Engineering Ethics Education for Social Justice

Elliot P. Douglas
Dept. of Environmental Engineering Sciences and Dept of Engineering Education
University of Florida
Gainesville, FL, USA
edouglas@ufl.edu

J. Britt Holbrook
Department of Humanities
New Jersey Institute of Technology
Newark, NJ, USA

***Abstract*—This Work-in-Progress Innovative Practice paper describes incorporation of social justice into engineering ethics education. Current teaching of engineering ethics pays inadequate attention to social justice, mirroring engineering education in general. While many authors have called for a reconsideration of the fundamental canons of engineering ethics, there has been relatively less work on teaching and developing ethics from viewpoints that highlight social justice. We have recently begun a project to address this gap, focusing on curriculum design and collecting preliminary data to demonstrate the efficacy of our approach. In this paper we describe the theoretical foundations for the class, the design principles, and the research approach to determine its effectiveness**

Keywords—ethics, social justice, Understanding by Design

I. INTRODUCTION

Riley and Lambrinidou [1] criticize engineering for its technical/social dualism, in which "real" engineering consists of technical calculations, while social considerations are considered "extra" and do not count as engineering. This dualistic understanding of engineering underlies the distinction between so-called "hard" and "soft" skills. Technical ("hard") skills form the core of engineering, while professional ("soft") skills comprise all the "extra" stuff: ethics, communication, teamwork, societal impact, etc. [2-4]. Such soft skills are supposed to be commonsensical, perhaps not requiring formal education, while technical skills are treated as difficult, requiring continual reinforcement in multiple classes.

The vast majority of engineering curricula pay little attention to social considerations [5, 6]. Although students initially value the social component of engineering, they experience cognitive dissonance between this value and the technocentric approach to engineering education, resulting in what has been called a "culture of disengagement" from seeing engineering as supporting public welfare [5, 6].

If engineering education in general tends to cultivate socioethical disengagement among engineering students, stand-alone courses in engineering ethics generally fail to cultivate a culture of engagement. The mere fact that such courses stand alone, usually as required courses for engineering majors, reinforces the dualism that contributes to a culture of disengagement [5]. Moreover, engineering ethics requires knowledge in both engineering and philosophy. However, this course is generally taught either by philosophers or engineers alone [7], making the problem worse.

Faculty teach what they know. Philosophers know philosophy, engineers know engineering. When taught by philosophers, many traditional approaches to teaching engineering ethics involve a good dose of philosophy, especially teaching engineering students about the major ethical theories, then teaching them how to "apply" those theories in the context of engineering practice [7]. Typically, philosophers teach this process of application to engineering cases. Cases present engineering disasters resulting from some ethical lapse, and students are asked to determine what an adherent of one or more of the ethical theories would say about how the engineer(s) in the case should have acted.

Another typical approach is to teach various engineering ethics codes as themselves philosophical documents [8]. Although courses in engineering ethics are supposed to endow students with an understanding of their professional and ethical responsibilities as engineers, philosophers tend to teach them to become applied philosophers instead of ethical and responsible engineers.

When taught by engineers, engineering ethics focuses on issues of professionalism and "practical" aspects of dealing with ethical dilemmas in the workplace, using the codes of ethics as the foundational document [7, 9, 10]. Thus, these courses address issues of microethics, such as receiving gifts from suppliers, being asked to change documents by supervisors, etc. Cases of engineering disasters are also discussed. When engineering ethics is taught by engineers it tends to teach students some elements of how to be a responsible engineer, but without a firm grounding in the ethical theories that could inform decisions.

Philosophers and engineers have long argued that something has to change in our approach to teaching engineering ethics. Herkert suggests that philosophers need to expand their focus on microethical issues (of, for instance, an individual engineer's professional responsibilities) and begin treating engineering – and the ethical issues associated with it – in its broader societal context [11]. By incorporating the approach found in the field of Science and Technology Studies (STS) and by engaging engineering professional societies, Herkert argues, engineering ethics courses can begin to incorporate macroethical topics, such as whether society should adopt a particular technology. After

Funding provided by NSF grants DUE-1933652 and 1933657

tracing the history of engineering ethics education, Mitcham draws a similar conclusion to Herkert's – engineering ethics education should take a 'policy turn', broadening itself to include topics that go beyond individual engineer's responsibilities to the profession and society [12].

