Ethics by the Dose: Medical Treatment Metaphor for Ethics in Engineering

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Abstract

Developing effective ethics training for engineers is an important but challenging proposition. When engineering educators teach ethics, we hope we are doing so in ways that will have powerful effects for our students: not just familiarizing them with tools they can use to navigate workplace legal structures, but also changing how they perceive engineering as a field for ethical action. In this paper, we consider the degree to which ethics are integrated into engineering courses. To this end, we examine the popular use of the medical metaphor of "dosage" in relation to ethics in the engineering classroom. We identify this usage pattern and use thematic analysis to consider its implications in engineering education literature. Taking medical metaphors seriously can sensitize us to certain troubles related to the limited integration of ethics into engineering classrooms. This has implications for projects related to education research and engineering education reform. Focusing on what we expect ethics education to do can help us to undertake, evaluate, and communicate about our work as educators, and to imagine new possibilities. Concluding, we reflect on the ethical "wellness" of a whole engineer–and, indeed, whole communities in which engineers live and work—to frame questions about what ethics education could mean if we approached it differently.

Introduction

Developing effective ethics training for engineers is an important but challenging proposition. When engineering educators teach ethics, we hope we are doing so in ways that will have powerful effects for our students: not just familiarizing them with tools they can use to navigate workplace legal structures, but also changing how they perceive engineering as a field for ethical action. Indeed, while only ABET outcome 4 deals with ethics as of 2019 (requiring students to develop "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts") [1], ethical implications remain a yardstick by which technologies, the processes of their design, and the implications of their use are constantly measured. As important as it is, incorporating ethics training into engineering coursework is still very much in development [2]. Recent work on ethics education has demonstrated the benefits of teaching what Herkert terms "macroethics," that is, in relation to broader social priorities and values, in contrast to "microethics" related to individual decisions [3]. In response, many educators are exploring strategies to help students understand engineering as a sociotechnical process inextricable from its context (see [4]; recent examples of these activities have been described at the ASEE by [5] [6] [7] [8] [9]). However, the scale at which we conceptualize ethics is not the only issue worth attending to in relation to engineering education. The degree to which materials related to ethics are integrated into coursework requires attention, too.

In this paper, we consider the degree to which ethics are integrated into engineering courses. To this end, we consider the popular use of the medical metaphor of "dosage" in relation to ethics in the engineering classroom. We identify this usage pattern and use thematic analysis to consider its implications in engineering education literature [10]. Taking medical metaphors seriously can sensitize us to certain troubles related to the limited integration of ethics into engineering classrooms. This has implications for projects related to education research and engineering education reform. Focusing on what we expect ethics education to do can help us to undertake, evaluate, and communicate about our work as educators, and to imagine new possibilities. Concluding, we reflect on the ethical "wellness" of a whole engineer—and, indeed, whole communities in which engineers live and work—to frame questions about what ethics education could mean if we approached it differently.

Engineering and Medicine

The fields of engineering and medicine are both professions in which highly specialized training is put to practical application. While there may be significant similarities across these fields, the specific ethical quandaries they frame and means of training students to engage with them are not shared [11], nor are their structures of governance [12]. Nonetheless, engineering educators frequently borrow terms from medicine, if not practices or organizational models. Terms like "dosage," "cure," and "treatment, " which might be considered technical in medical spaces, are used metaphorically in engineering education to discuss ethics training. While a medical context is not the only one in which these terms are ordinarily used, the prevalence of medically-useful terms in engineering education is notable.
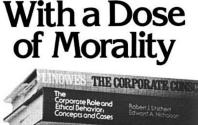

Figure 1: Medical language used in an article about ethics education at the Illinois Institute for

Technology. [13]

In just one example from the textbook *Teaching Engineering*, Wankat and Oreovicz stress that "the cure for cheating" is better approached through prevention rather than a more responsive approach of dealing with cheating after it has occurred. They call students who frequently cheat "chronic cheaters," indicating a persistent problem [14]. The engineering education literature is host to many such usages, some more overt than others. In light of the common use of medical metaphors in engineering education and how medical meanings of "dose" predominate in English language usage, we find it very likely that many of those who describe their ethics programs in this way are referencing, if only in the loosest sense, the medical meaning of the term.

