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The importance of Philosophy to Engineering

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ABSTRACT

Philosophy has not paid sufficient attention to engineering. Nevertheless, engineering should not use this as an excuse to ignore philosophy. The argument here is that philosophy is important to engineering for at least three reasons. First, philosophy is necessary so that engineers may understand and defend themselves against philosophical criticisms. In fact, there is a tradition of engineering philosophy that is largely overlooked, even by engineers. Second, philosophy, especially ethics, is necessary to help engineers deal with professional ethical problems. A case study of ethics requirements for U.S. engineering curricula substantiates this point. Third, because of the inherently philosophical character of engineering, philosophy may actually function as a means to greater engineering self-understanding.

Introduction

The thesis of the present paper is that, common presumptions to the contrary, philosophy is centrally important to engineering. When engineers and engineering students — not to mention those who make use of engineering services — dismiss philosophical analysis and reflection as marginal to the practice of engineering, they are mistaken on at least two counts: historical and professional.

It is also the case, I would argue, that engineering is important to philosophy — and that philosophers have made woefully insufficient efforts to appreciate and assess the technical realities that they too often presume to criticize. Were philosophers to set their own discipline in order with respect to engineering, philosophy would no doubt be even more important to engineering than is presently the case.

Nevertheless, even granted the inadequate attention conferred on engineering by philosophy, philosophy is of critical and increasing significance to engineering. The argument in support of this thesis will, appropriately enough, rely in key respects on engineering experience. It will proceed by means of a historical review of engineering efforts to do philosophy in part as a self-defense against philosophical criticism. Then, in a central case study, it will summarize and reflect on efforts in the United States professional engineering community to incorporate philosophy into engineering education curricula. The later sections of the paper will, however, make a more reflective effort to speculate about the deepening relations between engineering and philosophy in an increasingly engineered world. Engineers are, I will finally suggest, the unacknowledged philosophers of the postmodern world.

1. SELF-DEFENSE AND PHILOSOPHY

Let me begin, then, with the issue of self-defense. As preface to this issue, consider an engineering-like schematic presentation of the problem. The problem is that engineering and philosophy are typically conceived as two mutually exclusive domains, somewhat as follows:

Figure A

In the minds of most people, engineering and philosophy do not have much to do with each other. They are, as it were, giant islands separated by a large body of water.[1]

In fact, from the perspective of some members of the engineering community — not to mention those of the philosophy community — the situation is even worse. Engineering is customarily divided into a number of different branches: civil engineering, mechanical engineering, electrical engineering, chemical engineering, nuclear engineering, computer engineering, etc. Something similar goes for philosophy. It too includes different branches: logic, epistemology, metaphysics, ethics, aesthetics, political philosophy, etc. Representatives of some of these areas of the philosophy world, especially ethics and aesthetics, seem to have mounted canons on their areas of the philosophy island in order to fire away at selected domains of the engineering world.

At least since the 1960s, members of the philosophical community or its fellow travellers have been accusing engineers of building nuclear weapons that could destroy civilization as we know it, manufacturing transportation systems that are a blight on urban culture, designing communication technologies that can enhance central or authoritarian controls by both governments and private corporations, creating computers that depersonalize human life. Engineers have, in general, so the critics contend, been polluting the natural world with toxic chemicals and greenhouse gases while flooding the human world with ugly structures and useless consumer products.[2]

Martin Heidegger, one of the most prominent philosophers of the 20th century, has even gone so far as to argue that all such ethical and aesthetic failures are grounded in a fundamental engineering attitude toward the world that reduces nature to resources in a dominating Gestell or enframing.[3] Heidegger is perhaps more subtle on this point than is always recognized. But on one common interpretation, Heidegger can be construed to say that Herbert Simon's "sciences of the artificial,"[4] for example, promote a constrained and constraining ontology of mathematical reduction and an epistemology of virtual reality. Feminist critics have even associated engineering with patriarchal domination, the death of nature, and the loss of world-centering care.[5]

What such charges amount to is a major reactionary attack on the self-definition of engineering that goes back to the 18th century formulation of Thomas Tredgold, and is reiterated in such standard reference works as the Encyclopaedia Britannica and McGraw-Hill Encyclopedia of Science and Technology. According to the classic and still standard definition that engineers give of their own profession, engineering is "the application of scientific principles to the optimal conversion of natural resources into structures, machines, products, systems, and processes for the benefit of humankind."[6] The upshot of philosophical attacks would be to replace this traditional self-understanding with one that might read more like the following: "Engineering is the scientific art by which a particular group of human beings destroys nature and pollutes the world in ways that are useless or harmful to human life."[7]

Insofar as they have become aware of such attacks — and to understand and defend against them — philosophy is crucial to engineers. In the first instance, then, engineers have become involved with the study of philosophy in order to respond, to erect some fortifications against the philosophical onslaught. A whole school of engineer philosophers has in fact taken up this challenge, but it is a school that is incompletely recognized even in engineering institutes and colleges — and certainly not in the liberal arts faculties in which most philosophy is taught. Allow me simply to mention in passing some representative contributors to this school or tradition.[8]

First is Ernst Kapp (1808-1896), a contemporary of Karl Marx. Although originally educated as a philosopher, Kapp emigrated from Germany to central Texas, where he became a pioneer and developed a view of technology as a complex extension or projection of human faculties and activities. In a subsequent articulation of this philosophical anthropology of technology, he became the person to coin the phrase “philosophy of technology” or “philosophy of engineering.”[9]

