

Ethics and Engineering Education

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Introduction

In the US, the Accreditation Board for Engineering and Technology (ABET), recommends the study of ethics so that students acquire “an understanding of professional and ethical responsibility.” I must confess that I have never felt comfortable with this directive and with the way the subject is generally taught. The “cases” used to move students to ponder how they, as *individuals*, would act when confronted with a question of ethics cause me unease. These exercises are artificial, not that the problems I assign my students in structural mechanics are not an artifact of sorts, but my abstractions - like of this truss structure - do have immediate relation to, and implications for, the real world; they are an ingredient of standard engineering thought and practice, the fundamental basis for modeling and assessing a design.

The ethical cases used in many programs do not strike me as consonant with essential features of engineering practice¹. They may have their technical facts straight but they generally discount, or entirely neglect, the social nature of day-to-day engineering. In focusing solely on an *individual* agent's possible courses of action they oversimplify; they are not a valid abstraction.

Ethics ought not be neglected in engineering education, but more fundamental and prerequisite is for students to learn about the social, the organizational - even the political - complexities of practice. To accomplish this, a major renovation of engineering education is required - one that goes beyond adding an ethics course to the curriculum. What's needed is to open up the engineering classroom to perspectives other than those which see every task and challenge an engineer faces as a problem to be solved - as an individual, alone.

To ground my critique of ethics as taught, I consider two examples. The first exercise is a hypothetical case, used by Professor Peter Meckl of Purdue University in a controls course. The second concerns a real event - the decision to launch the challenger. I present both examples as the student might encounter them (I have taken them from the web), then offer a critique.

Two Cases

Professor Meckl's example is integrated in with the more abstract, technical material of an upper-level control systems course - a move I wholly endorse, despite my misgivings about the way this case is presented. Here is the exercise:

1. Others have found fault with the case method. See Winner, L., “Engineering Ethics and Political Imagination”, in Durbin, P.T. (ed.), *Broad and Narrow Interpretations of Philosophy of Technology*, Springer, 1990, pp. 53-64. For a wider ranging, critical review of a deontological-based teaching of engineering ethics see Didier, C., “Arguments et contre-arguments sur la Pertinence de l'Engineering Ethics”, *Cahiers du Lasmus*, LASMAS-Institut du Longitudinal/IRESCO, France, 02-1. http://www.cmh.ens.fr/cmh/cahiedoc/c021_didier.pdf (23 october, 2007).

Airbus Autopilot Case

You have been working for Airbus as a control systems engineer for about 1 year. After spending time mainly coming up to speed, you have just been asked to solve some problems on the autopilot software for commercial Airbus jets.

The software has been designed to perform many functions previously performed by the human pilot. Besides speed and heading control, it also tries to assess current conditions and makes decisions to improve current performance.

Early reports from airline pilots suggest that under certain conditions, the autopilot performs control actions that actually can cause the plane to stall and potentially crash. Only quick thinking by the pilots has saved the aircraft in the past.

You have been asked to figure out what's going wrong. However, in the meantime, planes are still flying with the installed software, posing the risk that a fatal crash is only matter of time.

What should you do?¹

The students generated different possible responses including: “write memo to airlines not to use autopilot”, “add code to make autopilot fail-safe”, and “make pilots aware of proper and safe operation of the autopilot”. This last was the most popular.

The second example - a case of “whistle-blowing” - concerns The Space Shuttle Challenger Disaster. The standard way this case is presented - my version found on a Texas A&M web site - starts with a detailed description of the failure of the O-rings meant to contain the hot gases during the firing of the solid rocket booster (SRB's); then comes a report of the teleconference, held the evening before the day of the launch, among engineers and management who were faced with making the decision to launch or not to launch the next morning. The story reaches its climax when NASA's SRB Project Manager, turns to Thiokol's Engineering Vice President, and says,

Take off your engineering hat and put on your management hat.²

The decision is made to go ahead with the launch.

The event is usually situated within a broader context, one that explains how NASA was under pressure to avoid any delays in keeping with their mission calendar.

There was probably also pressure to launch Challenger so it could be in space when President Reagan gave his State of the Union address. Reagan's main topic was to be education, and he was expected to mention the shuttle and the first teacher in space, Christa McAuliffe.

So it's “probably” politics and management under pressure that leads to an override of the strenuous objections to launch voiced by engineers - Roger Boisjoly in particular. He argued that the

1. Meckl, Peter H., *Integrating Ethics into an Undergraduate Control Systems Course*, http://ethics.iit.edu/eac/post_workshop/Ethics%20in%20Control.pdf (1 Oct., 07)

2. This and subsequent quotes are taken from “The Space Shuttle Challenger Disaster”, Dept of Philosophy and Dept of Mechanical Engineering, Texas A&M, <http://ethics.tamu.edu/ethics/shuttle/shuttle1.htm> (23 Oct. 07)

extremely low temperatures expected to prevail the next morning would keep the O-rings from working as they should. He was over-ruled and disaster followed.

