use—and the relation between the two. This is not to deny that engineering knowledge deserves more by way of historical and critical epistemological analysis than it has yet received. It would certainly be worthwhile to explore, among other issues, the emergence of engineering knowledge as a cognitive achievement and the relations between science and the engineering sciences, distinctions between craft and engineering skill, the methodologies of engineering design, and the epistemic structures of engineering knowledge about how the engineered world works. At the same time, it is relatively easy to find in the engineering educational curriculum more or less adequately delineated bodies of knowledge and skill sets that engineers themselves have decided are necessary to professional practice. All accredited engineering programs include in their curricula substantial courses in advanced mathematics, statistics, physics and chemistry (and sometimes biology), mechanics, thermodynamics, strength of materials, and design (or what Mitcham, 1994, has described as miniature making). In combination such studies can be argued to provide a relatively sound basis for technical competence and the exercise of informed judgment in the systematic design, manufacture, and operation of engineered structures, products, and processes. Otherwise engineering would suffer pragmatic failure as a profession—just as would medicine if physicians did not in practice possess more or less adequate knowledge and skill to treat illness and disease in order to achieve health or law if attorneys did not know how to legislate and to operate within existing legal structures to secure (at least procedural) justice.

But what is the commitment in engineering that indicates how its specialized or technical knowledge is to be used? What is the purpose, end, or service ideal of technical engineering knowledge and practice? What corresponds to the commitment in medicine to the promotion of health and in law to the pursuit of justice? (That the professional ethical ideals have been contested with regard to both medicine and law does not obviate an effort to identify what might be the functional equivalent in engineering—which, once named, might then also be contested.)

Historically, engineering arose from specialization within another profession, that of the military. The English word "engineer" and its cognates originally referenced a special group within the army—the corps of engineers—the members of which designed, built, and managed various types of fortifications along with "engines of war" such as battering rams and catapults. Indeed, during the same period in which societies of professional engineers were being established—e.g., the British Institution of Civil Engineers in 1818 and the American Society of Civil Engineers in 1852—Samuel Johnson's *Dictionary of the English Language* (1755) defined the engineer as "one who directs the artillery of an army" and Noah Webster's *American Dictionary of the English Language* (1828) described the engineer as "a person skilled in mathematics and mechanics, who forms plans of works for offense or defense, and marks out the ground for fortifications." (As members of the military, engineers can be presumed to have studied the art of employing armed force to secure national policy, and to have used that learning in obedience to authority.)

John Smeaton in the 1760s was among the first to attempt explicitly to detach engineering from its military origins by referring to himself as a "civil engineer"—meaning simply an engineer not in military service. In part this coinage seems to have been stimulated by an effort to carve out a kind of architectural work more closely allied with and based in natural science than was architecture itself. One contemporary commentator, for instance, argued that Dutch "hydraulic architecture" was really a form of engineering, precisely because it used and developed the new science of hydraulics. In part it reflected and no doubt contributed to a delimiting of the architectural profession—as had been classically reviewed, for instance, by Vitruvius's *De architectura*—and to a progressive reassigning of responsibility to a new profession for designing, constructing, and maintaining roads, bridges, water supply and sanitation systems, railroads, and such. This reassignment is clearly reflected in the full statement of Tredgold's definition of civil engineering as

> the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks, for internal intercourse and exchange; and in the construction of ports, harbors, moles, breakwaters, and light-houses, and in the art of navigation by artificial power, for the purposes of commerce; and in the construction and adaptation of machinery, and in the drainage of cities and towns. (Institution of Civil Engineers, 1828)

Human use and convenience is simply assumed to be synonymous with the advancement of commercial and industrial interests, a view that over the next hundred years will be subject to increasing social and philosophical criticism.