II. Why Social Justice?

Although we agree with Herkert, Mitcham, and others that engineering ethics education must go beyond narrow, microethical considerations to include broader, macroethical issues, we have begun experimenting with a different mechanism to achieve that end – incorporating considerations of social justice into our engineering ethics classes. In this section, we outline our motivations and how incorporating social justice relates to traditional approaches to engineering ethics instruction.

First, it is important to note that philosophers have created a subfield of the discipline of philosophy that focuses on social justice. As in many other subdisciplines of philosophy, there is a divide between more theoretical and more applied approaches.

Within theoretical approaches, there is a further divide. On the one hand, we find more traditional social justice theory, which is a branch of political philosophy that deals with how to organize society to maximize social benefit; on the other, we find cutting-edge approaches that deal with issues of race and gender, for example.

Applied approaches to social justice tend to grapple with particular instances of social *in*justice. A salient example is the work of philosopher Kyle Powys Whyte, whose work focuses on issues of environmental justice, climate change, and food sovereignty faced by Indigenous peoples. Importantly, Whyte's approach to social justice philosophy involves engaging and forming relationships with the Indigenous peoples facing these issues. The idea is not simply to apply social justice theory to such issues, then to speak with other philosophers, but rather to work together with the people facing such issues to explore possibilities for rectifying the injustices they face. As such, the sort of research Whyte performs embraces just the sort of 'policy turn' Mitcham recommends for engineering ethics [12], but in a different context.

Our own embrace of social justice came from a shared experience as members of a group thinking about the Flint Water Crisis at Camp Engineering Education AfterNext, held at Purdue University in July, 2018. In addition to the authors of this paper, the group included a resident of Flint, E. Yvonne Lewis, and two STS scholars, Yanna Lambrinidou and Wenda Bauschspies. Lewis is the founder and CEO of the National Center for African American Health Consciousness. Lambrinidou is an anthropologist and a water activist who played a key role in the Washington, DC water crisis. Bauschpies works on gender and culture in connection with science and technology.

Although we spent much of the time working on a paper that we later presented at the VIII World Engineering Education Forum & X Global Engineering Deans Council (WEEF-GEDC 2018), we also spent much time listening to and learning from one another. One thing that became clear over the course of working together was that neither engineering nor ethics (alone or together) were capable of dealing with the realities Flint residents faced on the ground. We certainly did not find a solution that would solve all their problems. The question that arose for engineering education was how to educate future engineers to do better. Of particular importance was how to educate engineers so that they would become sensitive, and know how to respond, to signals of *in*justice.

III. Engineering Ethics and Social Justice

Although we reject the idea that teaching engineers ethical theories and how to apply them to engineering cases is sufficient for effective engineering ethics education, we do think it is important to empower engineers to make ethical decisions. Nevertheless, we also reject the idea that there is a set *method* of ethical decision-making that, once learned, could be used effectively any time an ethical dilemma arose. We also want to break our budding engineers out of their technical, problem-solving mindset while convincing them to take seriously a course that many may come into the class thinking of as an unnecessary add-on to their technical education.

This section describes two ethics courses taught at two institutions in the United States. Both of these are public institutions, and the students in these classes are almost entirely US students. Engineering students from almost every subdiscipline of engineering take the class at New Jersey Institute of Technology. The class at the University of Florida is specifically for environmental engineering students.

A. Engineering Ethics at New Jersey Institute of Technology

The course begins with a period of reorientation. The assignments ask them, in various ways, 'why are you here?' We then learn the approach to ethical decision-making known as Principlism [13]. Principlism is a good introduction to ethical decision-making because, although it is most well-known for its use with respect to biomedical ethics or research involving human subjects (Principlism is the foundation of the Belmont Report), it can easily be adapted to other contexts, and it is not itself an overarching ethical theory. Nor does Principlism supply a *method* for making ethical decisions. Principlism is a framework that appeals to multiple ethical theories and employs principles based on what Beauchamp calls "the common morality" – ideas so basic that any moral agent would have to accept them, e.g., that we should respect other persons.

Once students get a feel for Principlism, they also learn various other approaches to ethical decision-making, including Casuistry [14]. Casuistry has the virtue of beginning in the opposite place from Principlism and proceeding in the opposite direction. Principlism begins with principles, then interprets, balances, and specifies them for particular cases. Casuistry begins with a particular case and may or may not arrive at any basic principles. In his *Justice* class, Michael Sandel begins with cases, moves to principles, alters the case in ways that make us reconsider our principles, and then repeats the process. Since the course introduces specific cases after giving students some different approaches to ethical decision-making, we also move back and forth between Principlism and Casuistry as they grapple with cases.

