# Teaching Ethics Across the Engineering Curriculum

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## Description

An essay by Michael Davis exploring the teaching of ethics and how problems used in ethics courses are developed.

## Body



The sponsors of this conference included a question mark at the end of the title to my talk. I think there is no better way to begin this accompanying paper (prepared after my presentation) than to point out that its title does not have a question mark. The question mark is absent because there is, I believe, nothing questionable about teaching ethics across the engineering curriculum. Ethics, as I will show here, fits nicely into every engineering course, from a first year Introduction to the Profession to analytic courses like Thermodynamics, from Calculus to senior design. I shall show this by giving a few examples of what can be done in engineering's most analytic courses. But, before I can show anything, I must explain what I am, and am not, proposing.

# I. Why Engineers Should Teach Ethics

"Ethics" has at least three senses in English: it can be 1) a synonym for ordinary morality, 2) the name for a field of philosophy, or 3) the name for a set of special (morally permissible) standards (for example, engineering ethics). The beginning of wisdom in the teaching of ethics across the curriculum is being clear about what you mean by "ethics".

"Morality", as I use the term here, refers to those standards of conduct everyone (every rational person at his rational best) wants every other to follow even if everyone else's following them would mean having to follow them too. Morality (in this sense) is the same for everyone, engineers included.

Because morality consists of *standards* of conduct, not conduct as such, the fact that a standard is not always observed does not prove that it is not part of morality. Were moral standards always observed, we would have no use for moral terms. "Should" implies "sometimes does not". Yet, if "should" implies "sometimes does not", it also implies "generally does". A moral standard not generally observed is an *ideal* standard, not an actual one. What we owe an ideal standard is an inclination to change the world so that observing it will become general. But, until the world has changed, we are not bound to observe the standard itself. Moral obligation presupposes general compliance with the standard in question (that is to say, a living practice), even if a moral obligation also presupposes less than universal compliance.

We were all quite young when we learned such basic moral rules as: don't kill; don't lie; don't cheat; keep your promises; and so on. We were still quite young when we learned that these rules have exceptions (for example, "except in self-defense" for

"Don't kill"). Now and then, we may change our interpretation of a particular rule or exception — for example, we may come to think that speaking the truth, intending it to be misunderstood, is (or is not) a form of lying. But, since we entered our teens, such changes have been few and relatively minor. Our students are much like us. They arrive in class more or less morally mature. We have little to teach them about ordinary morality.[1] Not so ethics in my other two senses.

In the second sense I identified above, "ethics" names a specifically philosophical discipline (the attempt to understand morality as a rational enterprise). In this sense, "engineering ethics" would be a field of philosophy concerned with morality as it applies to engineers. So, when a philosophy department offers a course in Engineering Ethics (or Moral Problems in Engineering), the course should attempt to understand engineering's special standards using the methods of rational justification developed for morality in general. While such a course usually contains as much of the history and sociology of engineering as a course in Engineering Ethics (or Professionalism) taught in an engineering department — including detailed study of parts of the code of ethics--, there should be differences in emphasis. For example, the philosophy course will generally attempt to connect the specific moral problems of engineering with distinctions, arguments, theories, and debates central to philosophy. Engineering students can benefit from such a course both in ways they benefit from other philosophy courses and in ways they benefit from a free-standing course in engineering ethics taught in an engineering department. But few, if any, engineers are equipped to teach ethics in this sense.

I shall use "ethics" in a third sense here. "Ethics" (in this sense) refers to those special, morally permissible standards of conduct every member of a group wants every other member of that group to follow even if that would mean having to do the same. Ethics applies to members of a group simply because they are members of that group. To say that ethical standards are "special" is to say that they do not apply to everyone. Research ethics applies to researchers (and no one else); Hopi ethics, to Hopis (and no one else); and engineering ethics, to engineers (and no one else). While it is a conceptual truth that rational agents are subject to (ordinary) morality, their subjection to ethics (in this third sense) is a contingent truth. One can be a decent human being without ethics (in this third sense of "ethics").

To say that ethics (for example, engineering ethics) applies only to members of the relevant group (engineers) is not to say that the standards in question may not resemble those of another group (or even be identical word for word). It is, rather, to identify the origin of the standard, the domain over which it has jurisdiction, and those who have authority to revise, interpret, or repeal it. Even when the ethics of two groups are identical, they need not have been and in time may not be.

