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Broadening and deepening engineering students' perspectives on morality and ethics

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Abstract

With the primary tenant of the National Society of Professional Engineers (NSPE) articulating that engineers shall "hold paramount the safety, health, and welfare of the public," and other professional engineering societies using the same or similar language, engineers need broader and deeper understanding of moral and ethical theories that can help them understand and make ethically informed decisions about their designs. Ethical understanding is necessary for engineers to determine the appropriateness of pursuing projects and to think through how these are likely to be used in current systems. From common devices to complex systems, the technology engineers design profoundly shape society and change our environment, which in turns affects society. As complex systems become more pervasive into our everyday lives, ethical decisions regarding technology and policy require engineers to consider multiple moral theories in more depth than "do the greatest good." With this guiding thought, we developed an *Ethics of Engineering Design* course to introduce engineering students to multiple moral theories with specific examples of how one could apply the theory to particular technologies. Over the course of the semester we introduced students to Moral Relativism, Ethical Egoism, Contractualism, Casuistry (reasoning by cases), Act-Utilitarianism, Rule-Utilitarianism, Pluralism, and Virtue Ethics. To provide inspiration and context for applying these theories, we discussed cases of whistleblowing, Flagstaff's Dark Skies policies, self-driving cars, DARPA's mach-20 glider, Universal Design (designing for disabilities), and the industrialization of agriculture. In addition to moral theories and cases, we introduce concepts and ideas about the impulse towards technological design, discrimination, capitalism, sustainability, governments and democracy, participatory design, and social justice. This paper will provide examples of how we carefully designed a course that systematically and progressively paired complex ethical theories and concepts with current technological questions and social realities. We believe the basic structure of this course provides students with a framework for integrating knowledge from liberal studies requirements (such as philosophy) into their engineering courses, and that such courses can, in the long run, enable more ethically reflective engineering choices.

Context

One of us teaches engineering design courses and courses in mechanical engineering. One of us teaches a variety of ethics courses in the philosophy department. We met two years ago on a team drawn together to design an ethics module for a course shared across several engineering majors. We are now in the process of piloting a full course in engineering ethics that we believe will be adopted by the university as a liberal arts course for engineering majors. This paper describes the approach we have pursued, often pointing out how it may be different from other similar courses at other universities.

The Need for Increased Breadth and Depth

An engineering career sometimes occupies and guides an entire human life, and unsurprisingly, therefore involves ethical decisions at different stages of life, at many different levels, in different contexts, and of many different kinds.

Engineering ethics textbooks written for undergraduates can too easily underestimate the complexities that such lives will involve. The same textbooks can also too easily underestimate the ability of undergraduates to appreciate and understand a genuine variety of ethical approaches. In the short run, these oversimplifications sometimes produces textbooks and courses that are often too bare to have much connection to the ethical decisions students are already making in their studies, will shortly be making when they enter their professions, and will make over the course of their lives. Unsurprisingly, ethics courses that do not respect the deep complexities raised by engineering design and technology are likely to generate students that walk away unimpressed with the ethical thinking offered them.[1] It is only later, when very difficult ethical choices are presented that engineers come to regret not being sufficiently prepared.

With these considerations in mind we have deliberately constructed a course so that students, as future engineers and designers, will have the chance to think broadly and deeply about a number of kinds of cases, and through many different ethical lenses.

Framing Together Ethical Theories and Engineering Design Problems

We begin the course by posing at least one engineering problem that calls for difficult and sustained ethical consideration, and which does not have an easy answer. Perhaps more precisely, we pose a problem that has multiple plausible answers, but no easy answer that is clearly better than all the rest. Our favorite so far involves the ethical issues raised by current, nascent self-driving cars. Such technology raises questions about the personal responsibility of designers, consumer choice, markets, and those subject to the effects of dangerous technology working in public spaces. We ask students to think through a scenario in which a self-driving car cannot help but injure someone. What ethical principles should guide the automated driving program that will make this decision? Who is morally responsible for it?

After showing that, for engineers, serious ethical decisions are unavoidable in design contexts, and require more than mere acquiescence to conventional thought, for much of the course we focus on carefully pairing engineering issues and decisions with relevant moral theories such that theory illuminates practice, and practice illuminates theory.

As will become clear, the number of ethical theories we draw from moral philosophy is likely far greater than many engineering ethics instructors may realize even exist. Too often, engineering courses offer a cursory explanation of codes of engineering ethics, utilitarianism, Kant, and perhaps a bit of virtue ethics. The examinations that these theories often get is far too brief, and being so brief, can implicitly encourage students to underestimate their worth. Furthermore, there are many *other* theories, often not covered at all in engineering courses, that are worth careful and deep consideration.