Once students become comfortable making judgments about cases, we throw in another wrinkle. We read Plato's *Euthyphro* and *Apology* to expand on earlier discussion of Virtue Ethics. Taken together, these two dialogues discuss the limits of expertise, including the limits of expertise where ethical decision-making is concerned. Essentially, Plato has Socrates argue that people who may be experts in one area often make the mistake of believing their expertise is a sign of divine wisdom. They think they know it all. True wisdom, at least for a human being, is to recognize that one does not possess divine wisdom. We might know a lot; but it is a mistake to think we know it all.

At this point, the course makes the social justice turn. With a series of readings on listening, students prepare for a field experiment. They learn something about engineering-related social issues in the city of Newark, and then they form groups of 3-4 and must engage a Newark resident in conversation on the topic (e.g., lead in water, various other infrastructure issues, or gentrification). Their assignment is simply to get the person talking, then to listen. They may not take notes or make recordings. They must listen. Then, they return to class and present on the experience. They are to say with whom they talked, where, and when. They are to say what topic they began discussing. Then, they must recount what the person said and what they learned. Finally, they must reflect on the assignment in the context of the class as a whole, including evaluating whether it was a valuable assignment.

B. Engineering Ethics at the University of Florida

At UF, the ethics class being considered for this paper is the one taken by environmental engineering students. Thus, the focus is on environmental issues (see for example Table I). The primary goal of this class is to create a change in the way students think about ethics. The class is focused on the affective domain of Bloom's Taxonomy of Educational Outcomes [15], as opposed to the more commonly known cognitive domain [16]. The affective domain describes how people consider values and attitudes. From the most simple to the most complex, the categories of the affective domain are: receiving phenomena, responding to phenomena, valuing, organizing, and internalizing values. Class activities are designed to expose students to topics that result in them confronting how they consider others' values and the ways in which their decisions may impact individuals and society.

This course begins in parallel to the course at NJIT, with a discussion first of Principlism, then other approaches and ethical theories such as Casuistry and Virtue Ethics. From there social justice is introduced through a set of case studies. Table I lists the cases and the corresponding topics. In most cases the students are asked to consider the perspective of various stakeholders. For example, in Case Study 1 (India Air Pollution), students are divided into two groups and take on the role of either a farmer (who burns his crop stubble to clear the fields after harvest) or a health advocate.

TABLE I. ETHICS CASES IN UF CLASS

Case	**Ethics Topic**
India Air Pollution	Moral Theories
Gulf of Mexico Dead Zone	Tragedy of the Commons
Flint Water Crisis	Moral Theories, Engineering Code of Ethics, Community Engagement
Baltimore Sewage	Community Engagement
Fracking Waste in Texas	Environmental Justice

Throughout the class students are exposed to a critical approach to ethics. For example, the pre-reading for the class on engineering codes of ethics is both the NSPE code and a paper by Tang and Nieusma in which they show how development of the IEEE code was partially influenced by concern for business over the public [17]. Discussion of the NSPE code includes an analysis of the way its language prioritizes an engineer's employer. For example, statements relating to the public are phrased as "Engineers are encouraged to…", while statements relating to employers are phrased as "Engineers shall…" Similarly, the class includes a critical analysis of Corporate Social Responsibility (CSR). It distinguishes between CSR activities intended to truly benefit society, and those that are done primarily to promote a positive public image of the company.

IV. FUTURE WORK

While the two courses described in the previous section were created to incorporate social justice into engineering ethics instruction, they were not designed using established approached for instructional development. Although these two courses have been successful (as determined by student evaluations), by more carefully defining specific objectives and associated activities for the course we can ensure the courses better prepare students for ethical practice as engineers. It is also important to understand the courses' impacts on students. To accomplish these goals we have recently received a National Science Foundation grant to redesign both of these course and test their effectiveness relative to standard engineering ethics instruction. In the next sections we describe our plans under this grant.

A. Course Redesign

In their classic book *Understanding by Design*, Wiggins and McTigh discuss curricular design for understanding [18]. They define understanding as "mak[ing] connections and bind[ing] together our knowledge into something that makes sense of things (whereas without understanding we might see only unclear, isolated, or unhelpful acts)" (p. 7). While learning objectives are expected to be based on observable actions [19], understanding according to Wiggins and McTighe is a necessary first step. Thus, they describe the stages of curricular design as 1) Identify desired results, i.e. enduring understandings and specific objectives; 2) Determine acceptable evidence; and 3) Plan learning experiences and instruction. Their book provides a design template for use in planning. They also provide a set of design standards, which are guiding questions for each of the design stages. Fig. 1 provides an example of the result of this design process.