It is against this background that there have emerged a number of different contemporary formulations of engineering ethics in terms of a commitment to public safety, health, and welfare. The trajectory from Tredgold to the present is complex, and made more so by the distention of engineering across numerous professional associations and the lack of unifying organizations such as those manifested in medicine and law. (The basic history of engineering as a profession in the United States as narrated by Layton, 1971, is especially revealing in this regard; for relevant complementary studies, see Vesilind, 1995; Mitcham, 1997; and Davis, 1998.) Yet such complexity need not affect the present argument. Here it is sufficient to note that the "Code of Professional Conduct" of the Institution of Civil Engineers states in its third rule that "All members shall have full regard for the public interest, particularly in relation to matters of health and safety, and in relation to the well-being of future generations" (Institution of Civil Engineers, 2008). In parallel, the "Code of Ethics for Engineers" of the National Society for Professional Engineers even more forcefully declares in the first of six "fundamental canons" that "Engineers, in the fulfillment of their professional duties, shall hold paramount the safety, health, and welfare of the public" (NSPE, 2007). Whereas in the early 1800s it was more or less assumed that the practice of engineering knowledge and skill would automatically rebound to human benefit, two centuries later an increasing need to assert the same and to ask engineers to be explicit in pursuing such a commitment has given rise to what is known as the paramountcy clause.

3. The Problem

Now comes the problem. The engineering curriculum in its technical component provides a reasonable basis for making sound technical decisions. But what about the ethical component? Although the professional ethical component of engineering education has become increasingly prominent, there are good reasons to doubt that it comes close to being as sufficient as the technical component—or that it even in principle could become so. It is true that accredited engineering programs commonly include some limited course work in professional engineering ethics. But such courses are almost wholly limited to discussions of professional engineering ethics codes, their explication, and/or social difficulties related to enacting them, mostly in the form of case studies or hypothetical scenarios. A typical engineering ethics course may provide some general ethical theory as background to the codes of specific professional engineering organizations and then explore the difficulties in, for example, practicing loyalty and honesty, avoiding conflicts of interest, and protecting public safety, given the real-world context of countervailing economic, social, and political pressures and the limitations of professional autonomy within which engineers work (for illustration, see the two most widely used U.S. engineering ethics textbooks, Harris *et al*., 2005; and Martin and Schinzinger, 2005). On what basis does this qualify engineers to make informed judgments about what constitutes public safety, health, and welfare?

The initial version of ethical commitment was, as noted above, to human use and convenience. Human use and convenience has never been a formal element of any engineering ethics code, in part because explicit ethics codes were not formulated until a hundred years after Tredgold, but also because there would have been no doubt about the end of engineering knowledge and skill. The connection between technical engineering and the service ideal of human use and convenience would have been argued in the form of an enthymeme or syllogism with a suppressed premise like this:

> Major premise: Technical engineering knowledge increases human power.
>
> Minor (unstated or suppressed) premise: Human power is always used to enhance human use and convenience.
>
> Therefore, engineering is for human use and convenience.

The articulation of an explicit service ideal for engineering and the substitution of public safety, health, and welfare for human use and convenience together can be interpreted to reflect an emergent awareness that the minor premise can no longer be assumed or go unquestioned.

To reiterate: There are two necessary (if not sufficient) elements of the engineering profession: possession of a body of technical knowledge and commitment to a goal of public service. Insofar as this is the case, engineering may be compared with the two classic professions of medicine and law, as indicated with the following table:

	Medicine	Law	Engineering
Specialized knowledge	of human anatomy and physiology	of the legal system	of the applied sciences, design methods, and artifact functionings
Public service	Human health	Justice procedural	Public safety, health, and welfare

In medicine, the specialized body of knowledge concerns human anatomy and physiology or some distinctive portion thereof and a commitment to the promotion of human health. In the case of law, the specialized body of knowledge is the laws and legal procedures of a state and a commitment to justice—at least procedural justice. For engineering, analogously, the specialized body of knowledge includes the applied or engineering sciences and design methods along with a commitment to public safety, health, and welfare.

In medical school, not only do students take courses explicitly devoted to understanding the nature and meaning of health (and a host of opposing pathologies), but virtually all courses necessarily include some learning about health. In order to study how the human body is structured and functions one must develop not just a descriptive but also a prescriptive appreciation of structure and function. What Ruth Millikan (1984) and some philosophers of biology call proper functions are an integral part of medical knowledge. Only from the perspective of proper functions can one learn to diagnose illness or disease and prescribe therapeutic responses. In the course of their studies physicians thereby develop a robust understanding of health, one that enables them genuinely to understand the anatomies and physiologies of their patients better than the patients could understand their own bodily functionings. Likewise in the case of law: The typical law school curriculum includes substantial doses of jurisprudence, and attorneys are genuinely able to understand what constitutes procedural justice better than their clients. Physicians and attorneys thus are reasonably committed to and charged with assisting those whom they serve and the public at large in understanding and pursuing health and justice.