Something similar is true of the relation of ethics to (ordinary) morality. Engineering ethics in fact includes standards of ordinary morality, for example, honesty (don't lie, cheat, or steal). Engineering ethics differs from ordinary morality, insofar as it does differ, only in demanding more ("a higher standard"). For example, honesty for an engineer includes a duty of candor that goes beyond ordinary morality. To say that engineering ethics applies only to engineers is not to deny any similarity between engineering ethics and (ordinary) morality but to deny that ordinary people are bound by whatever additional obligations engineers take on.

"Ethic*s*" (in this third sense) is not the plural of "ethic". An ethic, a way of living, may or may not be moral. Ethics (in the third sense) is always moral in at least two senses. First, it is moral because, by definition, ethics is "morally permissible", moral in the weak sense of "not immoral". But ethics is also always moral in a stronger sense, "immoral not to". The ethics of a group are always morally binding on its members (even though not morally binding on ordinary moral agents). The members of the group cannot act unethically without doing something morally wrong.

Ethics-as-special-standard thus suggests a question neither ethics-as-morality nor ethics-as-study does. How is it possible for a standard to be at once special (that is, not part of ordinary morality) and yet morally binding? The answer is simple (though its defense is not): Rational agents do not (except by mistake) set standards for themselves or others without some benefit in view, a benefit they believe they cannot otherwise achieve (or achieve as well). If we call a practice "cooperative" when the benefits that justify each in doing as the practice requires depends (in part at least) on others in the practice doing the same, then violating a rule of a cooperative practice is cheating (that is, taking unfair advantage). All else equal, cheating is morally wrong; hence, following the rules of such a practice is, all else equal, morally required.[2]

Ethics (in the third sense) defines a cooperative practice. An ethical standard therefore has much the same moral status as a (valid) promise. Though not morally binding on everyone, it is morally binding on those who bind themselves (whether by actually promising or merely by voluntarily participating in a morally permissible cooperative practice). Ethics (in this third sense) is "special morality".

Ethics resembles law in being a special standard, that is, a standard applying to those it applies to for reasons beyond mere rational agency. Like law, ethics is relative. Ethics differs from law in its closer connection with (ordinary) morality. Law *can* be immoral # or, at least, whether law can be is a question that enduring approaches to law answer differently. Ethics, in contrast, can no more be immoral than counterfeit money can be money. "Thieves ethics", "Nazi ethics", "torturers' ethics", and the like should always wear scare quotes. Because ethics is closer to morality than law, it can depend on morality ("conscience") for enforcement more than law can.

This third sense of ethics seems to dominate discussions of ethics among members of professions. That is not surprising. A profession is a number of individuals organized so that they can earn a living by openly serving a certain moral ideal in ways beyond what law, market, and (ordinary) morality require. A group cannot be a profession without setting itself special (morally permissible) standards, that is, without developing its own ethics (in the third sense).

Yet, while ethics is necessary for a group to be a profession, it is not sufficient. Many groups with ethical standards are not professions. For purely conceptual reasons, they belong to another class of entity. Charities, fraternal orders such as the Masons or Elks, and other philanthropic groups cannot be professions because they are not organized to help their members earn a living. Labor unions, trade associations, and other organizations of self-interest, though organized to help members earn a living, are not organized to help them earn that living by serving a moral ideal. A business with a code of ethics, though organized in part to serve a moral ideal, is not organized to help *members* earn a living. Those who earn their living from the business, the employees, are not members but agents; those who are more like members, the owners or principals, earn a profit, not a living, from the business (and, indeed, as owners, may be wholly inactive).[3]

To talk of "ethics" in my third sense suggests a question: "How can one benefit from requiring other members of one's group to offer services beyond what law, market, and morality require?" (Or, in other words, "Why would any group want a code of ethics?") The question is neither "Why have morality?" Nor "Why be ethical?" Morality is assumed (along with law and market). One decisive reason for individuals to be ethical is also assumed: to be unethical is to be immoral. The question is why not make do with (ordinary) morality (along with law and market).

