THREE KINDS OF ETHICS FOR THREE KINDS OF ENGINEERING

Introduction

Authentic discussion of the nature and ethics of the engineering enterprise demands contextual considerations. Yet, we engineers typically take context as an add-on, often as a feature we are forced to address. The social context of engineering, for example, can be reduced to strategies for compliance with FCC or EPA regulations. Context is marginalized and seldom given voice by the contemporary engineering enterprise. But, context is world, and engineering is inherently and fundamentally an in-the-world enterprise. The impetus to drive the engineering enterprise comes from the world and the products of the enterprise are let loose into the world. Precisely ignoring its fundamental worldliness allows the engineering enterprise to proceed in its business-as-usual fashion. Is this reductiveness, though, incontestable? Recouping the fundamental worldliness of engineering might in fact embellish rather than derail the enterprise. What kind of context conditions and colors the way engineers engineer the engineered? What are the dimensions of that context? Economic and environmental aspects are not the only ones. Political, historical, and psychological concerns are all involved. So are social justice and quality of life issues.

Context becomes crucial in instances when an enterprise experiences a breakdown or a breakthrough. [1] A breakdown like the 1986 Challenger disaster called context into direct consideration. There was much political wrangling about the decision not to delay the flight because it would prove to be an embarrassment to President Reagan. Environmental concern arose about damage to the ozone layer that shuttle flights produced. Social justice concerns were voiced about all the millions spent on shuttles that could feed the starving people of the world. Yet, as the Challenger incident receded into history, so did the contextual turmoil it engendered.

Breakdowns are fortunately sporadic but breakthroughs seem to be almost continuous. In particular, cyber-world breakthroughs have become everyday occurrences. The rise of net life has been raising eyebrows around the globe for several years now. What to make of this new virtuality and what is the role of engineering in the increasingly virtual world to come? The big questions that contextual concerns invigorate have to do with the nature of the engineering enterprise, what it has become, and what it ought to be.

From a web of worldly relationships, the elements of *the engineer*, *engineering*, and *the engineered* stand out as fundamental to the engineering enterprise. Each element is worldly in the sense of being integrated into a more or less coherent realm of thoughts, actions, words, things, roles, and goals. Corresponding to each of the three aspects or elements of the engineering enterprise is an appropriate and distinct type of ethics. *Virtue ethics* is appropriate to the engineer who engineers the engineered. *Conceptual ethics* is appropriate to engineering, which aims at the production of the engineered and requires the engagement of engineers. *Material ethics*, promoted by philosopher of technology Albert Borgmann [2], is appropriate to the engineered, which follows from the process via the efforts of the engineer. Engineer, engineering, and engineered cannot be separated – either from each other or from the contexts in which they are embedded – but they can be distinguished and they can be evaluated in their ethicality by different kinds of ethics.

Historically, the engineering enterprise has exhibited a variety of modulations in the engineer/engineering/engineered trilogy. I point out three such modulations, distinguishing three types of engineering enterprise, which correspond roughly to past, present, and future. In the era from the Egyptian pyramids to the Medieval cathedrals, there was a type of engineering I call *traditional engineering*. From the dawn of the modern age to the present time there has been a type of engineering I call *modernist engineering*. For the future I advocate a new kind of engineering, which I call *focal engineering.* It is a specific kind of focal practice, a practice, as proposed by Borgmann [3], that would aim to bring into the world devices, structures, systems, and networks that help to consolidate and focus our lives. These effects of the focal engineering enterprise ought to have prospects for *engagement* (following Borgmann) and for *enlivenment* (following the criterion for structures suggested by architect Christopher Alexander [4]).

These three types of engineering, although corresponded with specific temporal eras, are and have been and will be possible at any time. The contemporary engineering enterprise, however, is for the most part modernist. A traditional engineer in contemporary times would probably – though not necessarily – be seen as a technician rather than an engineer.

And being a rather strenuous endeavor, engagement in the broadly conceived focal engineering enterprise is admittedly rare. Though I advocate focal engineering, I am not implying that traditional and modernist engineering need to be abandoned. On the contrary, all three types of engineering need to work in harmony for the sake of enlivening and engaging as well as efficacious ways of being. There is a kind of telescopic effect here: just as modernist engineering includes the fundamental know-how of traditional engineering, focal engineering can be seen as including features of both modernist and traditional engineering.