Next I would mention Peter Engelmeier (1855-c.1941), one of the founders of Russian professional engineering. A hundred years ago Engelmeier, under the banner of the phrase “philosophy of technology,” argued for a more than technical education of the engineering profession. If engineers are to take their rightful place in world affairs, he argued, they must be educated not only in their technical fields but also in knowledge about the social impact and influence of technology.[10]

A third representative figure is Friedrich Dessauer, certainly a pivotal contributor to this tradition of engineering philosophy of technology. The inventor of deep-penetration x-ray therapy, a political opponent of Nazism, and a technical professional in dialogue with such philosophers as Karl Jaspers, José Ortega y Gasset, and Heidegger, among others, Dessauer put forth an interpretation of engineering invention as an experience that transcends the boundaries of Kantian phenomenal appearances and makes contact with noumenal things-in-themselves.[11]

Independent of Dessauer’s interpretation, and as a final example of the engineering philosophy tradition, New York civil engineer Samuel Florman has developed a related interpretation of “the existential pleasures of engineering” that both responds to many of its contemporary philosophical critics and defends engineering as in itself a fundamental human activity.[12] Engineering is not only instrumental to other human ends, it is in itself an existentially meaningful activity. Engineering possess inherent or intrinsic as well as instrumental or extrinsic value.

In the first instance, then, philosophy is important to engineering, because there are many who philosophically criticize engineering. Out of self defense, if for no other reason, engineers should know something about philosophy in order to handle their critics. Moreover, some engineers have in fact taken up this challenge.

2. SELF-INTEREST AND PHILOSOPHY

Philosophy is also important, in a second instance, because engineers actually face problems internally or professionally that they admit cannot be resolved simply with engineering methods alone. I refer here primarily of professional ethical issues.

There are times in the engineering world when engineers ask themselves questions about what they should be doing or how they should do it that cannot be solved by technical expertise alone. Although Clive Dym methodologically excludes aesthetics — and, by extension, ethics — from his analysis of design, in order to keep his discussion “bounded and manageable,” he also grants that ethics often has a serious role to play in engineering design.[13] Questions of safety, risk, and environmental protection are only the more obvious manifestations of variables that call for ethical judgment in assessing their proper influence on design decisions. Philosophy (especially ethics) is an internal practical need of engineering — and is so recognized by the professional engineering community.

To consider the point at issue here in a slightly fuller manner, let me compare the roles played by the sciences and the liberal arts in engineering education. For this purpose, allow me to examine, as an empirical case study, the engineering education certification requirements in the United States. By proceeding in this manner my aim is to let engineers, through their own professional community, speak for themselves about how they think philosophy is in the self-interest of engineers, and to provide some complementary elaboration.

The organization that certifies U.S. engineering education programs is the Accreditation Board for Engineering and Technology, more commonly known by the acronym ABET. (ABET grew out of the Engineer's Council for Professional Development or ECPD, which was founded in 1932.)

According to present ABET accreditation criteria,[14] engineering programs require a minimum of

—one year of mathematics and the basic sciences,

—one half year of humanities and social sciences, and

—one and a half years of engineering topics.

It is important to emphasize that these are minimal content requirements — and that the standard engineering degree in the U.S. requires four to five years of study.

These minimal content requirements exclude what are called "skills" courses focusing on the development of competence in written and oral communication, which are also required. If language communications skills course requirements are included with humanities and social sciences content course requirements — as they are in the traditional descriptions of the liberal arts — then ABET effectively requires engineering students to complete a year of studia humanitatis.

Consider now the justifications for the three primary components of engineering education provided by ABET.

The engineering topics criterion, of course, needs no justification, since it is engineering education that is at issue. Nevertheless, it is useful to note that engineering topics are explicitly said to include both the engineering sciences — as distinct from the basic sciences — and engineering design — as distinct from other types of design (IV.C.3.d.[3][a]).

As for the engineering sciences, these "have their roots in mathematics and basic sciences but carry knowledge further toward creative application" (IV.C.3.d.[3][b]). Such rootedness is what justifies course requirements in mathematics and the basic sciences. In the words of the ABET criteria: "The objective of the studies in basic sciences is to acquire fundamental knowledge about nature and its phenomena, including quantitative expression" (IV.C.3.d.[1][b]).

As for engineering design, this is defined as the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences and mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective (IV.C.3.d.[3][c].

Such an understanding of engineering design obviously provides a second and supporting justification for mathematics and the basic sciences.

But what about the half-year of liberal arts courses — or year, if one includes studies of written and oral communications? What is the justification for including the humanities and social sciences as a major component of the curricular requirements for an engineering education?

Before citing the ABET criteria answer to this question, note that the ABET criteria definition of engineering design silently drops one crucial aspect of the traditional definition of engineering. As mentioned earlier, Tredgold's and (until recently) the most commonly cited definition is that engineering is "the application of scientific principles to the optimal conversion of natural resources into structures, machines, products, systems, and processes for the benefit of humankind." ABET replaces the end or goal of being humanly useful and beneficial with simply meeting some "desired needs" or "stated objective." The normative aspect of the traditional definition is thus washed out in favor of a value-neutral or context-dependent process.

Therefore, at the point in the ABET criteria when the humanities and social sciences content requirements are described and justified, it is said that

Studies in the humanities and social sciences serve not only to meet the objectives of a broad education but also to met the objectives of the engineering profession. . . . In the interests of making engineers fully aware of their social responsibilities and better able to consider related factors in the decision-making process, institutions must require course work in the humanities and social sciences as an integral part of the engineering program. This philosophy cannot be overemphasized (IV.C.3.d.[2][a]).