The short answer to that question, sufficient for our purposes, is that practicing as a member of a profession, rather than as a mere individual, can have (morally permissible) advantages more than sufficient to pay for the constraints such coordinated practice imposes. Consider, for example, what an engineer's status would be if engineers generally did not do a better job than morality, law, and market demand. Engineers would be treated much as we treat plumbers, mere inventors, and others who belong to an honest occupation that is not a profession. Would engineers be in as much demand as they are now? Would we trust them with the same range of responsibilities as we do now? The answer to both questions is, I think, clearly no. A profession is much like a respected trademark. The only hard question is whether the higher status engineers now have is enough to pay for the constraints necessary to achieve it. The answer to that question depends on many factors, not least of which is what law, market, and morality would otherwise demand. Not every occupation should organize as a profession.

Generally, the special standards that constitute a profession's ethics are formulated in a code of ethics, in formal interpretations of that code, and in the less formal practices by which experienced members pass on to new members the special ways they do things. So, except for those students following a parent into a profession, no one is likely to learn much about a profession's ethics except at a professional school or while practicing the profession. Professional ethics is as much a part of what members of a profession know and others do not as their "technical" knowledge. Engineering ethics is part of thinking like an engineer. Teaching engineering ethics is part of teaching future engineers how to practice the profession.

Because this point is easily overlooked, let me put it another way: Professional ethics (in the third sense of "ethics") belongs neither to common sense nor to philosophy but to the profession in question. Knowing engineering ethics is as much a part of knowing how to engineer as knowing how to calculate stress or design a circuit is. Indeed, insofar as engineering is a profession, knowing how to calculate stress or design a circuit is in part knowing what the profession allows, forbids, or requires.[4]

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# II. What is Teaching Engineering Ethics?

Having explained what engineering ethics is, I must now explain what it is to teach that subject. That explanation will make two assumptions: The first is that engineering has "special" (morally permissible) standards of conduct (in large part) embodied both in practice and in such formal codes of ethics as those adopted by the National Society of Professional Engineers (NSPE) or the Accreditation Board of Engineering and Technology (ABET). The second assumptions is that most engineers can recognize those standards as (more or less) the ones they want other engineers to follow so much that they would be willing to do the same if that were necessary to get the others to pitch in.

Teaching engineering ethics (in my third sense of "ethics") can achieve at least four desirable outcomes: a) increased ethical sensitivity; b) increased knowledge of relevant standards of conduct; c) improved ethical judgment; and d) improved ethical will-power (that is, a greater ability to act ethically when one wants to).[5] How can teaching ethics achieve all this indeed, any of this?

Teaching ethics can increase student sensitivity simply by making students aware that they, as engineers, will have to resolve certain ethical problems. Generally, pointing out an ethical problem will mean pointing out the consequences of a seemingly inconsequential act ("a mere technical decision"). Just being exposed to a few examples of a particular problem will make it more likely than otherwise that the students will see a problem of that sort when it arises on the job. So, for example, a student who has seen how easy it is to overlook the effect conflict of interest can have on her technical judgment is more likely to spot and avoid conflicts of interest than a student who has not seen that. Why teaching ethics might have this effect is not hard to understand. The mechanism is much the same as for teaching students to see technical problems. Knowledge and practice sharpen perception, making it easier both to see a particular decision in context and to imagine what the context might contribute.

How can teaching ethics increase student knowledge of relevant standards? Again, the answer is much the same as for technical standards. For example, a student who has read ABET's "Code of Ethics of Engineers" is more likely to know what is in it than a student who has not. A student who has had to answer questions about the code is more likely to recall the relevant provisions than one who has not. And so on.

Knowledge of standards includes more than just knowing what the code says. Part of knowing a standard is understanding its rationale (especially the consequences of departing from it). Since all standards require interpretation, another part of knowing a standard is knowing how to interpret it, taking into account not only its rationale but moral, political, and even practical constraints, including the interpretation others are likely to give it. So, for example, part of teaching students to "hold paramount the safety, health, and welfare of the public" is helping them understand the dialogue between engineers, employers, and the public that underwrites the current definition of "safety". There is no sharp line between raising sensitivity and teaching standards.

How can teaching engineering ethics improve ethical judgment? Ethical judgment (like other judgment) tends to improve with use (as well, of course, as with relevant knowledge and sensitivity). If an instructor gives a student a chance to make ethical judgments, explain them, and compare them with those other students make, the student is more likely to judge well than if she gets no such experience. The classroom provides a safe place to make mistakes and learn from them ethical mistakes as well as purely technical ones.