My contention is that traditional engineering emphasized the engineer and virtue ethics was, or should have been, or should be the right type of ethics for traditional engineering. Modernist engineering emphasizes the process of engineering and conceptual ethics is suitable for this kind of engineering. For focal engineering, which stresses the engineered, material ethics is most appropriate to gauge the prospects for good of the systems, devices, structures, and networks to be let loose onto the planet.

Traditional Engineering and Virtue Ethics

The traditional engineering enterprise was inexorably tied to social and political worlds bound by the non-democratic and generally repressive rule of pharaohs, emperors, and kings. The traditional engineering enterprise, then, exhibited a truncated ethicality from the point of view of the traditional engineer. What the engineered – the project of traditional engineering – was to be was largely dictated to the engineer by the powers that be. The traditional engineering practice was largely implicit, lacking a clear and distinct form that could be put under the gaze of ethical scrutiny. Actual engineering practice proceeded, for the most part, by intuition, rough estimates, and design experience. But the traditional engineer still had some freedoms and some responsibilities. Ethical concern could emerge regarding the character and behavior of the traditional engineer, who was probably like a modern era foreman or official overseeing the design and construction of engineering projects.

Slaves may have built the pyramids, but engineers engineered them. Who were these engineers? Of the little that is known about engineers and the details of engineering projects in ancient times, there is evidence that some ancient engineers were of high, or at least interesting, character. Something of the character of the ancient engineer is seen in the epitaph Egyptian engineer Ineni (circa 1500 BC) wrote for himself:

> I have become great beyond words. I will tell you about it, ye people. Listen and do the good that I did, just like me. I continued powerful in peace and met no misfortune; my years were spent in gladness. I was neither traitor nor sneak, and I did no wrong whatever. I was foreman of the foreman and I did not fail. I never hesitated but always obeyed superior order, and I never blasphemed sacred things. [5]

Ineni was not exactly a modest fellow, but he knew his place and acquiesced to his superiors. For the most part, in the extant social hierarchy, ancient engineers were comfortably ensconced between the powerful and the powerless. And most engineers today are similarly ensconced. Many today would see ideal virtues embedded in Ineni's words. The character of this engineer, or a less exaggerated version thereof, was probably typical of many traditional engineers.

My argument – that within the traditional engineering enterprise, in the engineer/engineering/engineered trilogy, the engineer predominated – suggests that character issues should be paramount. Jumping a few millennia from ancient Egyptian times to mid-19th century, we find Samuel Smiles maintaining that the successful 18th and 19th century engineer was "orderly, regular in his habits, disciplined, predictable, methodical in his problem solving, even-tempered, and law-abiding." [6] A straight shooter. Not cynical like many moderns and postmoderns. The virtues Smiles pointed out would benefit the traditional engineer as well as the engineer of the 18th and 19th centuries. Many of the virtues encouraged in the character of yesterday's engineer would support today's engineer and tomorrow's engineer as well.

Smiles' books were very popular in the 19th Century. They mirrored the individualism that was advancing in the modern era. The rugged individual was making more and more available the products that the commodious individual could consume. [7] And these individuals were often the same person. Individuals of high principle and integrity, who were honest, open-minded, and industrious – as championed by Smiles – could be entrusted to bring forth a world worth living in. "Smiles reflected his age and also influenced it. He wrote especially of engineers, inventors, and industrialists as they transformed their environment – and society – through rapid industrialization." [8]

In his **Lives of the Engineers,** Smiles tells the story of several engineers, including James Brindley, John Rennie, and Thomas Telford. Brindley was an interesting example of what I am calling a traditional engineer, even though he lived in the modernist era. He was a self-taught genius. He could only minimally read and write. Yet he was very observant and

> ready at devising the best methods of overcoming material difficulties, and possessed of a powerful and correct judgment in matters of business. Where any emergency arose, his quick invention and ingenuity, cultivated by experience, enabled him almost at once unerringly to suggest the best means of providing for it. His ability in this way was so remarkable, that those about him attributed the process by which he arrived at his conclusions rather to instinct than reflection – the true instinct of genius. [9]