Considering the doses of ethical course content that engineering students experience with respect to the term's medical meanings can highlight certain issues that are important for educators as well as medical practitioners, even if we do not address the topic in all of its technical implications. Treating ethics training as a special dose implies that it is unusual, different in important ways from what engineering students are usually taught. Further, if ethical training is taken in doses, we can consider it to be understood as quite impactful even when an apparently small amount is administered.

Just as medical professionals may be interested in comparing the efficacy of medications in treating diseases, many conscientious engineering educators (especially those who are "teacher-scholars" or those who believe in research-informed teaching) are fascinated with comparing their ethics pedagogies [15] [16]. This paper does not offer a compendious literature review of these efforts, but a reflection on how we as a community understand, describe, and engage in the shared project of ethics education.

Ethical Dosage: Integration and Effect

In engineering education, different "doses" of ethics not only mean different pedagogical methods, but also suggest different ways of understanding what ethical intervention can mean in terms of integration with other classroom topics and potential efficacy for students. Analyzing how engineering instructors use the language of dosage in relation to ethics and the medical analogs that they draw upon when they do so can draw critical attention to how ethics are treated in engineering education.

Table 1: Dosage in Engineering Ethics and in Medicine

Dose Type	Engineering Ethics	Medicine
Micro	Short engagement with ethics often used in part of a technical lesson	A very small exposure often used in new drug testing protocol or other highly controlled exposure
Infusion	Ongoing engagement as part of technical coursework	Introduction of a new substance into an entire system
High	Dedicated course on ethics often used to focus students' attention only on ethical issues	Large exposure often used for conditions resistant to lower doses or with patients in especially poor condition

As Riley et al. explain, the lowest doses of ethics might be called "micro-insertions" into engineering coursework. They often complement technical coursework and gradually introduce students to the ethical implications of class topics [17] (see also [18]). A project designed by Mohagheghi for an electrical engineering course is an example of this kind of teaching. Students are given a scenario related to working for a Colorado power utility that has received funding for a wind farm. While calculating the technical specifications needed to build wind energy infrastructure, the students must also consider the project's potential environmental and community impacts [19].

Although the medical analog is a loose metaphor, this is in keeping with the basic medical theory on small doses. "Microdosing," one of the forms that low dosing can take, is a common practice in pharmaceutical drug development whereby human subjects are administered sub-therapeutic levels of a drug during Phase 0 testing. The purpose of microdosing is to provide evidence of a response in the body to both demonstrate viability and avoid any uncertain risks associated with a new drug [20]. Another, less common type of microdosing involves ingesting small amounts of psychedelics in order to improve creative thinking and problem-solving abilities [21]. In the engineering classroom, a microdose might entail a short portion of a lecture devoted to an ethical dilemma or a case study assigned as homework. This kind of ethics training may be particularly useful for engineering faculty who want to showcase connections between technical and ethical subject matter. It may also be useful for educators who do not specialize in ethics and do not feel qualified to teach more substantial engagements with it, as well as those who are concerned that they have limited time in their courses to spend on topics related to ethics. In this context, the microdose approach can be attractive because it allows engineering faculty to introduce some ethical material to students as a part of another lesson. Though integrating microdoses of ethics is often the result of substantial planning, it may not require investing too much class time in the process.

Sustained microdoses of ethics may be administered by "infusions," in which material related to ethics is connected directly and thoroughly to the technical content of engineering courses. This is particularly viable through a capstone project, thesis, or other participatory design process in which students engage with stakeholders ([22] see also [23] [24]). In these, material dealing with ethics is not considered separate from the main topics of the engineering course, but instead as inextricably related to it as blood is when infused into a human body. Infusions of ethics may entail complicated course planning that can be a challenge for educators who are inexperienced in method and topic areas, but they can nonetheless be strong options for helping engineering students see ethical implications in their work.