Just as important as increasing the breadth of ethical approaches to understanding and decision-making is the task of connecting these concepts to real-world engineering issues. Thus, we have put effort into carefully pairing ethical approaches with technological design problems. These connections quickly highlight the key features of various ethical theories, and at the same time what each theory can and cannot do in terms of providing insight and practical guidance.

Moral Relativism, Ethical Egoism, and Self-Interested Contractualism

In our combined experiences of teaching, there are three ethical principles that young engineering undergraduates are likely to gravitate towards initially: (1) some version of relativism, (2) some version of egoism, or (2) some version of consequentialism. More about consequentialism in a moment.

To bring the theories of Moral Relativism and Ethical Egoism into a discussion engineering students will find relevant, we have students consider the question: Why should an engineer attempt to follow their own profession's codes of ethics, or take seriously the ethical guidance offered by institutions like the NSPE's Board of Ethical Review?

The main claim made by Moral Relativism is that a person is morally required to follow the norms of their culture.[9] We carefully discuss the main features of this view, and use it to begin to show by example what ethical theories are and how to objectively evaluate them. We also carefully show many of the specific reasons why nearly all philosophers reject Moral Relativism as an adequate explanation for moral obligation. Thus, students are exposed to a critical discussion of one kind of answer that they might try to give in favor of following the codes.

Next we consider the answer given by Ethical Egoism—the principle that what a person morally ought to do is exclusively pursue their own self-interest. Here we use the most common, though flatfooted conception of self-interest, namely, something like professional success and recognition, monetary reward, social prestige, political power, etc. At a social level, such a narrow conception of self-interest finds its most natural extension in moral theory in versions of self-interested contractualism. On such contractualist accounts moral obligations are found in the rational agreements between individuals seeking their own self-interest, but aware that this requires at least some reciprocal cooperation from others. According to this sort of Self-Interested Contractualism, enlightened individual self-interest drives people to form agreements with others. This is one explanation that has been given for why engineers should promote and follow publically stated engineering codes.[2] It is in their collective interest says Contractualism. But, we also then work through some of the reasons that appeals to self-interest, whether in the form of Ethical Egoism, or in the more complicated versions proposed by Contractualism, cannot offer not a stable foundation for the ethical obligations of engineers. Primarily, both theories, grounded as they are in an individualistic conception of self-interest, are subject to problems revealed in so-called “prisoner’s dilemmas”—cases in which everyone is worse off if they follow their own narrow personal self-interest than if they did not.

Ethics by Cases and Analogy

Theories to this point have all been guided by some central principle, but a different and very common way of reasoning about ethics is through analogy. Analogical reasoning is systematically used, for example, in NSPE Board of Ethical Review decisions when engineering ethics committees cite previous cases as guiding precedents for new, unresolved cases. The method of using analogical reasoning across cases exploits the principle that like cases should be treated alike. Casuistic reasoning is ubiquitous in engineering design settings, and we carefully try to show how it works, when it does, through considering several BER cases. But then we also highlight its shortcomings as a comprehensive methodology for making engineering decisions, and why thinking about cases, even if cases play important roles in thinking about ethics and in making decisions, is usually driven back to thinking in terms of principles when pressed. In short, all analogical reasoning must come to terms with the problem of specifying which features of various cases are ethically significant, and that is exactly the kind of guidance offered by broader ethical principles.

Act-Utilitarianism and Rule-Utilitarianism

Perhaps no form of reasoning about ethics is more natural to engineers, or designers quite generally, than consequentialist reasoning. Engineering design is meant to *accomplish something*. This impulse resonates well within the consequentialist family of moral theories since they all share the common idea that we should evaluate the morality of our individual and collective choices, ultimately, by the consequences they bring about. If read carefully, it is clear that consequentialism is *not* in fact explicit in the directive that engineers shall “hold paramount the safety, health, and welfare of the public.” Nevertheless, such claims are almost always given a consequentialist interpretation within engineering contexts. The moral dimensions of commonly discussed engineering accidents, such as the Challenger disaster, are often read as morally bad *because* poor decisions led to bad outcomes.