The lack of a modernist scientific method or procedure did not stop Brindley or the traditional engineer of the pre-modern era from the enactment of monumental projects and the achievement of great works. Intuition, instinct, and experience – pivotal to the skills and know-how of the traditional engineer – were revealed in the ways he/she conducted his/her life. The power of character, so it appears, compensated the traditional engineer for the lack of an explicit method. Character is developed over a long period of time and requires the practice of the virtues: character issues are the concern of virtue ethics. Virtue ethics, then, is the appropriate type of ethics for gauging the character of the traditional engineer. And what exactly is character? Character is a power, a faculty, a capacity. Or as Ralph Waldo Emerson put it: "this is what we call Character – a reserved force that acts directly by presence, without means." [10]

Modernist Engineering and Conceptual Ethics

Means, methods, and procedures became explicit within the modernist era, which extended from the Renaissance to contemporary times. The engineering enterprise gradually came into its own as a unique practice, thanks in large measure to the development of a clear and distinct methodology. The methods of modernist engineering were exhibited in the process whereby engineering was actually practiced. Engineering, as process, in the engineer/engineering/engineered trilogy, began to stand out. The characteristics of the process began to matter more than the character of the engineer. The act became more important than the actor. In fact, in late modern times, for example, in computer-automated-manufacturing systems, the actor disappears altogether.

Many contributors to the early development of modernist engineering include Leonardo da Vinci (1452-1519), Francis Bacon (1561-1626), and Rene Descartes (1596-1650). Da Vinci used science in a serious way as an aid to his engineering projects. Bacon advocated the marriage of theory and practice for the benefit of humankind. And it was Descartes' method that engineering embraced.

The largely implicit method of traditional engineering practice was made explicit in modernist engineering by grounding it in Descartes' notions of *abstraction*, *dissection*, *reconstruction*, and *control*. [11] The first two are foundational to the practice of *analysis*, the second two to *synthesis*. Through analysis, science enters the picture in an explicit manner. The scientific method abstracts a realm of concern from its context and dissects it into its fundamental parts – for the sake, initially, of scientific understanding, i.e., unraveling a thing's essence (or whatness) by showing how it is an instance of a general interpretive framework. Scientific knowing-what gathers momentum as a major aspect of the modernist engineering process.

The synthesis part of the modernist engineering process covers the reconstruction and control aspects of the Cartesian method. The know-how of engineering synthesis, familiar even to traditional engineering, couples with the know-what of analysis within the modernist engineering enterprise. But this does not mean that engineering became applied science. Modernist engineering employs a scientific procedure, along with other activities, including design, testing, manufacturing, marketing, maintenance, and control. All these activities are contextually situated and constrained. All these activities contribute to the engineering process that aims at creating products that will be maximally efficient and of minimal cost.

Unlike engineering, pure science seeks objective and value-free truth for its own sake. Science operates at the level of theory, a theory of reality. A science of engineering, according to Taft Broome [12], must be a

Praxiology, a theory of efficient action. But a theory of engineering is not the same as engineering itself. Engineering is an action involving a process. That process is a human activity of producing a plan, which draws on resources available, whereby systems, devices, networks, and structures can be produced to fulfill human needs and desires. Only the barest outlines of this complex reality could be drawn into a theory of efficient action.

In fact, what makes a science or theory of engineering, as such, insufficient for a complete articulation of the modernist engineering phenomenon is that, as Steven Goldman puts it, "from beginning to end and every step in between, engineering theory and practice is shaped by manifestly arbitrary, that is, explicitly willfully imposed constraints expressive of a host of personal, institutional, social (including economic and political), and cultural (including aesthetic and religious) value judgments." [13] I am in pursuit of a contextualized description of, or narrative about, the unfolding modulations of the engineering enterprise. I am aiming at a phenomenology of engineering, not a science of engineering, though a science can certainly illuminate valuable structures.

A science of engineering is one thing. Engineering science is quite another. Engineering science is science drafted into the service of the engineering process. For example, a university course in engineering thermodynamics is very different than thermodynamics taught in a physics department. The physics version is a highly theoretical course. The engineering version includes engineering theories, descriptive regularities, engineering laws, and maxims. [14] The intention to further the process of engineering makes the engineering science course a very different affair than the pure physics course. And even a course like calculus may be taken by both a science major and an engineering major, but the intentions of each is quite different, resulting in different calculus experiences.