In other words, once the goal of engineering design has been reduced from being humanly useful and beneficial to a context-dependent process, then the humanities and social sciences are presented as a means to understand and evaluate such contexts. Otherwise engineers would just be hired guns — and could serve the profession equally well as designers of concentration camps or of green (non-polluting) chemical plants.

Thus, while mathematics and the basic sciences ground the engineering sciences, the liberal arts ground (in a different but related way) engineering design. Would it be too bold to conjecture that, just as the engineering sciences are thought to extend the basic sciences, by carrying "knowledge further toward creative application," so too engineering design may be described as creatively applying some modes of thought and ideals of the humanities and social sciences?

Consider briefly a contrast of two engineering experiences that may be interpreted to support, from quite different angles, just such a hypothesis. The first is imaginative, but real: that of Goethe's Faust. In Faust II, having abandoned first his liberal studies and then crude magic, Faust has become a civil engineer erecting dams and draining marshes — yet inadvertently killing innocent people.[15] The second is historical, but imaginatively reconstructed: the case of Russian engineer Peter Palchinsky.[16] Executed by Stalin because he refused to separate technical knowledge and humanistic ideals, it is the ghost of the executed engineer Palchinsky that emerges triumphant in the glasnost that accompanied the demise of the Soviet Union.

This point is reiterated at the end of the ABET criteria content statement. After asserting that competence in communication "is essential for the engineering graduate" (IV.C.3.i), it is further affirmed that, "An understanding of the ethical, social, economic, and safety considerations in engineering practice is essential for a successful engineering career" (IV.C.3.j).

ABET is currently in the process of revising and simplifying its criteria for accreditation. Its new criteria set, laid out in a document called "Engineering Criteria 2000," confirms the present argument by listing eleven "outcomes" upon which engineering programs will be assessed. Beginning in the year 2000, to be accredited by ABET, "engineering programs must demonstrate that their graduates have

(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

(d) an ability to function on multi-disciplinary 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 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.

Now of these eleven outcomes, four — or over one third — may readily be classified as engaged with the liberal arts. Thus, again, in a four-to-five year program, more than a year of course content can be expected to be humanitas focused."Such course work," appealing again to existing criteria, must meet the generally accepted definitions that humanities are the branches of knowledge concerned with man [sic] and his [sic] culture, while social sciences are the studies of individual relationships in and to society. Examples of traditional subjects in these areas are philosophy, religions, history, literature, fine arts, sociology, psychology, political science, anthropology, economics, and foreign languages . . . . Nontraditional subjects are exemplified by courses such as technology and human affairs, history of technology, and professional ethics and social responsibility (IV.C.3.d.[2][b]).

3. EXCURSUS: THREE QUESTIONS

This passage easily provokes at least three questions — questions that entail a brief excursus. The questions are:

One, what does it mean to invoke "generally accepted definitions" of the humanities and the social sciences? Are the humanities and the social sciences, including philosophy, historically or socially constructed?

Two, exactly what is philosophy anyway? What is the relation between philosophy and the liberal arts? Is it perhaps the case that philosophy — having been named first — could be more important than or differentially significant from other humanities and social sciences?

Three, in light of the generally accepted definition of philosophy as including ethics — together with statements here and previously regarding the importance of professional ethics to "a successful engineering career" — what is it, more concretely, that philosophy and ethics may do for engineering?

These are all serious questions. They are not to be answered either quickly or finally in the present paper. Indeed, they are the kind of open questions designed to provoke extended reflection more than the closure of straightforward solutions. It is nevertheless appropriate here to begin to explore elements of what might be termed some boundary conditions on such answers.

With regard to the first question: The passage is more insightful than many in its cautionary reference to "generally accepted definitions" of the humanities and the social sciences. It is indeed the case that these definitions are historically, socially, societally, and culturally constructed.[17] Such constructions as exist are also highly contested — in differentially constructed ways.

In the U.S. this multi-layered contest — with its contests about the contest — is known collectively and affectionately as "the culture wars." One front in these wars is fought between protagonists of the "dead white men" (from Homer on) school of culture and the "politically correct" (we are the victims of discrimination) school — to use the warring parties aspersion-casting names for each other. In this sense the ABET criteria statement is at once cautious — and then anything but cautious, with its description of the humanities as "concerned with man and his culture."

Leaving aside this egregious gaff, one may nonetheless note that early on engineers opened their own front in the culture wars. As John Staudenmaier has ably narrated in

Technology's Storytellers, the founding of the Society for the History of Technology in the late 1950s was done in part by engineers who found themselves left out of Western history just as much as women or various ethnic minorities.[18] History is technology as much as politics, the engineer historians argued. The humanities and social sciences have reflected the limited self-interests and ideological biases of non-engineers — not to say of those who use humanities and social sciences power/knowledge to discipline themselves and others.[19] Engineers have an interest in opening up the black boxes in history, to notice that political problems and their solutions often depend on engineering input, in order to include not so much another group of victims as unrecognized conquerors.[20]

The humanities and the social sciences, including philosophy, are thus historically and socially constructed. But it is also crucial to note that the same — although not so obviously — goes for engineering. Both engineering and philosophy — to focus on that element of the humanities and the social sciences most at issue here — have distinct historical origins, and have not always been understood or practiced in the past as they are today.