Students are asked to reflect on the event; to understand how important it is for managers not to ignore their own engineering experience or the “expertise of their own subordinate engineers” in making a decision like this. The ASME Code of Ethics is cited - the one that speaks of the need for engineers to “hold paramount the safety, health and welfare of the public in the performance of their professional duties” - and a conflict is posed between abiding by this code and another that stresses company loyalty.

Although company loyalty is important, it must not be allowed to override the engineer's obligation to the public.

One is tempted to conclude - if only the engineers had been more forceful, (stomped out of the room?) right scientific reasoning would have prevailed in the face of managerial pressures.

On the Nature of Engineering Practice

Understanding my unease, requires an explanation of how I see the nature of engineering practice¹:

Generally engineers work in teams, in groups large and small. Whatever the team size, different participants bring different expertise to a task. Each has their own disciplinary perspective; their own ways of abstracting and modeling; different methods for finding solutions to problems within their specialty. Each can rely upon an infrastructure with its own special instruments and tools, prototypical bits of hardware, reference texts, suppliers' catalogues, codes, and regulations. I say that different participants work within different *object worlds*. Each participant, with different competencies, responsibilities, and interests sees the object of design differently. The *one object* of design presents *multiple object worlds* to different participants

Within each world, models and methods can be employed to optimize performance relevant to that world - whether it be structures, electronics, software, controls, aerodynamics, etc. But participants' analyses, proposals and claims will conflict. Here lies the source of complexity of today's engineering task for there is no over-arching, instrumental way to reconcile these results in strictly object world terms..

As a result, each participant in a project has to articulate his or her claims, analyses, and proposals so that others, those who inhabit other worlds, can establish meaning both with respect to their own perspective and the project as a whole. Within object worlds, instrumental rationality may carry the day; but within this now more open world of exchange and negotiation, validity claims are not restricted to objective statements that describe the structure and function of the object from one or another specialist's perspective. Here, now, the field of play is open to the traditions and norms of a firm which guide (and constrain) question-posing and decision-making - open to business and managerial analyses and claims, open even to prevailing popular ideologies and political interests.

1. For a fuller exposition of this picture of practice, see Bucciarelli, L.L., *Designing Engineers*, MIT Press, 1994.

And engineers are essential participants in this kind of work. *Object-world work is indeed necessary to design but it is not sufficient.* What engineers do, and are expected to do, includes much more than rational problem solving and constructing efficient means to reach desired, externally specified ends.

Once one acknowledges that the challenges participants face are not wholly amenable to instrumental resolution and that social exchange and action is part and parcel of an engineer's work, engineering practice appears as a much richer experience, one in which values and value judgments, often not made explicit - about the user, about robustness, about innovation, quality, about responsibilities, safety, societal benefit, risks and cost - are made.

My division of the work life of the engineer into two modes - i.e., object world work characterized as solitary, instrumental, mono-paradigmatic, materialistic, value-neutral, hard, certain and calculative (yet challenging in a puzzle-solving way and empowering) and all the rest characterized as social, i.e., collective, negotiable, ambiguous, soft, qualitative, compromising, political - is no lofty categorization of structure unfelt, but real and recognized by engineers themselves. It is the case, however, that object-world work is the kind of labor seen as primary by engineering faculty - and consequently seen as such by our students. It is what they (we) explicitly teach in our core curricula - the "hard" stuff - whereas the social is generally not seen, neglected, or worse yet, made a laughing matter¹.

Others who write about engineering practice tend to see only object-world work as what engineers do, as if this is all engineers were expected to do and be responsible for. The other stuff, what I have lumped together under the word "social", is taken to be the province of managers, of corporate chiefs or politicians. The director of a dual-degree program in engineering and humanities/social sciences at North Carolina State University offers this caricature:

The prevailing engineering culture is readily recognized from both inside and out. Engineers are no-nonsense problem solvers, guided by scientific rationality and an eye for invention. Efficiency and practicality are the buzzwords. Emotional bias and ungrounded action are anathemas. Give them a problem to solve, specify the boundary conditions, and let them go at it free of external influence (and responsibility). If problems should arise beyond the work bench or factory floor, these are better left to management or (heaven forbid) to politicians².

Critical Analysis of the Cases

It is the lack of any substantive treatment, none the less recognition, of the social context of the situations with which we confront our students in these scenarios that is the source of my unease. The focus on the responsible, morally sensitive, *individual* agent, hanging there, alone, confronting some *given* critical question strikes me as too simple a representation of what an engineer faces in practice.

1. Although today we hear and read of the need for our students to learn teamwork and communication skills - the so-called "generic" skills - capabilities not bound to any particular object-world or engineering field.

2. Herkert, J.R., "Future Directions in Engineering Ethics Research: Microethics, macroethics and the Role of Professional Societies", *Science and Engineering Ethics*, 7, pp. 403-414, 2001.