Engineering science is only one part of the manifold of disciplines and activities that contribute to the engineering process, as based in the abstraction/dissection/reconstitution/control of the Cartesian method. Of all the sub-processes, like testing, design, proto-typing, manufacturing, marketing, maintenance, etc., design is commonly considered the essence or the heart of the entire matter. "Design may or may not be the essence of engineering, but it is unquestionably central to engineering, and design is an explicitly valuational activity." [15] Design is non-unique and involves aesthetic and non-analytical judgments. But the point is that at the dawn of the modernist era, the engineering process began to crystallize and its separate aspects emerged in various circumstances, dissected and reconstituted many times over, so that at the present time the engineering process is running along smoothly in the fullness of its being and articulateness.

The question arising throughout the development of the modernist engineering enterprise is how *ought* the process to proceed? As enacted by the engineer, the engineering process required a gauge of its activity. How right or how wrong might the process be? The process could be technically precise and efficacious and at the same time ethically problematic.

The incorporation of ethical standards within engineering gave rise to its professionalization. The engineer became less a foreman overseeing engineering projects, and more a professional implementing engineering processes. The establishment of professional engineering societies in the 19th Century, including the American Society of Civil Engineers (1852), the American Society of Mechanical Engineers (1880), and the American Institute of Electrical Engineers (1884), gave ethics a forum in which conflicts concerning the 'ought' could be resolved. The ethics of the day sprung from the work of Jeremy Bentham (1748-1832) and John Stuart Mill (1806-1873), who developed and promoted the philosophy of utilitarianism, the concept that advises us to do whatever advances the greatest good for the greatest number. Also, a generation before Bentham and Mill, Immanuel Kant (1724-1804) gave ethics the concept of the Categorical Imperative, which advises us to act in such a way that, if everyone did the same, the good would be served. These notions of ethics, which I call conceptual ethics, guided the ethicality of actions and dominated the modernist era and modernist engineering in particular. Conceptual ethics is to the act – the process of engineering – as virtue ethics is to the actor – the engineer.

Conceptual Ethics came into the service of modernist engineering quite naturally because modernist engineering and conceptual ethics were both grounded in the general scientific and theoretical mind-set that characterized the modernist world-view. The emerging professional engineering societies struggled to balance their freedoms and their responsibilities, and these struggles crystallized into codes of engineering ethics. Today the dimensions of conceptual ethics are encapsulated succinctly in a number of professional engineering codes, like the IEEE Code of Engineering Ethics. [16]

Focal Engineering and Material Ethics

Assuming that an engineer is of virtuous character and sticks closely to his/her code of ethics in the enactment of his/her engineering process, it may still be the case that he/she contributes to the engineering of products that are deadening and disengaging. Readers, I am sure, will have their favorite examples of this. Ubiquitous computing immediately comes to my mind. In a possible scenario, all my household appliances are networked. My toaster talks to the fridge in which are the bagels whose container senses the disappearance of the bagels and informs my internet agent who is preparing my shopping list for the week while simultaneously balancing my household expenditure accounts. To be is to be wired. But as a colleague of mine puts it: "the smarter my house gets, the dumber I get." Too much disburdenment leaves me disengaged. Are there options?

Focal engineering is dissatisfied with just know-how and know-what; it needs to also know-why, or at least look for the why and the wherefore, the whence and the whither, causes and purposes, reasons and consequences. Focal engineering is not content just to do no harm. It seeks to actually do good with the products its process brings forth. Good in what sense? Following Borgmann and Alexander, I suggest that material ethics should guide the ethicality of the engineered by insisting that it contribute to engaging and enlivening ways of being.

At the heart of the focal engineering proposal is the requirement that the outcome must be good, do good, or contribute to the good, within the context of the end-user's involvements. Being-in-the-world means being bound up with social and political contingencies. Such worlds, in which and to which I am fettered, can be thought of as engineering ecologies, along the lines of information ecologies, as discussed by Nardi and O'Day. [17] Such an ecology indicates a "local habitation."