Philosophy emerged as a recognized human way of life in 5th century BCE Greece. According to Aristotle's account, philosophy originated when human beings replaced speech about god or the gods with speech about phusis or nature.[21] Today, however, few members of that community which practices the discipline of philosophy — and discipline is not the same as a way of life — speak or write about phusis or nature. They are more likely to speak or write about phenomena and language.

Engineering, too, emerged as a recognized human activity at a particular point in history — namely the 17th and 18th centuries. The first engineers were members of the military who designed, constructed, operated, and maintained fortifications and engines of war such as battering rams, catapults, and canons. The term "civil engineer" originally denoted the attempt to transfer the kind of activity and knowledge involved in such military concerns into non-military contexts. The formulation of Tredgold's definition of engineering, as cited earlier, was part of the historical and social effort to bring about this displacement.

Indeed, both engineering and philosophy exhibit quite different characteristics across geographies as well as histories — even if one only compares cases from as closely related communities of discourse as those of Europe and the United States.

It may be accepted, then, that both engineering and philosophy are historically and socially constructed. Such an admission would seem to grant to history and the social sciences priority in the liberal arts.

At the same time, history and society are not only about change; they are also about continuities. Historical and social construction is, after all, not ex nihilo. Indeed, it is perhaps better described not as construction but as re-construction. Our efforts to name what is undergoing historical re-construction — and thus what to some degree transcends history — are themselves subject to revision. At any one point in time, however, we must logically (if provisionally) accept our own socio-historical constructions about how best to indicate such trans-sociohistorical — or perhaps better, multi-sociohistorical — features of our constructs.

With regard to the second question in this excursus, then, we inquire about what multi-sociohistorical features are exhibited by philosophy. What is it about philosophy that, since its 5th century BCE origins, has enabled us to speak about the presence of this or related phenomena at other times and places? What is it that we mean now by philosophy?

Today the common or uniting elements in philosophy involve some mixture of the following:

—Conceptual analysis, which helps us clarify and correct both practical and theoretical uses of terms. This includes but is not limited to logic.

—Reflective examination of practice and thought, so as to deepen insight and understanding of, extend, or criticize both dimensions of experience. This includes the core areas of philosophy known as ethics, epistemology, and metaphysics, often with an emphasis on their rational methodologies.

—Thinking about aspects of experience that are more global than customarily dealt with by any one discipline. Here the emphasis is likely to be more substantive than methodological. Such thinking may also involve inter-, multi-, trans-, and anti-disciplinary consideration of what is right and good (ethics), knowledge (epistemology), and the structure of reality (metaphysics).

—The practice of a distinctive way of life and thought, one taken to be good in itself, with its own unique knowledge of reality. Philosophy in this sense may also be regionalized into the general guiding practices or principles of an individual or group, as when we refer to someone's personal philosophy or the philosophy of a firm.

In each of these manifestations philosophy may be further described as engaged with non-empirical issues rather than empirical ones — though not without empirical or real-world reference. Each of the core areas of philosophy — ethics, epistemology, and metaphysics — exhibits both descriptive and normative dimensions. But it is the normative dimension that is at once crucial — and most difficult to pursue, without abandoning its conceptual and critical dimensions.

It may also be noted, historically again, that philosophy has functioned as a kind of seedbed from which many of the sciences and the humanities have sprung. Natural philosophy gave rise to natural science; it was philosophers such as Bacon and Descartes, together with natural philosophers such as Galileo and Newton, who constructed the physical sciences. It was social philosophers such as Comte, Marx, Durkheim, and Weber who constructed the social sciences. From philosophical reflection and conceptual analysis have also emerged economics, anthropology, psychology, religious studies, and other humanities and social science disciplines. The very idea of a discipline, defined either in terms of its object or its method, is one that philosophy in its inter-, multi-, trans-, and anti-disciplinary thinking both conceptually clarifies and reflectively criticizes.

In this way, particularly, philosophy does reasonably appear to be differentially significant from the other humanities and social sciences — to be, as it were, first among equals. Such significance provides reason to hypothesize that philosophy, more than the other humanities and social sciences, may matter to engineering in a special way.

Thus, with regard to the third question in this excursus — a question that returns us again to the main theme — one may consider anew what it is that philosophy, especially philosophy in the form of ethics, contributes to professional engineering.

4. ENGINEERING AND ETHICS

It is certainly not the case that philosophy has sponsored engineering in anything like the way it has sponsored the sciences, the social sciences, and the humanities. Indeed, engineering has a strong tendency to distinguish itself from philosophy, not in a manner that would acknowledge philosophy as that from which it has emerged but as that in relation to which it is definitively other.

As Louis Bucciarelli observes in his ethnographic studies of engineers, when students are doing engineering problems it is generally thought that they "ought not to get bogged down in useless `philosophical' diversions."[22] As he notes on more than one occasion, in the realm of engineering philosophy has strongly negative connotations. Yet at the conclusion of his study, Bucciarelli the engineer, having argued that engineering design is a social process, points out how this means there are alternatives. When there are alternatives, he says, then there can be better and worse. In such a situation, “The really important and interesting question becomes: What do we mean by a better design?”[23] But such is an eminently philosophical question.