Some of those who argue for teaching engineering ethics through such discussions have argued for the explicit use of moral theory. Their arguments seem to me to rely on a confusion between ethics-as-study and ethics-as-special-standard.[6] My experience is that an instructor can easily lead probing, systematic, and enlightening discussions of ethical questions without mention of any moral theory (and, indeed, without knowing any moral theory). What an instructor needs is not a toolbox with one or more theories but one easy-to-use method for guiding discussion, focusing on reasons, and forcing judgments. That is something much less exalted than a moral theory (though such a method can use ideas various theories develop). (For an example of such a method, see Appendix.)

But how can teaching engineering ethics increase a student's ethical willpower? Consider: Isn't an engineer who knows that he shares with other engineers a commitment to a particular standard of conduct more likely to follow it than one who believes himself alone in that commitment? One benefit of discussing ethics in the classroom is that the discussion itself shows students how much consensus there is among members of the class and, by extension, their profession on most of the profession's standards of conduct. There is power in numbers. That is one source of willpower. Another is a sense of a standard's reasonableness. A student who believes he understands what makes a standard reasonable is more likely to try to explain its reasonableness to others and so, more likely to win their support and act accordingly.

Having stated these aims, I should add two warnings. First, I do not mean to suggest that a college, university, or any other institution should try to send out graduates who are perfect in ethical sensitivity, knowledge, judgment, or willpower. Perfection is not possible. The most we can reasonably aim at is substantial improvement improvement relative to what students would have been had they learned nothing more about ethics at the institution than they would have before ethics was taught across the curriculum.

So, second, I think we should take care not to claim too much for what teaching ethics does. No matter how much ethics instruction engineers have, there will be some engineering scandals. Teaching ethics seldom turns the evil from their course; it cannot protect the thoughtless from doing what they know they should not or ensure that the well-meaning will not give in to overwhelming pressure. Teaching ethics can, at best, assure that the well-meaning will be substantially less likely than otherwise to do what they should not. And even that is hard to prove.

The problem is not measuring improvements in ethical sensitivity, knowledge, and judgment. They are easy to measure in just the ways we measure improvement in technical sensitivity, knowledge, and judgment. We can give students a problem and ask them to identify the ethical issues. The more they identify, the more sensitive they are. We can ask students about codes of ethics, procedures for gaining support for their position, and so on. The more such questions students can answer, the better their ethical knowledge. We can also ask students what they should do in a particular situation and why. The more ethical issues their choice takes account of and the more ethical knowledge they bring to bear on the choice, the better the ethical judgment they demonstrate. We can also credit them for any choice they make that is not clearly unethical (giving more credit for those choices that are clearly ethical than for those that are marginal at best). [7]

The problem is measuring improvements in ethical willpower. The test of willpower is action in the appropriate circumstances, a kind of test educational institutions find hard to arrange. Long-term comparative studies of graduates who have had ethics and those who have not, should yield some measure, provided the effects of will-power can be disentangled from other effects, including those of sensitivity, knowledge, and judgment. For now, we can explain why teaching ethics should improve ethical will-power, but we cannot prove that it does, much less make any estimate of how much it does.

Those concerned with ABET assessment will probably want to keep these comments on measurement in mind. They may, in consequence, want to develop ethics across the curriculum in such a way that it leaves behind a trail of homework assignments, exam questions, and lab reports that can be used to document that students are a) learning to identify ethical issues, b) learning about resources for dealing with those issues, and c) developing good ethical judgment.

So much for what teaching ethics is. We must now consider how we might reasonably teach ethics given the realities of budget, personnel, and other options.

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# III. Fitting Ethics Into the Curriculum

There are at least eight ways to teach engineering ethics in an academic environment (in addition to such informal ways as setting a good example).[8] These eight ways are more or less consistent with each other, indeed mutually supportive where necessity does not force a choice.

Two ways are outside the curriculum. One is independent study, for example, giving students the appropriate code of ethics and telling them to read it. The other extra-curricular way is by special event, for example, a public speech on engineering ethics or a movie like *Apollo 13* or *China Syndrome* with a discussion afterward of the ethical issues it raises.