On what possible basis, however, are engineers more qualified than anyone else to understand or determine the safety, health, and welfare that should be associated with engineered structures, products, or processes? In Walter Vincenti's lucid analysis of *What Engineers Know and How They Know It* (1990) there is little indication that engineers qua engineers know anything about safety, health, or welfare. These are simply not things engineers know, and there seems to be no way specific to engineering to acquire such knowledge. With regard to welfare, engineering education requires no courses in the subject, and surely welfare economists and psychologists are more expert in the nature and meaning of human welfare than engineers. With regard to health, physicians are obviously more expert than engineers. With regard to safety, it may be that engineers possess a modicum of relevant expertise, insofar as safety factor analysis is included in some technical courses. But what constitutes safety (or its obverse, risk) is a much more socially constructed notion than that of health. (See, e.g., Blockley, 1992, who presents engineering safety as a social/technical interface issue.) There is no such thing as "proper safety" as an objective feature of the engineered world, the way proper functions are understood as objective features of the biological world. Indeed, there is no such thing as a proper function for any artifact. In artifacts there are only what Pieter Vermaas (2007) terms "fiat functions," that is, ascribed functions, which can change or be added to when people come up with a new creative uses. Although law and justice have strong socially constructed dimensions, the social construction of the legal system is one in which negotiation has reached at least provisional conclusion in statutory or administrative law. The law is composed of what might be called well-entrenched fiat functions. With safety, however, except insofar as it is legally specified, social construction is seldom manifest in a clearly defined consensus and as a result remains continuously up for renegotiation.

As one engineer philosopher, Samuel Florman, has objected with regard to safety: It would be crazy for engineers to determine "what criteria of safety should be observed in each problem" encountered. Things can always "be made safer at greater cost, but absolute freedom from risk is an illusion." Levels of safety are "properly established not by well-intentioned engineers, but by legislators, bureaucrats, judges, and juries [and it] would be a poor policy indeed that relied upon the impulses of individual engineers" (Florman, 1981, pp. 171 and 174). The most engineers can do is help clients and the public understand the relevant degrees of safety and then invite them to decide how safe is safe enough. Engineers qua engineers are no more qualified to make such determinations than anyone else; they legitimately participate in making such determinations, but only as consumers, users, and citizens.

As the quotation from Florman suggests, this problem of the lack of any specifically engineering competence or expertise with regard to an implied professional commitment to public safety, health, and welfare has not gone completely unrecognized. In fact, one can identify at least three efforts to respond to the problem. One is that represented by Florman himself, who rejects an internal service ideal of public safety, health, and welfare in favor of external, democratically determined and governmentally enforced regulations for engineering practice. Florman even imagines that a special cadre of public service engineers could well contribute to the intelligent creation and administration of such regulations. But the consequences of imposing the protection of the public good on the consciences of all engineers would be chaos: "Ties of loyalty and discipline would dissolve, . . . organizations would shatter [and whistle blowing] would become the norm, instead of a last and desperate resort" (Florman, 1981, p. 171).

There are, however, two weaknesses with such a rejectionist stance. On the one hand, since engineers are to have no special ethical obligations as engineers, the rejection of a service ideal would seem to deprive engineering of professional status. On the other, by raising the possibility of a special cadre of guardian engineers in public service, Florman would seem to presume the possibility of such status in a way that simultaneously promotes a fissure within the engineering community. Additionally, the extent to which the public service cadre possesses any knowledge that would warrant its contribution to the establishment of regulations remains questionable.

An alternative to Florman's notion of engineers as observing minimal and in fact common ethical commitments to competence and integrity while working within externally determined frameworks provided by law or regulation is that of creating an alternative ethical ideal. In fact, Florman's very notion of a cadre of engineers who "do the research, write the codes, and make the inspections that keep technology in check" (Florman, 1981, p. 175) would seem to require some notion of an internal technical ideal. Thorstein Veblen in *The Engineers and the Price System* (1921), as a result of his economic analysis of public welfare, argued that a major cause for the diminished quality of life in techno-capitalist society was the capture of engineering by captains of industry who sacrificed the making of good products to the making of money. For Veblen the "instinct of workmanship" and commitment to efficiency inherent to engineering should be liberated from the distorting shackles of commercial interests. Steven Goldman (1991), without endorsing Veblen's response, has made a similar argument with regard to the social captivity of engineering.