Within much of western philosophy consequentialism dominated the landscape from the early 19^{th} century until the middle of the 20^{th} century, and it is still one of the major players in contemporary debates among philosophers. But too little of what has been learned about its strengths and limitations end up in engineering ethics textbooks. For example, the explicit discussion of consequences and how to deal with them takes about three pages of Whitbeck’s book *Ethics in Engineering Practice and Research,*[10] though Fledderman’s discussion under the heading “A Brief History of Ethical Thought” is truth in advertisement, and only takes seven.[3] Too often it is assumed in such short discussions that we all basically know the nature of the good that engineers are supposed to bring about—most typically something like public safety combined with the promotion of consumerist choices. It is also typically assumed that engineers should in some sense maximize such goods—the more the better.

In contrast, in our course we carefully discuss the ways in which John Stewart Mill's Act-Utilitarianism, arguably the most historically influential form of consequentialism, uses psychological pleasure as a basic value, and how pleasure features in its standard of aggregate maximization. We also show how early versions of utilitarianism, which focused on the rightness or wrongness of *acts* insofar as they brought about the best consequences evolved into new versions of consequentialism that employed rules. Rule-utilitarianism claims that we should evaluate rules in terms of the good consequences that follow from following those rules, and then evaluate actions in terms of their conformity to the best rules.[9] This idea, that good engineers are those that follow *good rules*, resonates with engineers.

There are many engineering questions and topics that illustrate consequentialist reasoning. But we have found it very useful to focus on topics that are slightly off the beaten trail, such as how consequentialist reasoning deals with the technology of agricultural systems, and how it deals with algorithms that purport to better predict criminal recidivism than human judges. Such topics are not as well worn as questions about, for example, the safety of bridges or buildings. Because of this students are more likely to be a little caught off guard by the implications of consequentialist reasoning, which can be startling. We discuss nighttime artificial light pollution, for example, and the relevant ethical consequences of it, including: public safety, public feelings of safety, efficient lighting design, scientific access to unlit night skies, the environmental damages of excess artificial lighting at night, human health concerns that trace back to over-lighting, and so on.

As a transition out of purely consequentialist theories, we point out that many living consequentialist philosophers have accepted that there may be many fundamentally different *kinds* of consequences that matter.[9] We make the point of reminding students that, even from the very beginning of the course, it has been clear that in engineering contexts there are almost always *different kinds of ethical concerns*—concerns about cultural norms, self-interest, work-place conditions, special family obligations, happiness, fairness, and so on. More comprehensive ethical theories—theories that can embrace the full variety of ethical concerns raised in real-world engineering decisions—are going to have to provide some way of containing and resolving all of these very important, and sometimes conflicting concerns.

Pluralism

The penultimate ethical theory that we consider with respect to personal responsibility is W. D. Ross' pluralism. Pluralistic ethical theories are well known and often studied by philosophers of ethics.[9] On these theories, ethics is a matter of a limited set of equally basic, but fundamentally different, set of moral principles for acting. In contrast to theories on which one kind of fundamental ethical consideration (e.g. overall human happiness) always matters in exactly the same way (e.g. more human happiness is always better), pluralist ethical theories hold that there are a multiplicity of kinds of things that matter morally, and in particular situations they can interact in complex ways. In particular, for Ross, there are seven fundamental sources of moral obligation. Depending upon the particular circumstance we can have moral obligations with respect to benefiting others (beneficence), self-improvement, giving others what they deserve (justice), avoiding harming others (nonmaleficence), being trustworthy (fidelity), being grateful, or addressing harms we have caused (reparation).

The complex and subtle ethical situations described by pluralist theories are nothing really new to engineers familiar with the vagaries of the real world. And for those students who have not already worked, for example, as an intern in an engineering setting, many of the previous engineering issues raised in the course have already illustrated the possibility that ethics is not one unified concern, but rather many. Such a possibility was seen in issues raise by self-driving cars, engineering codes, the nimble analogical reasoning displayed in BER discussions, and so on. But in our experience engineering students are not aware, as most of the public is not aware, that the theory that posits such a landscape has a name—"pluralism." Nor are people generally aware that philosophers have been working on pluralistic theories for several generations, and have worked towards some of its most plausible forms. Our course takes pains to show engineering students that pluralistic theories like Ross' attempt to accommodative multiple kinds of considerations in systematic fashion without just giving in to the vague platitude that engineers will just have to use their best professional discretion.

Technology, Society, and Virtue

The final section of the course attempts to situate individual engineers within broader social and normative contexts. By expanding their conceptions of what engineers are plausibly responsible for in the first part of the course—through discussing the various theories of personal ethical responsibility—students are in a good position to think about larger forces that shape their moral lives. It is to the good to insist that students take as much moral responsibility for their engineering careers as they can. But if the world is a moral ocean, they need to understand more than the boat they are piloting. They also need to see and read the ocean currents.