One of my colleagues, Robert Ladenson, has been experimenting with another device, "ethics bowl". Students form teams of four each to compete, much as on Public Television's College Bowl. The chief differences between College Bowl and an ethics bowl are: a) the teams must answer questions asking for a decision in a specific situation; b) the responses are evaluated by a panel of practitioners (as in a diving contest) with the emphasis on the identification of moral issues, the ingenuity of the proposed solution, and the reasoning offered in its defense, rather than on giving "the right answer"; and c) the teams have the right to criticize the "official answer" if they believe their own is better (with the panel counting the effectiveness of this criticism in making their final evaluation). After two years of experiment with this format at IIT, both in class and at public events, Ladenson organized the first intercollegiate ethics bowl in Spring 1995. The most recent intercollegiate ethics bowl, the fifth, had teams from eighteen colleges and universities. Students enjoy the competition while appreciating the opportunity ethics bowl gives them to practice making ethical decisions.

While these first two ways of teaching ethics are not likely to accomplish much alone, or even together, they are better than nothing and can help to set a tone the other ways of teaching ethics can take advantage of.

The third way of teaching students engineering ethics is supra-curricular (operating inside the curriculum as well as outside): hold students to an engineering code while they are still students. I am not talking about an "honor code". Honor codes are codes of student ethics, not of engineering ethics. A student will learn more about engineering ethics living by an engineering code than by living by an honor code. Of course, "living by an engineering code" means more than having an administrator announce each fall that students will be held to it. Students should have a part in administering it. There should be frequent opportunities to discuss its interpretation, to apply it to particular cases of student conduct, and to evaluate it in light of that experience.[9]

Most engineering codes are sufficiently like an honor code for this purpose, but sufficiently different to be worth a student's effort to learn the particulars. Deciding, for example, whether a code provision that requires engineers "[to] give proper credit for engineering work to those to whom credit is due" means giving credit to those who helped one write a term paper would provide useful practice in interpreting the code (as well as useful insight into the rationale for crediting others in one's academic work).

The other five methods of teaching students engineering ethics are all internal to the curriculum. The easiest, my fourth way, is the guest lecture. (If the guest stays all semester, the course is "team taught".[10]) By itself, the guest lecture makes engineering ethics look optional: "If all engineers are supposed to know this stuff, why doesn't my (engineering) prof know enough to teach it?" A similar question arises for the fifth way, the sort of course I teach now and then, a free-standing course in engineering ethics taught *outside* an engineering department, whether optional or required. ("Why doesn't someone in my department know enough to teach it?") A different question arises for my sixth way, a course in engineering ethics which, while taught by an engineer in an engineering department, is still optional: "If this stuff is important, why isn't it required?"

My seventh way, the free-standing required in-house course, answers all these questions, but only at the cost of raising two others: 1) "How do we fit this into the curriculum?" and 2) "How do we make what it teaches seem a routine part of engineering?" The last of my eight methods, the pervasive, provides an answer to both questions: "You don't have to fit a new course in because you can do something better. You can teach engineering ethics in a way that brings home how integral it is to engineering work. You can make engineering ethics pervade the curriculum."

My focus hereafter will be on the pervasive method. But that focus should not be taken as condemning any of the other seven ways of integrating ethics into the curriculum. "Ethics across the curriculum" is much like "writing across the curriculum". The more ways you can get ethics in, the better. My only global claim is that the pervasive method has an advantage no other method has. It makes ethics a routine part of what engineering students have to think about.

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# IV. Examples

Consider the following problem from a standard text in (second year) Thermodynamics:

A vapor-compression refrigeration system for a household refrigerator has a refrigerating capacity of 1000 Btu/h. Refrigerant enters the evaporator at -10$^{o}$F and exits at 0$^{o}$F. The isentropic compressor efficiency is 80%. The refrigerant condenses at 95$^{o}$F and exits the condenser subcooled at 90$^{o}$F. There are no significant pressure drops in the flows through the evaporator and condenser. Determine the evaporator and condenser pressures, each in lbs/in$^{2}$, the mass flow rate of refrigerant, in lb/min, the compressor power input, in horsepower, and the coefficient of performance for (a) Refrigerant 12 and (b) Refrigerant 134a as the working fluid.[11]

As it stands, this problem calls for six routine calculations. There seems to be no room for ethics. Yet, with a little rewriting, this ordinary problem can become an interesting ethics problem. Here is how one professor of mechanical engineering at IIT rewrote it:

You work for an appliance manufacturer and are asked by your manager to produce a preliminary analysis and recommendation for a new line of electric household refrigerators. The vapor-compression refrigeration system is to provide an average cooling capacity of 1000 Btu/h and use company components wherever possible. Your company's compressors have an isentropic efficiency of about 80%, their evaporators operate between -10$^{o}$F and 0$^{o}$F, and their condensers operate with a saturation temperature of 95$^{o}$F and (subcooled) exit temperature of 90$^{o}$F. Neither the evaporators nor the condensers have significant pressure drops. Both Refrigerant 12 and Refrigerant 134a are to be considered as the working fluid. Pressure values throughout the unit are necessary to spec the plumbing and components. The required compressor input power is obviously necessary for choosing the compressor unit. The advertising department wants the annual operating cost (using \$0.08/kW · h) and coefficient of performance estimates. Generate a brief report which includes your analysis, pros and cons for each working fluid, and your final recommendation.

*Extra Credit:* Include additional pros and cons for each working fluid by researching beyond the text. (0 - infinity)

The analysis students must perform is identical in the two versions of the problem except for an additional one-line cost calculation in the second version. The student should find that the R-12 (Freon) unit holds a 3% advantage over the R134a (ammonium-based coolant) unit with respect to input power, operating cost, and coefficient of performance. This advantage must be weighed against the negative environmental impact of R-12. Using information in the text, student could be make an argument for the company "jumping on the environmental bandwagon" or being prepared for a legislated ban of R-12. Additional research beyond the text might reveal that there are differences in the cost, corrosive characteristics, and lifetime of the two refrigerants, all favoring R-12.

The chief difference between the original problem and the revised version is an enlargement of context. An abstract problem has been given a realistic context and become a "mini-design problem": the student ("you") now have to make an engineering decision. The abstract problem was always implicitly a practical problem; all engineering problems are. But now its practicality has been made explicit.

There is nothing subtle or philosophical in this; yet it embodies the central idea of integrating engineering ethics into the technical curriculum. The ethics comes with the practicality. Once you have understood this example, you will see that integrating ethics into technical engineering courses need not involve bringing in anything extraneous. Ethics need not be an add-on; it can work like an alloy, adding strength to the course without adding anything volume.

How might this problem be used? It can, first, be used much like any other homework problem I call this "hit and run in class, you just go through the calculations for this problems as you would any other problem, noting at the end that cost and efficiency are not the only relevant factors in making a recommendation:

As the code of ethics says, the public health and welfare are also relevant. You need to balance risks to individuals that R134a poses against the risk to everyone R-12 poses. Even a seemingly simple engineering decision can bring you face to face with deep questions about the environment, safety, and public welfar

You could then go on to the next problem. Hit-and-run takes almost no class time.

If you grade homework assignments, you would grade the calculation part just as you would grade any other. You might grade the ethics part by counting the number of relevant factors identified (or by using a more complicated procedure taking importance into account).

Or, second, you can lead a brief discussion, asking students what factors they identified as relevant to the decision and listing them on the board. If the students missed any obvious ones, you can point that out and ask why they missed them. Usually, the first time, the answer is that the students didn't think that engineers were supposed to take such things into account or that they just didn't think of them. This is an opportunity to talk about what makes a consideration relevant to engineering.

You can conclude that brief discussion by taking a vote: "how many for R-12?" and then "how many for R134a?" A vote forces students to pull together what they've heard and make a judgment; it also gives closure and helps students assess what other members of the class think important.

Or, third, you can lead a longer discussion, in which you provide more background on how a design decision such as this might be made, bringing out, for example, why an engineer should take into account what "advertising" wants (and why an engineer cannot be bound by what advertising wants). Here too might be a good opportunity to say something about looking for technical alternatives to escape the dilemma the problem poses. What other options might there be beside R-12 and R134a?

The effect of such problems does not depend on any one problem but on their accumulation over a semester and, indeed, over many semesters. Many hit-and-runs are probably better than one or two long discussions.

The variations on this example are many. Let me sketch one from a course that may seem even less likely to have room for any ethics.