It is an abstraction that may work well if the intent is to teach moral philosophy - part of a moral philosophy object-world so to speak. From this perspective, the cases can be read as “set-ups” for an exposition of philosophical concepts and principles, just as my stick figure of a truss structure (with frictionless pins) is a set-up for my teaching structural analysis. This may provide an effective way to introduce students to different bases for ethical choice - individual rights, utilitarianism, deontology, Kantian imperatives - perhaps useful too in showing students how to reduce an ethical problem down into its factual, conceptual and moral dimensions - but the abstraction is so deficient in attending to the context of engineering work that it diminishes the import of ethics¹.

Consider the Autopilot Case: The ethical situation faced by “you” - the student - strikes me as unreal because it pictures the neophyte controls engineers so distant from any other participant who might have a legitimate interest in solving the problem². In its neglect of the social, the case doesn’t do justice to reality. I recast it now in the light of my view of the character of engineering practice:

Airbus Autopilot Case

A year out of university, John joined a team at Airbus as a control system’s engineer. The team - consisting of a seasoned pilot, a senior software engineer, and another, more experienced, control’s engineer - had designed, developed, and tested an upgrade to the autopilot software for Airbus’ commercial craft.

The team had been asked to solve some problems in the software. The software had been designed to perform many functions previously performed by the human pilot. Besides speed and heading control, it also tries to assess current conditions and makes decisions to improve current performance.

Early reports (but not in flight test?) from airline pilots suggest that under certain conditions, the autopilot performs control actions that actually can cause the plane to stall and potentially crash. Indeed, on the rare occasion when this problem occurred the aircraft tended to enter a stall and the pilot had to quickly over-ride the autopilot and take control in order to prevent more disastrous consequences.

The team has been asked to trouble shoot the design, determine the cause(s) of the problem, and recommend a fix to the software - while the planes are still flying.

What should John do?

1. Michael Davis, at the Center for the Study of Ethics in the Professions, at IIT, claims that, while most textbooks in engineering ethics have a section on moral theory, “...many new teachers of the subject...as they gain experience, they drastically cut back on theory - and a few of us...actually teach no moral theory at all in the engineering ethics course (or teach theory only “on demand”) - to make room for history, sociology, law, and the like...because we soon see these subjects to be necessary to provide context for the decisions in question - and more useful to our students.” Davis, M., “Engineering Ethics, Individuals, and Organizations,” *Science and Engineering Ethics*, **12**, 223-231, 2006.

2. Use of the second person might also prompt a defensive stance on the student’s part, generating the feeling that he/she is on the witness stand, or in the prisoner’s box accused or about to be cross-examined. Alternatively, the student might dismiss the possibility that he/she would ever encounter a problem of this nature. “The disadvantage to this pedagogy is that some students will say, well, this is very interesting but the chances I will be involved in a Challenger accident are very small, so all this talk about ethics doesn’t apply to me”. Kline, R.H., “Using History & Sociology to Teach Engineering Ethics”, *IEEE Technology and Society Magazine*, Winter 2001/2002, p. 17.

The technical, object world facts are the same, but what has happened to the ethic's problem? It hasn't exactly disappeared but certainly it has taken on a different thrust¹. Making the individual, John, part of a team alters the story in a significant way; not only is it less dramatic, and less threatening to the student, but the responsibility for remedial action is no longer your's alone, rather John's alone, but the team's, the group's.

Is this an ethical problem at all? Would John, on the job, think of it as such? Would the student - say he walked in late to Professor Meckl's controls class - see it as an ethics problem? I conjecture he would not without instructor guidance.

Accepting my revised scenario as a more authentic, yet still hypothetical representation, one will have to do some work to bring ethical considerations to the foreground. On the other hand, it might prove pedagogically effective to allow students at the start, to view the problem as an engineering problem, say as a design challenge (which might very well be a student's initial reaction to the original scenario) and let them try to construct a technical "fix". In this case, a student might claim that nothing should be done, arguing that the aircraft has a buzzer that sounds (his dad is a pilot) whenever the plane approaches a stall condition. So perhaps this will keep the pilot awake, sensitive to the fact that he needs to stay alert, in overall control. The software no longer presents a "bug" but a "feature" - hence there is no ethic's problem.

To refocus the class on the ethics, faculty would have to move students off this tack, try to convince them that something more than an improved technology might be required to deal with the situation. As long as faculty are not too dogmatic and the students' attempts at engineering a solution are not discounted out of hand, this reading of the revised scenario as an ethics "problem" should lead to question the case as posed; students should see that more information, over and above what is given in the narrative, is required to think through the situation e.g.,

Why wasn't the threat of stall encountered in flight testing? Why isn't someone from flight testing on our team? Are we sure the source of the problem is in the software? What do the pilots report? Have they complained, informally or formally? Why are the planes still flying? Within what organizational structure are we operating? Who has authority to command changes? Who is responsible for signing off? And why is John singled out to act (or not)?