Only through conceptual analysis, rational reflection, and general modes of thought can such an issue adequately be addressed. Precisely because of numerous specific manifestations of this type of question — the question, that is, of “What do we mean by a better design?” — engineers have built bridges, even though neither they nor philosophers may not always have recognized them as such, from engineering to philosophy, especially to that branch of philosophy constituted by ethics. So summarized again by means of schematic diagram, the situation has been transformed from two mutually exclusive circles to something like the following:

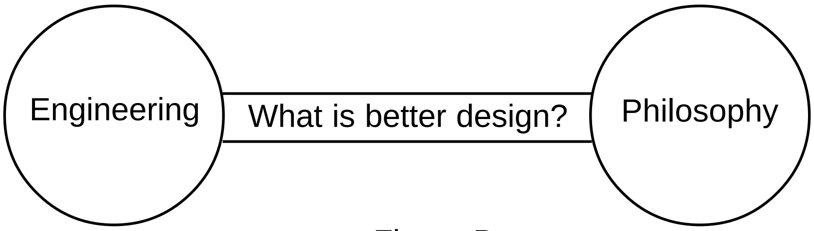

Figure B

In the effort to begin to address design and operational dilemmas that have emerged for scrutiny in such particular cases as the Ford Pinto gas tank that was subject to rear-end collision explosions,[24] the San Francisco Bay Area Rapid Transit (BART) Automatic Train Control system failure,[25] DC-10 cargo bay door and engine mounts,[26] the field joints on the solid rocket booster of the space shuttle Challenger,[27] — to cite only four well-known U.S. examples representing the areas of automotive, computer, aeronautical, and structural engineering — engineers themselves such as Stephen Unger,[28] Roland Schinzinger,[29] Charles Harris and Michael Rabins,[30] Aarne Vesilind and Alastair Gunn,[31] and others

—have undertaken conceptual analyses of right and wrong, good and bad, in engineering practice;

—have sought a reflective deepening to their insight and understanding of the ethical dimensions of engineering experience; and

—have pursued interdisciplinary, cooperative research into professional ethics codes, disciplinary procedures, moral educational strategies, and more.

Yet beyond the efforts of these engineer ethicists to analyze professional codes of conduct, reflectively enhance the ethical dimensions of engineering practice, reconstruct professional organizations to better support appropriate engineering autonomy, and engage in interdisciplinary pedagogical efforts one can discern right in the core of the engineering analysis of design a fundamentally ethical impulse. For want of a better phrase, let me call this the imperative to remain connected.[32]

A failure to remain connected to the limitations of the human condition is, for instance, one way to define the problem of Faust as engineer. A determination to remain connected to what is pragmatically known about the world is what has cost many engineers such as Palchinsky their jobs if not their lives.

One of the drivers behind Clive Dym’s computer modelling of design representation, for instance, is to promote communication between design engineers and construction personnel that would avoid the kind of disaster precipitated, as in the Kansas City Hyatt Regency atrium walkway failure, by a fabricator failure to grasp the significance of a crucial design specification.[33]

The Hyatt Regency contractor error was, in turn, set up by a design engineering failure to recognize the construction problem entailed by the crucial design specification at issue.

Hanger rods long enough to transmit a second floor walkway load through the fourth floor walkway, directly to the roof trusses above, were not available. The contractor, not understanding the load transfer dynamics involved, substituted two rods instead, in effect hanging the second floor walkway from the fourth floor walkway. The identified need for better communication — that is, better connection — between design intention and construction reification, is a moral as well as a technical imperative.

It may well be the case that, as engineer Henry Petroski argues, design failures are inherent in the fallible practice of engineering and the learning curve that constitutes technical progress.[34] But conceptual analysis and reflective examination reveal that not all failures are equal. Moreover, philosophical analysis and reflection are part of the very process by which engineers learn from design failures. Again, Clive Dym's work on the languages of representation in design is a case in point.

It is central to the argument at this point to note that disciplines ought not to be conceived so much as barriers to all trespassers, as selective niches for the promotion of differential growth. We are all to some extent engineers, insofar as we design, construct, and operate in the microworlds of our lives. Something as simple as packing a box is a quotidian mini-design problem. Likewise, we are all to some extent students of philosophy, insofar as we undertake to conceptually analyze, reflect on, and generalize about aspects of our lives and works.

Only because this is the case — only because we are selectively enhanced persons — is it possible and does it make sense for us to reach out and call to another differentially enhanced individual or community of practitioners for assistance. Because engineers already to some extent do philosophy, it makes sense for them to build bridges to philosophers (who also already to some extent practice engineering) and ask for assistance. This is precisely what engineers such as Unger, Schinzinger, and Rabins have done — to which philosophers such as Tom Rogers, Mike Martin, and Michael Pritchard have responded.[35] In each case we have more than simple bridge building between engineering and ethics. What we now see is the actual partial merging or overlapping of the engineering and philosophy worlds, which may be represented thus:

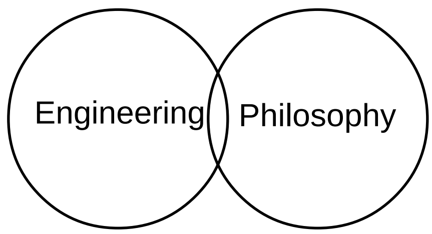

Figure C

5. SELF-KNOWLEDGE AND PHILOSOPHY:

BEYOND APPLIED ETHICS

Engineering in the past may have been historically and socially constructed so as to alienate philosophy. Philosophy in the past may also have sought to keep engineering at bay. But times and the world change. Engineering has changed. It has, I would even venture to suggest, become much more philosophical. Indeed, engineering is ripe not just with philosophical problems but with a philosophically significant way of life. Philosophy, for its part, is becoming much more open to engineering thought and practice — though not as fully or as fast as some think appropriate.