Veblen's proposal to turn decision making over to engineers nevertheless flounders on two problems. One is that the resulting technocracy would be opposed to both democracy and the free market. Another is that efficiency as a concept is as context dependent as safety. Efficiency as a ratio of output divided by input is dependent on what are counted as outputs and inputs. Output and input determinations are specified by contexts external to engineering—in the most rigidly quantitative terms by the economy but in softer forms by politics, culture, and fashion. It is difficult to see how the ideal of efficiency could escape the problem of the relation between economic internalities and externalities, as these are manifest by problems related, for instance, to environmentalist debates.

Still a third response is to subordinate public safety, health, and welfare to free and informed consent. This is the argument advanced initially by Mike Martin and Roland Schinzinger (1983) and then in a different form by Taft Broome (1989). In the restatement of their argument in a widely adopted engineering ethics textbook, philosopher Martin and engineer Schinzinger argue for viewing "engineering as social experimentation." Engineering projects are experiments insofar as they are undertaken in partial ignorance, outcomes are uncertain, and future engineering practice is modified by knowledge gained as a result. More crucially, these experiments impact users, consumers, and those societies in which the engineered structures, products, and processes are created and deployed.

> Viewing engineering as an experiment on a societal scale places the focus where it should be: on the human beings affects by technology, for the experiment is performed on persons, not on inanimate objects. In this respect, albeit on a much larger scale, engineering closely parallels medical testing of new drugs or procedures on human subjects.

In consequence, "the problem of informed consent . . . should be the keystone in the interaction between engineers and the public" (Martin and Schinzinger, 2005, p. 92). Just as medical research with human subjects or participants is moral only to the extent it respects the free and informed consent the persons involved, so must engineering undertake to respect the autonomy of those it affects. Commitment to public safety, health, and welfare as a substantive ideal is replaced by the ideal understood in proceduralist terms; the basic form of safety, health, and welfare is not to be subjected to risks, deprivations, or harms to which one has not knowingly acceded, so that the practice of free and informed consent becomes the basic form of engineering ethics. Public safety, health, and welfare are then publicly determined by those affected through their free and informed involvement.

Engineer philosopher Broome advances a slightly different but related argument. For him, the fundamental misconception about engineering is to think of it as an application of science that partakes of its reputed cognitive certainties. In fact, engineering is based not on scientific knowledge but depends crucially on practical conjecture, so that engineering takes the form of a heroic quest. Engineers have the obligation to include the societies in which they work in their heroic explorations and adventures. As Broome reformulates the public paramountcy principle:

> The engineer shall not claim that engineering necessarily assures good public health and welfare. Instead, [the engineer] shall advise the public of the risks associated with [engineering] and seek to obtain public acceptance of these risks. (Broome, p. 9)

But it is one thing for physicians, who work with individual patients, to practice free and informed consent—even undertake heroic medical efforts to save lives or discover new cures for disease. It is quite another for engineers to try to imitate such practices in projects that implicate whole groups, populations, and even future generations. Broome's notion of a heroic quest could easily morph from a techno-odyssey of adventure to a techno-campaign of conquest—from Magellan to Captain Ahab.

Again, the difficulties of establishing appropriate protocols and practicing free and informed consent with regard to individual research programs and human subject participants are legion; they can only be enlarged when the practice rises to the level that Martin and Schinzinger suggest is necessary. Although they admit the problematic character of informed consent, for which they seek to substitute "valid consent" grounded in a simple responsibility of engineers to provide users and consumers "information about the practical risks and benefits of the process or product in terms they can understand" (Martin and Schinzinger, 2005, p. 93), this still leaves protocols open to the point of vacuousness. (One operationalization option they neglect to consider is the practice of consensus conferences, as has become something of a standard practice in Denmark.)