Now normally this kind of behavior is off-limits in the engineering classroom; one does not have license to challenge a (single answer) problem statement. Student trusts that the teacher will provide all the information necessary to solving the problem - and no extraneous information please. So moving students to question and even challenge the statement of the problem will require instructor encouragement. But this questioning of the given scenario is precisely what is needed in order to deal with integrity with the scenario as an ethics case.

My critique suggest that if an ethics scenario is to be an authentic representation, albeit an abstraction, of what an engineer might encounter in practice, distinguishing the ethical problem from the technical problem may not be so easy and would require constructive effort (social construction) on the part of teacher and students. Initially making the scenario, as revised, the basis for an engi-

1. Woody Allen might respond that what John should do is make sure he shows up on time at the next meeting called by the team leader.

neering problem-solving (redesign) session, then moving students to see something more might be required, i.e., to act responsibly, (or maybe not) strikes me as a more authentic representation of what's liable to be the case in practice.

To ensure a mature discussion, one must encourage the students to question and probe the problem as stated. This should lead the discussion away from ethics, as well as software de-bugging, and toward conjecture and analysis of the social complexities of engineering practice - that there is something more to doing engineering and dealing with ethical issues than finding answers to well posed problems within a moral philosophy object world – but, again, that is precisely what is needed in order to teach “ethics” (and engineering!) with integrity.

This is particularly true if one is to do justice to the Challenger case. Here, fortunately, we have the scholarly work done for us. Diane Vaughan, in her “revisionist history and sociological explanation” *The Challenger Launch Decision*¹, challenges the conventional interpretations - those that claim that “...the launch decision rested on a rational choice theory of decision making: amorally calculating managers, experiencing production pressures, weighting costs and benefits, violating safety rules, then launching” (Vaughn, p. 403).

Her analysis reveals, not a case of unethical behavior, but the “sociology of a mistake”. In her concluding chapter she elaborates:

The explanation of the Challenger launch is a story of how people who worked together developed patterns that blinded them to the consequences of their actions...No rules were violated; there was no intent to do harm. Yet harm was done. Astronauts died. Although the explanation of the Challenger launch is not a story of harm done through amoral calculation, we can find no relief in the tale that has been told in these pages. It is a story that illustrates how disastrous consequences can emerge from the banality of organizational life....No fundamental decision was made at NASA to do evil; rather, a series of seemingly harmless decisions were made that incrementally moved the space agency toward a catastrophic outcome. (p. 409/410).

But what about

“[It’s time to] take off your engineering hat and put on your management hat”?

To read this as meaning that management over-ruled the solid analyses and data of engineers is wrong, according to Vaughan. All participants in the decision-making were engineers, had been educated and trained as engineers. The engineering data was not conclusive (is it ever?). Those participants with engineering responsibilities² - including Boisjoly - agreed that the data was not water-tight. He and others strongly opposed the launch and

...they did literally every thing “in their power.” And so did managers. The engineers were willing to maintain the silence imposed by bureaucratic and political account-

1. Vaughan, D., *The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA*, Univ. of Chicago Press.

2. “The 34 participants did not divide cleanly into the categories “managers” and “engineers”. [p.299 more]

ability because, despite their opposition, apparently they did not believe the SRB joint would fail. They believed that they were entering into an area of increased risk, that more damage to the O-rings might occur, but with the exception of Bob Ebeling (who did not state a position during the teleconference), no one thought that a complete ring burn-through was possible. (Vaughan, p. 380)

This is not to deny that the pressure to launch was a factor, but to find in this the sole motivation for decision-making is wrong and misleading. Individuals act with mixed motivations. Nor is it to deny responsibility on the part of participants, attributing the failure to the conjunction of certain social forces and/or cultural patterns alone. But it is the responsibility of individuals as part of a collective, a shared responsibility that is the issue here¹.

What becomes of the ethics problem after reading Vaughan's book? Again, it seems to melt away or at least become something more complex. To understand events, to move beyond myth-making about whistle-blowing, to prepare students for recognizing the antecedents of, and sociology of mistakes, one might start with Vaughan's summary analysis, contained in her final chapter. There she talks about "paradigm" and "structural" (not engineering structure, but sociological), and "script" and "social construction" and "culture" and how to do good history (ethically), and calls upon the insights of authors like Kuhn, Latour, Geertz - so they need to be read and evaluated if one is to grasp the full force of her analysis.

And what do we learn? What do we take away from Vaughan's analysis? In the simplest terms, organizational culture matters; it sets the context for beliefs about what is important, what can be ignored; it signals who is important, who not so; it guides and constrains modes and channels of communication - informal as well as formal.

But over and beyond this, we learn that object-world work, instrumental rational thinking, never suffices in design and decision-making. Decision making in engineering is a multi-factored affair and not all factors can be quantified. Engineers frequently, if not daily, are concerned with, and participate in "soft" management decisions. In this, uncertainty in the form of the unknown is always a potential disturbing factor; this and ambiguity are part and parcel of engineering work. In the case of the Challenger, SRB object-world analyses, models, field and laboratory test data did not suffice. The engineering narrative, in terms of the object alone, did not convincingly show that the O-ring would fail if launch were to happen at the low temperatures expected to prevail the following day. What appeared to Biosjoly as hard evidence for the potential for failure of the O-rings at low temperature, appeared to others as ambiguous, tentative, unconvincing.