Why is philosophy important to engineering? The first reason, I have argued, is self defense against philosophical critics. The second reason is self interest, to help deal with issues of social context and ethics within engineering practice. But there is also a third reason why philosophy is important to engineering: engineering is modelling a new philosophy of life. In this instance there is some tectonic plate movement. Not just bridges are built, but continents actually begin to overlap and geologically alter each other.

But just as tectonic plate movement is imperceptibly slow and thus difficult to appreciate, so too is this third interaction of engineering and philosophy. It is also an interaction that is both grounded in and calls for increased self-knowledge on the part of all participants.

What might conceptual analysis, reflective insight, and interdisciplinary thinking have to contribute to engineering? To pose the question in this way is virtually to answer it. Is not engineering, too, characterized by conceptual analysis, reflective insight, and interdisciplinary thinking?

As we increasingly construct the world we increasingly recognize the world as constructed. As human beings have moved from a natural to a carpentered and then engineered world, surely it is no accident that natures and essences have been called into question, that process has replaced substance, that knowledge is increasingly framed by economics and politics as much as cognitive methodology, that ethical issues have moved to the forefront in public as well as technical discussions across a broad spectrum of human activities, from medicine to computers.

The applied philosophical discourses of bioethics, environmental ethics, computer ethics, and engineering ethics are nevertheless no more than the tip of an iceberg breaking apart in a sea of metaphysical speculations (from scientific cosmologies to the new existentialisms of risk projection, electronic networking, and virtual reality), epistemological explosions (trans-human and remote sensation and perception, automated instrumental data gathering and analysis, research articles as advertisements and promotional campaigns for the next round of funding grants), and aesthetic constructions (graphic media presentations and probability analyses, hypertext communications, macro- to micro-engineering projects, interactive Internet web sites). Food, housing, transportation, communications, economics, art, literature, music, sex, are all being transformed by technological makings. These re-makings are themselves the continuous subjects of exoteric and esoteric theoretical discussions, philosophical debates, and ideological disputation.

Our world may be shot through with technology, but our technology is in turn interpenetrated with philosophical dialogue. Indeed, it is precisely such lifeworld transformations that postmodern philosophy has made the primary subject of its discourses, even as engineers create the very transformations that philosophers talk about. But the engineers have remained silent. Precisely because of their silence, they have in a paradoxical manner marginalized their powers — failed to recognize themselves and their practices as central to the cultural superstructure they engender, which in turn engenders them.

Consider one case in point: the Xerox Palo Alto Research Center (PARC). This engineering research center, perhaps even more than Bell Labs, is one of the truly great innovation centers of history. In the late 1960s and early 1970s it invented virtually all the major elements of what became the personal computer revolution: the graphic interface, the mouse, etc. But its corporate sponsor failed to capitalize on its pioneering technical innovations.[36] Xerox PARC creativity was stimulated in part by its philosophical interactions with and sensitivity to cultural developments. At the same time, on one reasonable interpretation it failed to be able to promote those innovations because of its passive receptivity with regard to precisely the philosophical stimuli of the culture.

Mark Weiser, the current chief technologist at Xerox PARC, influenced by the essentially philosophical reflections of Herbert Simon, Michael Polanyi, Hans Georg Gadamer, and Martin Heidegger, projects beyond mainframes and personal computers and third wave of what he terms "ubiquitous computing" or "ubicomp" for short.[37] With ubicomp Weiser and other engineers at Xerox PARC are working to let computers merge into the background of our lives, to blend in with the environment. Similar radical engineering innovation centers such as the Media Lab at MIT[38] nevertheless exhibit a strong tendency only to absorb postmodern philosophical influences, even while they exhibit or live them out.

The engineering design process embodies and exhibits precisely the kind of contingent, decentered, boundary crossing, and emergent ordering processes that postmodernity analyzes, explores, and celebrates. Engineers live but do not speak postmodernism.

Engineers are the unacknowledged philosophers of the postmodern world. What is distinctive about the material base of postmodernity is that it is an engineered materiality. Robert Venturi's playful postmodern architecture is the playfulness of a skilled engineer.[39] François Lyotard's postmodern condition of self-reference mimics the self-referential iterative practices and processes of engineering design.[40] Donna Haraway's border-crossing coyote-cyborg could not exist without biomedical technology.[41]

For literally thousands of years human making and using relied on what was given in nature. Under such conditions, artifice remained unalterably limited in both quantity and substantiality. Indeed, its lack of quantity was reflected in a hand-and-mind crafted particularity, the evident beauty of which was never more than skin deep. "If a bed were to sprout," wrote Aristotle, "not a bed would come up but an oak tree."[42]

The engineering extraction from nature of both hidden materials and energies, together with the design of minded machines, made possible the quantitative proliferation of artifice and its coordinate standardization. Standardization appeared to deprive the world of crafted beauty as a necessary trade-off for affluence. The standardization that engineers constructed, not just with their machines and industrial processes, but behind the scenes through the negotiation of technical codes, nevertheless foreshadowed a fabricated substantiality at the base of a new ecology of artifice.

With the extension of engineering processes into the micro, nano, genetic, molecular, atomic, and even sub-atomic levels our new artifacts, when they sprout, sprout not their old matters deprived of form but in newly informed structures.