A math professor at IIT had for years been trying to get students to think about whether their answers made sense. After taking my ethics-across-the-curriculum workshop, he decided to allow students, mostly engineers, to sign off on their calculus problems on homework and exams. If they signed off and were right, they got ten percent above full credit. If they signed off and were wrong, they got no credit. If they didn't sign off, they had to explain what seemed to be wrong with their calculation. They would get partial credit for the part of the calculation they got right, plus something for accurately identifying what was wrong with their calculation. When students asked why they couldn't get partial credit without identifying their calculation as suspect, the math professor would say,

People will be depending on your calculations. You have a professional obligation to reveal any doubts you have so that any errors can be corrected. If a building falls down because you miscalculated, neither you nor anyone else will care that you did most of the calculation right.

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# V. How Do You Develop Problems Like These?

Developing an ethics problem differs little from developing other exam questions or homework assignments. You begin by identifying the purpose of the problem: what do you want the problem to teach? What issues do you want it to raise at that point in the semester? You should then consider what your students will know at that point and what they need to know.

If you have trouble thinking of any ethical issues relevant to your class, or any ethical knowledge your students should have, I recommend looking for inspiration in the following ways:

1. Look in the appropriate code of ethics. What is there relevant to what you are doing in class? If it is in the code, it probably comes up.
2. Draw on your own practical experience, especially when you were "learning the ropes": what bothered you about choices related to matters relevant to this part of the course?
3. Look at ethics problems in textbooks in the field (if there are any).
4. Ask practitioners what comes up when they do work of this sort. Many good ideas can be picked up at what would otherwise be dull parties.
5. Think about writing a report on research, design work, or evaluation of the material you are teaching: what problems arise in reporting technical results? What should be put first? What put last? What buried in a footnote? What left out? What explained? How? Why?
6. Ask your students to identify ethical issues related to work of this sort.
7. If all else fails, ask how someone using what you are teaching could harm someone or embarrass members of your profession.

Once you have identified an issue, you are ready to go looking for a problem. Often, identifying an issue will also give you one or more problems. So, for example, a practitioner will seldom give you an ethical issue without describing one or more times when she faced that issue herself. If, however, identifying an issue has not given you a suitable problem, you should begin looking for one in a file you should have been keeping. This file would contain newspaper stories raising ethical issues relevant to your course, parts of novels or short stories raising such issues, problems out of text books, problems your colleagues have given you, problems students have given you (and given you permission to use), problems you developed for other purposes, problems published online, and so on. If all else fails, start asking colleagues, students, and practitioners if they know of a problem raising the issue. If this fails to identify a suitable problem, perhaps the issue you have identified is not live — and so, not worth discussing.

Once you have identified a "problem", you must still put it in a form suitable for use in your class. Problem writing becomes easy pretty quickly, but it is no more a science than writing a paper is. The first step is to draft the problem so that it seems to do what you want it to do. When your draft is done, you should be able to answer yes to the following question:

- Is the story line clear (clear enough)?
- Does it contain enough information (but not too much)?
- Does it raise the right issues (and not too many others)?
- Will students care?

If you cannot answer yes to all four, you should keep revising until you can. Once you do answer yes, you should put the draft aside for few days. That should be enough time to see room for improvement. Make the improvements and then test the problem on a student or colleague. Such a test should uncover a number of points in need of clarification by addition, subtraction, or wordsmithing. Rewrite accordingly and then use in class. Classroom use usually reveals a whole new set of imperfections. Rewrite accordingly.

Like a paper, a problem is never really finished. But, at some point, we decide that the improvements that may be possible are no longer worth the effort necessary. That is the point at which to stop rewriting and to declare the problem finished (for now).

# VI. Conclusion

The ideal engineering curriculum would probably include a first-year Introduction to the Profession in which students would learn something about the history, organization, and practice of engineering. Such a course would be a natural place to introduce students to the profession's code of ethics, to a general approach to analyzing ethics problems, and to a number of classic problems. During the second and third years, professors teaching analytic courses could do enough ethics in their courses to be sure students not only do not forget the first-year's lessons but also get used to looking for ethical issues in everything they do. Different courses might emphasize different ethical concerns to avoid the impression that there is not much variety in engineering's ethical problems. The senior design course should give students the opportunity to bring together what they have learned over three years in an environment much more like that of actual practice. For example, they might, as part of their final written report, be asked to identify all the ethical problems that came during the design project, explaining how they resolved each.