We see too that in the working up, operation and maintenance of complex engineering systems, control and responsibility is shared among participants in a project. Seeking a root cause and/or fingering a single individual to blame (or praise) for failure (or success) might make a good story but it is likely to be a superficial rendering of events and, as such, does a disservice to the intelligence of our students.

1. Here I differ with one scholar's reading of Vaughan's analyses: Davis states "The trouble with Vaughan's approach, apart from the fact that it takes a book to make the argument, is that it effectively frees the decision-makers at Morton-Thiokol of responsibility for the decision they made the night before the launch." (Davis, op. cit., p. 225).

This is why the Challenger disaster is an interesting case to study - for the questions it raises about engineering practice; about the norms embedded in organizational culture; about the limits of rational instrumental thinking; about uncertainty and ambiguity; about engineering as a social process.

The deficiencies in the ordinary ethics case representation of the social complexities of engineering practice is one reason for my unease. Part of this is due to the centering of the case on the actions of a single individual, apparently a consequence of the need to ground the teaching of ethics in moral philosophy. A related source of my unease is the image of the engineer that emerges when one turns to the codes of ethics and explore their implications for the individual at work.

The Ethical Engineer - according to code.

We have already encountered the engineer as rational, no nonsense, object-world, problem solver. A study of the codes - the dozen or so “Fundamental Canons” and the criteria for their interpretation¹- adds another dimension to this picture.

The ethical engineer now appears further deformed; a modest individual, fully competent but so only within a narrowly defined domain

Engineers shall perform services **only** in areas of their competence...;

The ethical engineer should not step outside the bounds of his expertise; this suggests that he or she should not question a (competent) colleague’s work - unless, of course that colleague breaks the rules of ethical conduct, at which point he is required to blow the whistle.

Engineers **shall not** seek ethical sanction against another engineer unless there is good reason to do so..

He is conservative, speaking with authority only when all the facts, data, and analyses are firmly in hand and under control.

Engineers shall prepare articles for the lay or technical press which are **only factual**²;

and he is, first and foremost, a loyal member of the firm

Engineers shall act in professional matters for each employer or client as faithful agents or trustees

One might conclude that to be an ethical engineer, one has to be very, very careful, not only with “the facts” but also with people;

Engineers shall associate **only** with reputable persons or organizations

and there is no suggestion of negotiation, of social/political exchange and debate.

1. See, for example, THE ASME CRITERIA FOR INTERPRETATION OF THE CANONS, 29 November, 2006, link at http://www.asme.org/NewsPublicPolicy/Ethics/Ethics_Center.cfm (accessed 23 Oct. 2007)

2. What constitutes a “fact” does not appear to be a problem.

Even the “public welfare” canon

Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

does little to brighten the image; “safety, health and welfare of the public” is read as a demand for product safety - as a means to avoid liability - not as a call to social responsibility.

This image of the engineer, while somewhat more fleshed out than our object-world problem solver, is not very inspiring. But it’s one that resonates with the popular image of the hard working student of engineering - intensely struggling to grasp the concepts and principles of thermodynamics, computer science, biology, mechanics, differential equations et. al. and apply them in the solution of well defined, given, problems that admit of a single right answer - an individual in competition with his peers, conservative and constrained in thought, loyal to, and unquestioning of, the business of engineering science. The connection is made explicit in the following quote from a summary of observations made by an MIT Corporate Advisory Panel in the not too distant past:

MIT Graduate: Not as perfect for industry as before. Typical product of MIT education - an excellent individual performer but often considers it *just about unethical* to use results of other people’s work. This attitude must change¹. (emphasis mine).

I have puzzled over this observation since the summary report crossed my desk more than a decade ago. Why would a student consider it *unethical* to use the results of the work of others? I don’t think it refers to a lack of respect for proprietary information and the intellectual property rights of others. If that were the case, if that was the message the MIT Corporate Advisory Panel wished to convey - “...this attitude must change” - we are in deep trouble. I think it is the graduate’s (product’s?) distrust of the work of others, a felt need to do all the work on one’s own, that is at issue here².

Unfortunately, some seem to expect little more from the engineer. Consider how Norman Bowie, a professor who holds the Elmer Andersen Chair in Corporate Responsibility at the Carlson School of Management at the University of Minnesota sees the good engineer

What is a good engineer? A good engineer is one who lives up to the obligations of her employment contract, who conforms to the etiquette of the job situation she finds herself in, and whose *individual* (emphasis mine) engineering practice at least equals the performance standards of the profession³.