But would it not be more honest to adopt Florman's straightforward but tragic affirmation of "the existential pleasures of engineering" (Florman, 1976)? Grounded in creative self-realization, engineers and their supporters, "aware of the dangers and without foolish illusions," would nevertheless "press ahead in the name of the human adventure," believing that "without experimentation and change our existence would be a dull business" (Florman, 1981, p. 193). Such would also seem to be Broome's notion of engineering heroism. The ultimate commitment to safety, health, and welfare—indeed, to use and convenience—would then be conceived as the creative practice of engineering itself, safe in affirmation of ourselves as technological beings whose health and welfare is as much found in identification with the engineering spirit as with any more mundane forms of well being.

4. Conclusion

The thesis argued here is that a philosophical analysis of engineering reveals a substantive inadequacy, not to say incoherence or contradiction, in the profession: a commitment to public safety, health, and welfare that is incapable of enactment. Although efforts have been made to respond to this fundamental problem, all have weaknesses—some of which fail to recognize the depth of the difficulties at issue, some of which may be worse than the original problem itself, others of which simply wind up affirming engineering creativity as an end in itself with spill over benefits.

The fundamental problem can be restated as follows. When a physician correctly diagnoses and treats an ill or diseased patient, a return to health on the part of the patient directly confirms diagnosis and treatment. When an attorney counsels a client, the counsel can be judged by its benefits or not at court. It is true that physicians and lawyers may have a deeper appreciation of the therapy or legal brief than the public, but the bottom line assessments of the public will readily agree with those of the experts. In both cases the professions are relatively able to achieve their ends—health or justice, respectively—with similar assessments reached regarding the degree to which this occurs by both professionals and those they serve.

With engineers, however, the situation is different. Engineers can come up with good structural, product, or process designs that go unappreciated, are criticized, or even rejected by the firms or clients for which they work—not to mention the marketplace into which engineering designs may be introduced. Good engineering is mostly recognizable as such only by other engineers. Technical efficiency and engineering elegance are often confirmed only in the breach by some happenstance of corporate decision-making or market success. To say the same thing in a different way: The first-order ends of health and justice operative in the professions of medicine and law, respectively, are not enclosed within some second-order end of public good; they are the public good. In engineering, by contrast, the first-order technical end, however defined, which was once assumed to be itself a public good, is now conceived as subordinate to a second-order end that is not operative in the profession itself. This is a contrast that would seem to stand even if one rejects as naive or qualifies the comparisons with medicine and law.

The situation with engineers may be compared to that of scientists. Seldom will the public have any basis for appreciating and accepting a new scientific discovery. Indeed, in many instances the public will resist or reject a scientific discovery as a problematic imposition on common sense or accepted beliefs. Only after a long period of accommodation are many scientific observations and theories allowed to replace the folk truths or falsities accepted by the general public, because the first-order end of knowledge in science is not identical with a second-order end of the public good—or has to be argued to be so in many cases. In like manner, only over extended periods of time do some instances of efficiency and technical elegance slowly insinuate themselves into publicly accepted artifice. Quite common are the public adoptions of less than adequate engineering designs along with their false efficiencies and profit-making potentials enhanced by superficial glamor and the push of marketing. Such would seem to be at least one cautionary moral of the only engineering ethics textbook to take the paramountcy clause as its central theme, a novel with commentary by Alastair Gunn and Aarne Vesilind (2003).

The gap between first- and second-order ends in engineering can account for both student disinterest and professional resistance to the study and discussion of engineering ethics, especially when this study and discussion becomes focused in terms of public safety, health, and welfare. For despite the claims of some engineers and engineering ethics educators, there is considerable evidence that students and practicing professional engineers are not very interested in ethics—except perhaps to protect them from societal critics. Because commitment to public safety, health, and welfare is simply not integral to engineering, to try to impose it on the profession intuitively strikes many students and professionals as artificial and inappropriate. Additionally, it is failure to recognize this gap that accounts for many false expectations among the public with regard to the responsibilities of engineers for technical failures and disasters. The public tends to expect more of engineering than is possible or appropriate. Only recognition of the philosophical inadequacy of the contemporary conception of engineering will enable both the profession and the public to develop a more sound understanding of a form of knowledge and skill that has nevertheless become increasingly important in our technolife world.

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