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# Appendix: Seven Step Guide to Ethical Decision Making

- State problem (e.g. "There's something about this decision that makes me uncomfortable" or "Do I have a conflict of interest?").
- Check facts (many problems disappear upon closer examination of situation, while other change radically).
- Identify relevant factors--e.g. persons involved, laws, professional code, other practical constraints (e.g. under $200).
- Develop list of options (be imaginative, try to avoid "dilemma" not "yes" or "no" but who to go to, what to say).
- Test options, using such tests as the following:

1. Harm test -- does this option do less harm than alternatives?
2. Publicity test--would I want my choice of this option published in the newspaper?
3. Defensibility test--could I defend choice of option before Congressional committee or committee of peers?
4. Reversibility test--would I still think choice of this option good if I were adversely affected by it?
5. Colleague test--what do my colleagues say when I describe my problem and suggest this option as my solution?

6. Professional test--what might my profession's governing body or ethics committee say about this option?
7. Organization test--what does the company's ethics officer or legal counsel say about this?

- Make a choice based on steps 1-5.
- Review steps 1-6: What could you do to make it less likely that you would have to make such a decision again?
- Any precautions can you take as individual (announce your policy on question, change job, etc.)?
- Any way to have more support next time?
- Any way to change organization (e.g., suggest policy change at next departmental meeting)?

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# Footnotes

- 1 Of course, moral judgment does seem to improve in college (and most graduate programs) more than outside. But these improvements, though real, are relatively small, probably too small to justify even one course with the improvement of general moral judgment as its object. Courses with other objects can, however, make much the same improvement in moral judgment simply by teaching ethical judgment.
- 2For those with (post-Nozickian) doubts about appeal to the principle of fairness, see my "Nozick's Argument FOR the Legitimacy of the Welfare State", Ethics 97 (April 1987): 576-594; and Richard Arneson, "The Principle of Fairness and Free-Rider Problems," Ethics 92 (July 1982): 616-633.
- 3 For more on the distinction between business and professions, see my "Is Engineering Ethics Just Business Ethics?", International Journal of Applied Philosophy 8 (Winter/Spring 1994): 1-7.
- 4 For a mgore extended defense of this analysis of engineering as a profession, see my "Is there a Profession of Engineering?", Science and Engineering Ethics 3 (October 1997): 407-428; and *Thinking like an Engineer* (Oxford University Press: New York, 1998).
- 5 While I think this list of aims identifies the chief ones in a way especially useful for thinking about teaching engineering ethics, I do not consider it to be

either complete or canonical. Compare James Rest, "The Major Components of Morality." in Morality, Moral Development, and Moral Behavior, W. Kurtines and J. Gewirtz, eds. Wiley: New York, 1985. Sarah Pfatteicher's three objectives ( "EC2000 and the Engineering Ethics Dilemma", a paper prepared for this conference) seem to correspond to mine my first three more or less, though her suggestions about grading suggest she may not have a clear idea about how judgment can be taught and graded. In any case, her list completely misses my fourth objective.

- 6See, for example, Pfatteicher.
- 7 For an extended defense of these claims, see my *Ethics and the University* (Routledge: London, 1999).
- 8 I shall here ignore outreach to practitioners, whether formal extension courses or less formal sensitivity raising (such as having students interview engineering managers about how an engineer's ethical question would be handled in her company). I ignore outreach not because I consider it unimportant but because I consider it both too important and too large a topic to be crammed into a paper on the curriculum. But I cannot resist pointing out how important outreach is. Nothing we do to teach ethics to pre-professionals will have much effect if, upon graduation, they enter a workplace where no one takes ethics seriously or where, almost as bad, no one knows how to talk about ethics. In such an environment, ethical sensitivity, knowledge, judgment, and will-power (like other unused sensitivity, knowledge, judgment, and will-power) will shrivel.
- 9 For a good critique of the honor system, see the entire issue of *Perspectives on the Professions* 14 (January 1995).
- 10 Institutionally, a team-taught course is quite different from a mere guest lecture. It requires two salaries rather than one and, if the teachers come from different departments, complex administrative arrangements as well. Team taught courses generally seem to be one way faculty have of learning from one another. After a few semesters, the team generally breaks up, with one member (or both) going on to teach the same course alone. For faculty, a team taught course is like a workshop (rather than, as it seems to students, a convenient way of dividing work).
- 11 Problem 10.21, Moran & Shapiro, *Fundamentals of Engineering Thermodynamics*, 2nd edition, John Wiley & Sons, 1992.

## Notes

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