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1. “Key Points”, MIT Industrial Liaison Program, Corporate Advisory Panel, Meeting of 10 April, 1992
 2. It would be interesting to see if students today think the same way about using the results of the work of others. I suspect it has changed; witness the way software is developed, the way “objects” (black boxes) are relied upon, downloaded and incorporated into code though it still may be that the developer feels the need to open the object and redo bits if necessary.
 3. Bowie, Norman E., “Are Business Ethics and Engineering Ethics Members of the Same Family?” Journal of Business Ethics, R, pp. 43-52, 1985. Reprinted in Davis, M. (ed.) *Engineering Ethics*, Ashgate, 2005.

Obligations of an employment contract? Etiquette of the job? (What does that mean?) Practice which minimally meets standards of practice? Is that all that we can expect of our engineering talent? If this is a “good engineer” how will we ever attract any into the profession?

What room for creativity? The esprit of a team effort? What’s really good about being a “good engineer”? Where is the good life, the virtuous effort? I think of our students’ positive inclinations to “do good”, to better the environment, conserve energy, bring appropriate technology to developing countries, bio-engineering for the improved health and welfare. I think too of the projects students engage outside the curriculum, usually without significant monetary reward (if any) or academic credit - projects intended to be socially beneficial¹.

Other critiques

The focus on the individual in the teaching of engineering ethics, the neglect of the social, and the acceptance of the codes, narrowly read, as the framework for defining what constitutes an “ethical problem” has been called into question by others. In the face of today’s problems with the environment, climate change due to human intervention, unintended global effects of rapid technological advancement, we hear calls for collective response by the profession. Engineers, as well as corporate leaders, speak of the “greening of America”, of the need for “sustainable development”, energy sufficiency, and an industry that is more “ecological”. What needs attention is the social responsibility of the profession as a whole².

Students themselves are tuned in to this movement and are seeking ways to contribute, even going so far to write their own code. For example, *The Graduation Pledge of Social and Environmental Responsibility* initiated by students at Humboldt State University in 1987³ reads

I pledge to explore and take into account the social and environmental consequences of any job I consider and will try to improve these aspects of any organization for which I work.

A code that interprets public welfare narrowly, as ensuring product safety (so as to avoid legal suit) will no longer suffice. Tending to my own affairs within my cubicle is not enough. I must work to improve the attitude of the organization vis a vis society and the environment.

1. Michael S. Pritchard, in “Professional Responsibility: Focusing on the Exemplary”, *Science and Engineering Ethics*, 4, pp. 215-233, 1998, critiques the ‘minimalist view’ (stay out of trouble) and offers brief descriptions of several cases of exemplary practice engaged by students.

2. Herkert, in “Ways of Thinking about and Teaching Ethical Problem Solving: Microethics and Macroethics in Engineering”, *Science and Engineering Ethics*, 11, pp. 3375-385, 2005, explores how “...macroethics applies to the collective social responsibility of the profession...”, notes the relevance of corporate social responsibility programs, and quotes a statement of the American Association of Engineering Societies, to wit, “Engineering education must instill in its students an early respect and ethical awareness for sustainable development...” AAES (1994) *The Role of Engineering in Sustainable Development*.

3. <http://www.humboldt.edu/~career/gpa/history.html> (23 Oct. 07); Dalhousie University, School of Management, Nova Scotia is one of the seventy. The pledge is not for engineering students alone. <http://bmgmt.management.dal.ca/Current%20Students/SER%20Pledge/> (23 Oct. 07); A listing of colleges and universities offering the opportunity to sign the pledge will be found at <http://www.graduationpledge.org/schools.html>. The pledge emphasizes different social concerns (e.g., workplace conditions as well as the environment) at different institutions. It appears that several of the sites have gone ‘dead’.

A more expansive reading of the existing code of ethics with some updating has been suggested and tried by the professional societies themselves. This does not look too promising a path to meeting today's challenges. Vesilind, in an analysis of the way the American Society of Mechanical Engineers (ASME) and the American Society of Civil Engineers (ASCE) have attempted to include some measure of responsibility to the environment in their respective codes of ethics, finds these attempts inadequate.¹ The problem with relying upon a supplementing of the existing codes is that in order that they retain their universality and moral force, they must be stated in a general way. Yet, in avoiding specifics, they leave so much room for free interpretation that they are rendered irrelevant in practice.

Beyond tinkering with codes of ethics in order to foster a greater level of social responsibility on the part of engineers, some have explored how professional societies might play a more active role. But if the past is any guide, the potential for initiative looks bleak. Herkert, focusing on the IEEE's stance vis a vis product liability found the society disinclined to take a more active macro-ethical role.²

This concern with the need for a more collective response to today's problems on the part of the profession is not new. In 1979 John Ladd wrote:

Perhaps the most mischievous side-effect of codes of ethics is that they tend to divert attention from the macro-ethical problems of a profession to its micro-ethical problems. There is a lot of talk about whistle-blowing. What is really needed is a thorough scrutiny of professions as collective bodies, of their role in society and their effect on the public interest. What role should the professions play in determining the use of technology, its development and expansion, and the distribution of the costs (e.g., disposition of toxic wastes) as well as the benefits of technology? What is the significance of professionalism from the moral point of view for democracy, social equality, liberty and justice? There are lots of ethical problems to be dealt with. To concentrate on codes of ethics as if they represented the real ethical problems connected with professionalism is to [bury one's head in the sand]³.