The topics we have so far trialed include: the social shaping introduced by the impulse towards technology,[6] militarism within engineering education, relations between technology and colonialism and globalization and democracy,[8] human technological enhancement and disability,[7] automation and employment, technology within free markets, and environmental impacts of technology in industries like mining. Each of these topics is important in its own right, and we discuss each as such. But all of these topics, given their location in social reality above and beyond any particular personal choice, also naturally lead into the last theory of personal ethical responsibility we discuss—virtue ethics.

There have been a handful of articles in engineering journals that attempt to show that virtue ethics is a good framework to understand the ethical responsibilities of engineers.[5] In general this makes a lot of sense, because one central thread of all versions of virtue ethics is to evaluate actions in terms of the underlying character traits they express. And such good stable traits—*the virtues*—are presumably what we really want out of our engineers when all is said and done. Our hope is not just that engineers will always design safe versions of what they are told to design. More than this we also hope that engineers will create and pursue worthwhile projects, make good friends along the way, and cultivate all of the various forms of excellence that good engineering requires of them—both in design contexts and as participants in democracy. Thus, our course introduces and discusses virtue ethics, so far an ethical framework not typically included in courses focused on engineering design or technology. Our hope is that virtue ethics can draw in all of the most plausible kinds of ethical considerations emphasized in previous theories, and connect them with larger questions of living a human life well.

Student Assessment

The main aim of the course is to get students to think as deeply as they can about different ethical approaches to their engineering decisions, and to see them in the context of larger social forces. In this way, the course focuses first and foremost on the *activity* of participating in moral philosophy well, rather than giving students a pre-set list of conclusions that they should reach. We emphasize that there are in fact, at least in many cases, better and worse answers, and better and worse choices. But it is not the aim of the course to either try to guess which specific engineering ethics choices students will later face, or to give them principles so general that they will be discovered to be uselessly vague later. We are satisfied if students show a sustained and increasing ability to take in ethical concepts and theories and think through them carefully, and to draw connections between these theories and real world cases.

With such an aim in mind, one backbone assignment given to students is to have them complete small writing assignments about assigned material for the class before they arrive. They are asked to think through material—a philosophical essay, a textbook chapter, a news article, a documentary—and compose one main claim about that material worth discussing. Given the diversity of the materials assigned, students will do a lot of different things to prepare for different discussions: they might propose a criticism, they might elaborate and idea, they might draw a comparison to previous material, and so on. These small assignments are graded primarily on whether they demonstrate a preparedness to have a serious philosophical discussion in class about the material.

In conjunction with these assignments we also devote a large portion of course grades to their philosophical contributions in class. Students are given a detailed description of what counts as good philosophical teamwork. We emphasize, again, that the main aim is to participate well in the *activity* of philosophy.

The other large assignments are exams. Small portions of exams are dedicated to basic comprehension, as tested by True/False questions. But the majority is short answer and long essay. In short answer questions, students are asked to explain key concepts, arguments, or objections in their own words. In long essays, they are typically asked to explain an ethical issue such as modern agriculture, apply two different ethical approaches to it, and comparatively evaluate the insight offered by each.

As bookends to the course, we also do a pre/post activity. As described at the beginning of this paper, we have students think through a thorny engineering case, for instance self-driving cars. As their very first activity in the course, they write a response to such a case formed as a prompt. At the end of the course they are given the identical prompt again. Though data is so far quite limited, it appears that students, in their second attempts, are generally displaying a wider range of sensitivities to various ethical considerations, and are thinking through them more precisely and carefully. In the very same case, on a second time through at the end of the semester, they are identifying *more kinds* of ethical considerations and developing engineering design responses to them that are more thorough and more creative than at the beginning of the course. Though this is so far inconclusive, it is a bit of promising data that many students are getting from the course what we hope they are.

Conclusion

It is important that a courses addressing technology and engineering ethics rise to the real-world complexities that engineers are likely to face in the course of their careers. The course we have designed is meant to broaden and deepen the kinds of theories and issues that are standardly taught in university courses. This is an area where only broad and deep philosophical reflection can offer what engineering education requires, and we believe instructors in such classes should not shy away from it. We hope our suggestions here can help guide those who would like to design or modify their own courses to acknowledge and embrace the ethical difficulties in the life of engineering design.

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