A "high dose" of ethics, on the other hand, might entail a larger-scale endeavor such as a dedicated course of study focused explicitly on engineering ethics [25] [26]. Such an intervention is meant to cultivate not only ethical awareness and sensitivity, but often ethical commitment and judgment among students. As such, courses designed to administer high doses of ethics may be core components of students' professional formation [27]. In medicine, a high dose is one that exceeds ordinary exposure within a conventional treatment regimen. Treatments are administered this way to patients who are resistant at lower dosage levels and those who could benefit from aggressive care. Depending on patients and their circumstances, high doses may be administered over a brief course to treat acute conditions or over a longer term to treat chronic afflictions. Examples include aggressive chemotherapy treatments for certain types of cancer [28], antibiotic regimens for treating bacterial infections [29], and increased antidepressant doses for patients with severe clinical depression [30]. Many engineering education programs today administer high doses of ethics, perhaps in light of an understanding that lower doses have been unreliable or ineffective, or even that students are in serious need of such treatment.

Provoking Side Effects and Treating Symptoms

As engineering educators, we dose students with ethics with the goal of preventing them from experiencing or causing harm in their professional capacity as engineers. Further, we do not contest the idea that ethics may often be a foreign element in engineering curricula, or that ethics education can have powerful and productive effects for engineering students. The dose model we describe in this paper has developed in light of certain very real challenges and needs. However, we also consider it worthwhile to confront the challenges involved in engaging engineering students with ethical curricula. Drawing on and extending the medical metaphor here to consider side effects helps us outline critiques of the way engineering educators approach dosing students with ethics.

Table 2: Advantages and Challenges Associated with Dosing Students with Ethics

Dose Type	Advantage in Engineering Ethics	Challenges in Engineering Ethics
Micro	Integrate with other coursework; take up little course time; show students that ethics are central to engineering	Requires modifying course planning; requires integration across curriculum; may be designed for the wrong symptoms
Infusion	Integrate with other coursework; show students that ethics are central to engineering	Challenging course planning; benefits from broad integration across curriculum; may be designed for the wrong symptoms
High	Extended time to discuss ethics material in-depth; can directly address problem areas	Students may perceive as irrelevant; benefits from broad integration across curriculum; may be designed for the wrong symptoms

Microdoses have the advantage of being relatively controlled. They are excellent ways to test out an idea. Their strength is also their weakness. The limited scope of this kind of ethics coursework can limit the depth of students' exposure to concepts or ideas. Microdoses require modifying technical course planning and may sometimes be—to extend the medical metaphor—too weak for the symptoms that they are designed to treat. Infusions, on the other hand, can facilitate more sustained engagement with ethics as well as technical topics. They may also be complex to plan out, requiring that instructors have both technical expertise and knowledge of ethics. Finally, high doses provide opportunities to discuss ethical material in depth and can directly address "treatment resistant conditions." Courses dedicated to ethics may seem extraneous for engineering students accustomed to thinking about their training as primarily a matter for technical topics.

It is worthwhile to consider how doses of ethics may cause irritation or side effects. For example, in high dose ethical treatments, failure to integrate ethics training and technical course material can reinforce the idea that ethics is not part of engineering. Scholars including Davis describe this situation as a matter of suggesting that ethics are "add-ons" and superfluous to technical education [23]. When students do not see how ethics are related to their course of study, they may not recognize the topic as important for their future profession. Students may not only perceive such ethics training as irrelevant, but may be bored or resistant to engaging seriously with the material.

Comparatively limited doses of ethics training, may be integrated into technical coursework and can be made directly pertinent to technical material. However, limited engagements are often not enough to significantly affect how engineering students understand themselves and their field.

As participants at a workshop on science and engineering ethics organized by the National Academy of Engineering point out, a single dose of ethics education may not have lasting effects. Ethics is not, they argue, a vaccine that "can be administered in one dose and have long-lasting effects no matter how often, or in what conditions, the subject is exposed to the disease agent" [31]. While there may be a broad consensus among many educators and scholars, a recent review of research-intensive universities' responsible research training plans showed that 86% of 91 plans reviewed simply employed a "single-dose inoculation" model [32].