No one has lived more deeply in this world living artifice than engineers. Engineers are only beginning to share their design lives with the larger world by means of conceptual analysis and critical reflection. This is an analysis and reflection from which the philosophical world would nevertheless profit, and to which they might contribute, if they would but make the effort to begin to enter it.

Why is philosophy important to engineering? Ultimately and most deeply it is because engineering is philosophy — and through philosophy engineering will become more itself.

Engineers of the world philosophize! You have nothing to lose but your silence![43]

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NOTES

1. The classic presentation of this view is, of course, C.P. Snow's The Two Cultures and the Scientific Revolution (New York: Oxford University Press, 1959); expanded edition: The Two Cultures: And a Second Look (New York: Oxford University Press, 1963).

2. Well known examples include Jacques Ellul, La Technique o l'enjeu du siècle (Paris: A. Colin, 1954); and Lewis Mumford, The Myth of the Machine, 2 vols. (New York: Harcourt Brace Javonovich, 1967 and 1970).

3. Martin Heidegger, "Die Frage nach der Technik," in Vorträge und Aufsätze (Pfullingen: Neske, 1954), pp. 13-44.

4. Herbert Simon, The Sciences of the Artificial (Cambridge, MA: MIT Press, 1969; 2nd ed., 1981; 3rd ed. 1996).

5. See, e.g., Caroline Merchant, The Death of Nature: Women, Ecology, and the Scientific Revolution (San Francisco: Harper and Row, 1980).

6. New Encyclopaedia Britannica, 15th ed. (Chicago: Encyclopaedia Britannica, 1995), Micropaedia, vol. 4, p. 496. The McGraw-Hill Encyclopedia of Science and Technology, 8th ed. (New York: McGraw-Hill, 1997), vol. 6, p. 435, modestly truncates then expands on this definition when it describes engineering as, "Most simply, the art of directing the great sources of power in nature for the use and the convenience of humans. In its modern form [it] involves people, money, materials, machines, and energy." Thomas Tredgold's original wording was that "Engineering is the art of directing the great sources of power in nature for the use and convenience of man" (from Tredgold's draft charter of the British Institution of Civil Engineers, 1828).

7. Cf. C.S. Lewis, The Abolition of Man (New York: Macmillan, 1947), p. : "[W]hat we call man's power of nature turns out to be a power exercised by some men over other men with nature as its instrument." [annexed 370.1L585a]

8. For more extended narratives concerning the engineering philosophies of technology cited below, and related ideas, see Carl Mitcham, Thinking through Technology: The Path between Engineering and Philosophy (Chicago: University of Chicago Press, 1994), pp. 19-38. Some of this material can also be found in the author's ¿Qué es la filosofía de la tecnología? (Barcelona: Anthropos, 1989), part one.

9. Ernst Kapp, Grundlinien einer Philosophie der Technik: Zur Entstehungsgeschichte dur Cultur aus neuen Gesichtspunkten (Braunschweig: Westermann, 1877). The German "Technik" may be translated as both "technology" and "engineering."

10. The best study of Engelmeier is V.G. Gorakhov's Petr Kliment'evych Engel'meier: Inzhener-mekhanik i filosof tekhniki, 1855-1941 [Peter Klimentevych Engelmeier: Mechanical Engineer and Philosopher of Technology, 1855-1941] (Moscow: Nauka, 1997).

11. See, e.g., Friedrich Dessauer, Streit um die Technik (Frankfurt am Main: J. Knecht, 1956; abridged version, Freiburg; Herder, 1959). This is a completely re-written and much expanded version of the author's Philosophie der Technik: Das Problem der Realisierung (Bonn: F. Cohen, 1927).

12. Samuel Florman, The Existential Pleasures of Engineering (New York: St. Martin's Press, 1976; 2nd ed. 1994). See also the author's Blaming Technology: The Irrational Search for Scapegoats (New York: St. Martin's Press, 1981); The Civilized Engineer (New York: St. Martin's Press, 1987); and The Introspective Engineer (New York: St. Martin's Press, 1996).

13. See Clive Dym, Engineering Design: A Synthesis of Views (New York: Cambridge University Press, 1994), p. 15. (In personal conversation, Delft, The Netherlands, 17 April 1998, Dym has acknowledged the importance of ethics.)

14. All quotations from ABET materials are taken from documents available on the Internet at http://www.abet.org.

15. Goethe, Faust II (c. 1830), act V. See also George Schillinger, "Man's Enduring Technological Dilemma: Prometheus, Faust, and Other Macro-Engineers," Technology in Society, vol. 6, no. 1 (1984), pp. 59-71.

16. See Loren R. Graham, The Ghost of the Executed Engineer: Technology and the Fall of the Soviet Union (Cambridge, MA: Harvard University Press, 1993).

17. For present purposes I use the terms "historical" and "social" as the primary qualifiers, but with recognition that in other contexts more careful distinctions would need to be drawn.

18. John M. Staudenmaier, Technology's Storytellers: Reweaving the Human Fabric (Cambridge, MA: MIT Press, 1985), especially chap. 1, pp. 1-8.

19. The allusion, of course, is to Foucault. See, e.g., Michel Foucault, Power/Knowledge: Selected Interviews and Other Writings, 1972-1977, ed. and trans. Colin Gordon (New York: Pantheon, 1980).