Let's leave the codes aside then. Forget about them. How might one then teach engineering ethics? Can we dare speak of moral responsibility and ethics - even of virtue - of the profession? By this I do not mean to imply that a professional institution, e.g., a professional engineering society as a corporate entity ("ideal type") in itself possesses virtues or exhibits virtuous behavior, rather I mean that the collective of persons who are members of the profession - better said, participants in the professional culture - share certain values and beliefs and abide by (mostly unwritten) norms about what contributes to, or denigrates, the public welfare, that these shared values define the integrity of the profession, and guide engineers in their day-to-day efforts⁴.

1. Vesilind, P. Aarne, "Vestal Virgins and Engineering Ethics", *Ethics & the Environment*, 7, pp. 92-101, 2002.

2. Herkert, "Future Directions...", op. cit.

3. John Ladd, "The Quest for a Code of Professional Ethics: an Intellectual and Moral Confusion", in Chalk, R., Frankel, M.S. & Chafer, S.B. (eds), *AAAS Professional Ethics Project*, (Workshop, Nov. 1979), AAAS, Wash. DC, 1989. See Herkert, op. cit., for a taxonomy of micro/macro ethics domains.

4. See Michael Pritchard, "Responsible Engineering: The Importance of Character and Imagination", *Science and Engineering Ethics*, 7, pp. 391-402, 2001, for a discussion of the importance of certain virtues in the practice of engineering (and science).

Deborah Johnson in “The Social/Professional Responsibility of Engineers”¹ distinguishes between (individual) personal and (collective) professional values and judgements. These are linked, relate, but she notes that it is the personal that gets all the attention, as in the codes. Johnson argues that any recognition of professional values, points to the commitment of all engineers to a shared value, the good of humanity.

... the importance of a commitment to such a value, however general the value may be, should not be underestimated. It defines the framework within which members of the profession must make their decisions. It provides the common ground upon which individual engineers or groups of engineers may (agree and)/or disagree.

She contrasts two conceptions “... of professions in the world, and two different conceptions of engineering.”

One conception is to view professions as being value neutral, with the values directing them coming from outside. On this model it follows that engineers can and should be guns for hire....

The other conception is to view professions as enterprises committed to a social good and being structured (constrained in various ways, privileged in others) so as to achieve that social good....In this conception of a profession, and only in this conception, can we understand engineering as a morally worthy enterprise, worthy, that is, of individual commitment and social recognition.

If you accept the vision of engineering practice promoted and sustained by the object- world notion - that the work of engineers is instrumental and value free - then it seems to follow that the profession is “value neutral”, that we are all but “guns for hire”. This vision is implicit in all of our teaching in the core of our disciplines. But it is a myopic vision: Engineering work is more fully human, more social, even political, and value-laden than what this vision allows. Professional values matter; the profession of engineering is not value neutral.

That this is so is reflected in the ethics teaching of some scholars. Caroline Whitbeck, too, questions the value of abstract, intellectual exercises “...devoid of any historical or social context.”² She promotes the open-ended, engineering design process as a framework and analogy for addressing ethical situations;

teaching examples should preserve the open-ended, multiply-constrained, and ambiguous character of problem situations as experienced by the agent.

Other scholars have documented the shortcomings of the prevailing approach and have made recommendations on how to improve the teaching of engineering ethics, while sticking with the case

1. Annals of the New York Academy of Sciences, 577, pp. 106-14, 1989; Reprinted in Davis, *Engineering Ethics*, 2005.

2. Whitbeck, C., “Teaching Ethics to Scientists and Engineers: Moral Agents and Moral Problems”, *Science and Engineering Ethics*, vol.1:3 (1995), 299-308. <http://onlineethics.org/essays/education/teaching.html>. See also “Ethics as Design: Doing Justice to Ethical Problems”, Chapt 1. of her book, *Ethics in Engineering Practice and Research*, Cambridge University Press, 1998.

method. William Lynch of Wayne State University and Ronald Kline of Cornell write in their abstract to their paper “Engineering Practice and Engineering Ethics¹”

We suggest modifications of both detailed case studies on engineering disasters and hypothetical, ethical dilemmas employed in engineering ethics classes. Investigating the sociotechnical aspects of engineering practice can improve the initial recognition of ethical problems in real-world settings and provide an understanding of the role of workplace organization and culture in facilitating or impeding remedial action.

Kline, in another article titled “Using History & Sociology to Teach Engineering Ethics” goes further in his critique of “disaster ethics”, advocates adopting the perspective and analyses of STS scholars to provide “... a more in-depth picture of engineering practice and its wider ties with politics, economics, and other occupations...”².