Doses of ethics, whether low or high, part of a series or taken alone, must be designed to appropriately address the different conditions and needs of students, just as any medical treatment might. When ethical training focuses on teaching students about formal regulations, legal obligations, or ethics codes associated with professional engineering rather than giving them tools to consider their values, skills, and actions in context, it may not be helpful for confronting real ethical conundrums that they will face as professionals. As a recent study by Sochacka et al. has shown, approaching ethical work as a process of engagement rather than as an opportunity for box-checking requires a radical shift in perspective and process, but can also have transformative effects for participants [33]. Such approaches can even be folded into engineering-friendly criteria for evaluating projects (see [34], also [35] [36]).

Discussion

The models for ethics education that we describe here vary significantly. Microdoses of ethics can be introduced in relatively small interventions, and may afford testing and evaluating pedagogical strategies before investing scarce resources. Large doses or infusions can demonstrate the importance of ethics for engineering practice. However, each of these methods runs the risk of turning students off if administered in inappropriate contexts or to treat the wrong symptoms. They may be less than effective if not repeatedly reinforced and supported throughout curricular and co-curricular experiences. They may focus student attention on formal, legalistic box-checking rather than inspiring engaged, critical practice.

There are certain implications for engineering education practice to be considered here. Exploring medical metaphors can prompt us to consider how the engineering education that we develop is calibrated with our students' particular conditions and needs. It prompts us to ask whether and how we are taking their values, experiences, and knowledges into account in mixing and preparing their ethics lessons for them, or whether we are, instead, passing along what comes readily to hand. It gives us new terms by which to assess and celebrate student-centered techniques like asset-based education, and to be skeptical of banking or deficit-based models premised on their ignorance and status as homogenous and empty vessels (see, for example, [37]), and inspire us to build ethics pedagogy with serious self-reflection components (as in [38]).

These methods, of course, should be studied and disseminated. Medical research and

communication often examine patients' meaningful preexisting conditions. It could be useful if those involved in engineering education research and communication consider whether we do the same with our students. While we often address some aspects of student identity when we develop, study, and communicate about our teaching interventions (e.g., student gender, student race, etc.), we may take these categories as self-evidently important without asking what their identities and experiences might mean for students themselves. These categories, like any social category, are never simply given. Specific experiential and culture-bound issues can have consequences for how students approach values and ethics in engineering [39]. We might do well to find ways to take this seriously in our research and writing.

When engineering educators report their experience implementing certain ethics pedagogies, they are encouraged to provide detailed instructions on the use of these pedagogies, similar to how pharmacists may give medications to patients with specific instructions. Engineering education researchers might consider the utility of carefully reporting under what circumstances their ethics pedagogies are effective, in what sense, and with what potential side effects for how students understand and engage with ethical concepts and related issues of power, responsibility, and justice in their profession. Engineering educators who have created and tested these ethics pedagogies should to be aware that ethics pedagogies may only be effective in achieving certain learning outcomes while generating negative impacts in relation to other learning outcomes. We would do well to consider whether having some ethics instruction is *certainly* better than having no ethics instruction. Like medicine, ethics education is not always devoid of side effects, even when it achieves its manifest treatment goals.

Finally, there is the issue of broader educational reform. When we address health, we readily make distinctions between treating symptoms and fostering wellbeing. Considering the role of medical metaphors in engineering ethics education can help us frame new challenges for ourselves. Dominant forms of ethics education are designed to treat ethical maladies and prevent unethical behavior by future engineers. Like medical professionals, engineering educators need to be careful about the potential danger of perceiving ethics education as merely a matter of treating symptoms. Focusing solely on treating students' "ethically problematic symptoms" (e.g., cheating) may lead engineering educators to overlook more fundamental cultural and institutional problems deeply rooted in the engineering education system (see [40]). We note that there are other ways to think about ethics, including aspirational ethics that direct attention to reform and empower students to imagine their agency to transform their world [41]. If, directed by our reflections on medical metaphors, engineering educators considered the ongoing ethical wellness of a whole engineer—or even a whole engineering profession—rather than seeking to inoculate our students against taking dangerous or irresponsible action in the future or address less-desirable habits they have already developed, what else might student engineers and engineering educators aspire to?

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