> By this we mean settings in which we as individuals have an active role, a unique and valuable local perspective, and a say in what happens. For most of us, it means our workplaces, schools, homes, libraries, hospitals, community centers, churches, clubs, and civic organizations. For some of us, it means a wider sphere of influence. All of us have local habitations in which we can reflect on appropriate uses of

> technology in light of our local practices, goals, and values. [18]

The project of focal engineering aims to make the engineered world, the engineered ecology, engaging and enlivening as a result of incorporation of this or that system, device, structure, or network. Even if the engineered is seemingly immaterial, for example, a virtual reality, it still has material consequences. These are of concern to material ethics. What kind of prospects does a focally engineered system or device need if it is to be enlivening and engaging? It must be able to provide enrichment and fullness of contextualized being, conceptual continuities, and community attunements. And, of course, these mean many different things to many different people. Opening the dialog is the point of departure for focal engineering.

For instance, a dialog involving structural engineers, urban planners, architects, social activists, and concerned citizens must be enjoined if a new park is to be focally engineered in the center of town. The contemporary modernist engineer ordinarily works in a team of engineers that includes, for example, a test engineer, a design engineer, a manufacturing engineer, and others. The focal engineer is inevitably part of a team too, but his/her team involves more than just other engineers. A Technology Assessment type team is common for a focally engineered project. The team needs to weigh the deadening and disengaging possibilities out against the enlivening and engaging prospects of any proposal for a new network, structure, device, or system. What about, say, a new internet feature: who will prosper from it, how, and why? What kind of community life enrichment can be expected as a result of employment of the feature? And these kinds of questions inevitably invoke others in an on-going and open-ended fashion. When to cut the talk and start the work is a major issue for the focal engineer, because the talk is part of the work and the work needs the talk.

Conclusions

The contemporary engineer is typically modernist, which implies that he/she takes on features of traditional engineering as well as a scientific perspective. Many projects, judgments, calculations, and decisions can be carried out in a traditional engineering way. Design is often a matter of intuitions. But also design can be science based. Modernist engineering, in an explicit manner, employs science in the service of its methods and processes, particularly the design and manufacturing procedures, key ingredients in the production process. And the *aims* of this production process, as distinguished from the process itself and its methodology, bring modernist engineering face to face with the possibilities of focal engineering. At this more exalted level of engineering, the enterprise can be directed toward the big problems of the day, like global warming, ozone depletion, declines in biodiversity, growing rates of resource depletion, and exponential population growth. Yet focal engineering seeks most earnestly to act locally, to embellish local ecologies with systems, devices, and structures whose prospects are good for advancing the engaged life in a convivial society. The "best practice" for a focal engineering enterprise might be not to bring forth such and such, but rather to decide against letting loose into the world another product that would lead to disengagement and dislocation.

Material ethics is the discourse in which the engineered can be evaluated as to its possibilities for engagement and enlivenment. Value functions might include measures of equilibrium, resonance, integrality, needfulness, functionality, and elegance. Unless a certain valuation is attained, the product would be deemed unacceptable as far as material ethics is concerned. Negotiation and dialog among stakeholders is required. And voice must be given to those disenfranchised who may be affected by the proposed product.

As engineering educators, I believe we need to try to keep the dialogue of material ethics open to our students. Raising why questions can only enrich our classroom interaction by encouraging engagement with the idea of the good. As Langdon Winner puts it: "Our moral obligations must now include a willingness to engage others in the difficult work of defining what the crucial choices are that confront technological society and how intelligently to confront them." [19] Clearly, the crucial choices for the ideal engineering enterprise are choices about engineered devices, systems, networks, and structures that are to be brought into the world.

Since the engineer and engineering are so integral to the engineered, virtue ethics and conceptual ethics integrate with material ethics in the ideal engineering enterprise. The ideal engineer engineering the engineered is characterized by a tasteful harmony of traditional, modernist, and focal engineering structures. The engineer/engineering/engineered trilogy resonates with place or context of an enlivened engagement. It might, in fact, turn out that herein, in view of the suggested exaltedness, that the engineer/engineering/engineered trilogy transforms secular space into sacred place. Then does the trilogy become a trinity, a belonging together of the three-fold, with an emphasis on the belonging? [20]

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