Engineering Education - beyond Ethics

There is one other aspect of the emphasis upon engineering ethics as a requirement that makes the enterprise suspect: It is as if those who are responsible for ABET’s recommendation, recognizing that preparing students for instrumental, object-world work, does not constitute an adequate preparation for engineering practice, looked outside (toward the Humanities and Social Science’s end of campus) and discovered “ethics” to be the needed supplement. I find this vision of what an engineer needs to be fully enlightened myopic. But what to do?

There are several options:

1. Forget ethics altogether as a specific requirement; we engineering faculty are not qualified to teach ethics; there’s no space in the curriculum; it’s not our job; our responsibility is to teach object-world, value-free engineering. But we can encourage (or require) students to take ethics as an elective.
2. Integrate the teaching of ethics in with the content of an engineering course(s) - course taught in collaboration with people who do have the competence to teach; e.g., philosophers. I call this the “separate but equal” approach.
3. Reform the whole of the engineering program in the spirit of the teaching of Whitbeck, Lynch and Kline, - e.g., to enable students (and faculty) understanding of the social as well as instrumental challenges of contemporary professional practice and what this might entail as the profession’s “social responsibility” (and ethical behavior of the practicing engineer).

It’s the third option that I favor and see as necessary. But I would go beyond the addition of a course or two in STS. Such would not suffice. The current value system underlying our teaching of the “hard” subjects, even the prevailing approach to teaching most design courses has to change.

1. Lynch, W.t., & Kline, R., “Engineering Practice and Engineering Ethics”, *Science, Technology, & Human Values*, vol. 25, no 2, Spring 2000, pp. 195-225.

2. Kline, R.R. “Using History & Sociology to Teach Engineering Ethics”, *IEEE Technology and Society Magazine*, Winter 2001/2002 pp. 13-20.

The way we structure our curriculum and teach our subjects all conspire to instill in the student the idea that engineering work is value-free. Object-world work may be, but that is but one part of engineering competence. While teaching the “fundamentals” of science and mathematics, and the engineering sciences remains necessary, we must do so in more authentic contexts, showing the uncertainty and ambiguity inherent in problem setting as well as solution, and how social and political interests contribute in important ways to the forms of technologies we produce. We ought not as faculty claim, or imply, that solving single answer problems or finding optimum designs, alone, uncontaminated by the legitimate interests of others is what engineers do all of the time. This is irresponsible.

There are curriculum models for this – those that structure their entire program on project or problem-based learning, and/or design. The best examples are in Europe, e.g., The Design and Innovation Program at the Danish Technical University is one example. In this country, RPI’s Product Design and Innovation Program is another. These programs center learning on tasks that are open, that admit of more than one “good” response and, just as important, more than one way to get there. Another possible model is the Engineering and Society Program at McMaster University in Ontario, Canada. All of these programs employ a mixed faculty - hard and soft, engineering and humanistic - in the teaching of their core courses. All promote inquiry, reflection in practice, as well as problem solving. This openness pervades and dominates the whole of the student’s experience - throughout all years of undergraduate study.

Once one opens up the engineering classroom to discussion and debate, allowing students to challenge the “givens”, even the suitability of ends, then the door is open for the infusion of questions of an ethical nature as integral to doing the task. But this is the way it should be; students and faculty exercising their moral imagination side by side with their engineering imagination in an assigned, engineering task.

What is needed is a schooling of engineers rooted in a more “liberal”, general engagement with studies, still with science and technology as their focus, but approached with an air of critical reflection as well as experiencing the power of techniques for modeling and problem solving, design and building. This will require a new faculty, a mixed faculty, not individually generally knowledgeable about all dimensions, but as in engineering practice itself, each able to articulate their interests to others and to listen with full respect.

A three-two program suggests itself. Three years of liberal general studies¹, then two years focused at a masters level. The first phase would be the responsibility of a mixed faculty of philosophers, historians, sociologists, even classicists, as well as scientists, mathematicians and engineers with authority and control over content and context shared². The engineering sciences would

1. I am not advocating the kind of liberal program promoted by Samuel Florman in *Engineering and The Liberal Art. A Technologist' guide to History, Literature, Philosophy, Art and Music*, Mc Graw-Hill, New York, 1968.

2. To ensure this would not degenerate into a collection of independently taught humanities subjects and engineering science courses, accreditation would be by a mixed review board.

be part of this but not dominate; critical appraisal of origins and impacts, reflection on values implicit in the doing of engineering would hold center stage.

Conclusion

I have argued that ABET's recommending the study of engineering ethics is misguided and misleading; that the way in which ethical issues are presented, with their focus on the individual acting alone, avoiding wrong-doing, both mis-represents the context of practice and paints too wooden, conservative, instrumental an image of the engineer. I have conjectured that even if done better and/or if the focus shifted to "macro-ethics", this would engender or require a more expansive and critical study of engineering, including its social/political dimensions - in effect displacing ethics as a subject in its own right, moving it aside in order to get at more fundamental features of practice. In engineering we take pride in teaching "the fundamentals". It's time to explicitly recognize that what is fundamental to engineering practice goes beyond scientific, instrumental rationality; to fail to acknowledge this is "just about unethical".