20. Although "black box" opening has become identified as a program of (sometimes historically oriented) sociologists of technology such as Bruno Latour and Wiebe Bijker, the original suggestion came from engineering historian Edwin Layton's "Conditions of Technological Development," in Ina Spiegel-Rösing and Derek de Solla Price, eds., Science, Technology and Society: A Cross-Disciplinary Perspective (Beverly Hills: Sage, 1977), p. 198. It was then first developed by economist Nathan Rosenberg in his Inside the Black Box: Technology and Economics (New York: Cambridge University Press, 1982) before being put forth as a technology studies program in Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch, eds., The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology (Cambridge, MA: MIT Press, 1987).

21. Aristotle, Metaphysics XII, 6; 1071b27.

22. Louis L. Bucciarelli, Designing Engineers (Cambridge, MA: MIT Press, 1994), pp. 105-106.

23. Bucciarelli, Designing Engineers, p. 197.

24. Douglas Birsch and John H. Fielder, eds., The Ford Pinto Case: A Study in Applied Ethics, Business, and Technology (Albany, NY: State University of New York Press, 1994).

25. Robert M. Anderson, Robert Perrucci, Dan E. Schendel, and Leon E. Trachtman, Divided Loyalties: Whistle-Blowing at BART (West Lafayette, IN: Purdue University, 1980).

26. See Martin Curd and Larry May, Professional Responsibility for Harmful Actions (Dubuque, IW: Kendall/Hunt, 1984); and John H. Fielder and Douglas Dirsch, eds., The DC-10 Case: A Study in Applied Ethics, Technology, and Society (Albany: State University of New York Press, 1992).

27. Roger Boisjoly, "The Challenger Disaster: Moral Responsibility and the Working Engineer," in Deborah G. Johnson, ed., Ethical Issues in Engineering (Englewood Cliffs, NJ: Prentice Hall, 1991), pp. 6-14; and Diane Vaughan, The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA (Chicago: University of Chicago Press, 1996).

28. Stephen H. Unger, Controlling Technology: Ethics and the Responsible Engineer, 2nd ed. (New York: John Wiley, 1994).

29. Mike W. Martin and Roland Schinzinger, Ethics in Engineering, 3rd ed. (New York: McGraw-Hill, 1996).

30. Charles E. Harris, Michael S. Pritchard, and Michael J. Rabins, Engineering Ethics: Concepts and Cases (Belmont, CA: Wadsworth, 1995).

31. P. Aarne Vesilind and Alastair S. Gunn, Engineering, Ethics, and the Environment (New York: Cambridge University Press, 1998).

32. For a different but related explication of this engineering ethical imperative, see Carl Mitcham, “Engineering Design Research and Social Responsibility,” in Kristin Shrader-Frechette, Ethics of Scientific Research (Lanham, MD: Rowman and Littlefield, 1994), pp. 153-196 and 221-223; reprinted in Kristin Shrader-Frechette and Laura Westra, eds., Technology and Values (Lanham, MD: Rowman and Littlefield, 1997), pp. 261-278.

33. R.D. Marshall et al., Investigation of the Kansas City Hyatt Regency Walkway Collapse (Washington, DC: U.S. Department of Commerce, National Bureau of Standards, 1982). For Dym’s analysis, see Clive L. Dym, “The Languages of Engineering Design: Representing Objects and Articulating Processes,” paper for a workshop on “The Empirical Turn in the Philosophy of Technology,” Technische Universiteit Delft, 16-18 April 1998.

34. Henry Petroski, To Engineer Is Human: The Role of Failure in Successful Design (New York: St. Martin’s Press, 1985).

35. Philosopher C. Thomas Rogers participated with Unger in engineering ethics research work, and is cited in Unger, Controlling Technology, p. 115. Philosopher Mike W. Martin co-authored with engineer Roland Schinzinger, Ethics in Engineering. Philosopher Michael S. Pritchard has worked extensively with engineers Charles Harris and Michael Rabins, a collaboration reflected not only in their book Engineering Ethics: Concepts and Cases but also a collection of more than thirty cases study scenarios available at http://ethics.tamu.edu.

36. Douglas K. Smith and Robert C. Alexander, Fumbling the Future: How Xerox Invented, the Ignored, the First Personal Computer (New York: Morrow, 1988).

37. Mark Weiser, “The Computer for the 21st Century,” Scientific American, vol. 265, no. 3 (September 1991), pp. 94-95, 98-102, and 103. Further information is available at http://sandbox.xerox.com/hypertext/weiser/UbiHome.html. Cf. also the philosophical receptivity evidenced in engineers Terry Winograd and Fernando Flores, Understanding Computers and Cognition: A New Foundation for Design (Reading, MA: Addison-Wesley, 1987).

38. See Stewart Brand, The Media Lab: Inventing the Future at MIT (New York: Viking, 1987).

39. Robert Venturi, Complexity and Contradiction in Architecture, 2nd ed. (New York: Museum of Modern Art, 1977).

40. Jean-François Lyotard, La condition postmoderne: Rapport sur le savoir (Paris: Editions de Minuit, 1979).

41. Donna Haraway, “Manifesto for Cyborgs,” in Simians, Cyborgs, and Women: The Reinvention of Nature (New York: Routledge, 1991).

42. Aristotle, Physics II, 1; 193b10.

43. The present argument was first developed as a public lecture at Technische Universiteit Delft, The Netherlands, 16 April 1998, in conjunction with an international workshop on “The Empirical Turn in the Philosophy of Technology.” A more extended published version is planned by TU Delft. A proceedings volume from the workshop, to be guest-edited by Peter Kroes and Anthonie Mejiers, is also scheduled for publication in a future issue of Research in Philosophy and Technology.