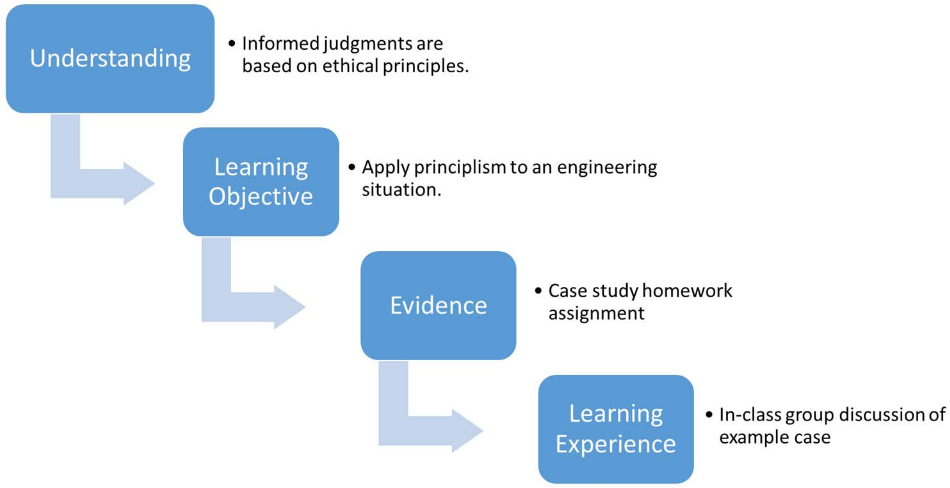

Fig. 1. Example of the result of the design process. It should be noted that there will be multiple understandings for the course, and for each understanding there will be multiple learning objectives, sources of evidence, and learning experiences.

B. Research on Course Impact

The goal of the research component is to understand the impact of this course on students. While moral judgment is an important aspect of engineering ethics education, we believe that necessary first steps to moral judgment are perspective taking and moral efficacy. As described above, a key element of our approach is guiding students to understand the social implications of the ethical choices they make. Doing so requires that they can empathize with the publics they serve (perspective taking) and are comfortable that they are able to make moral judgments (moral efficacy). The hypotheses we are testing are:

Hypothesis 1: Students who take an engineering ethics course revolving around social justice will have greater improvements in perspective taking than students in a traditional ethics course or students with no ethics instruction.

Hypothesis 2: Students who take an engineering ethics course revolving around social justice will have greater improvements in moral efficacy than students in a traditional ethics course or students with no ethics instruction.

Our data collection approach is guided by the work of May and Luth [20]. Perspective taking will be measured using the perspective taking subscale of the Interpersonal Reactivity Index [21]. This subscale consists of seven items which ask respondents to respond on a five point Likert-type scale, from strongly disagree to strongly agree, to statements such as "I believe that there are two sides to every question and try to look at them both" and "I sometimes find it difficult to see things from the "other person's point of view" (reverse scored) [21]. Moral efficacy will measured using items based on Parker's instrument [22]. This instrument consists of 10 items which ask respondents to respond on a five point Likert-type scale on how confident they would feel at conducting tasks such as "Analyzing an ethical problem to find a solution" and "Making suggestions to management for an ethical problem". We will also collect demographic data (gender, race, ethnicity, year in school, self-reported GPA).

Data will be collected in the classes of the two authors, as well as two traditional ethics class (positive controls) to determine if our class is more effective than standards ethics instruction on the outcome variables, and two classes with no ethics content (negative controls) to control for test-retest artifacts and ethical development simply due to being in school [23].

The instruments will be delivered using a pre-/post-test design. In order to test for equivalence of the students in each class, MANOVA will be conducted on demographic variables. Analysis of the two dependent variables (perspective taking and moral efficacy) will be conducted on pretest scores, posttest scores, and the difference between posttest and pretest scores. The primary analysis technique will be two way ANOVA with location (UF, NJIT) and treatment (social justice & ethics class, traditional ethics class, non-ethics engineering class) as the independent variables. The two way ANOVA will provide three different F-statistics, one each for location, treatment, and interactions of location and treatment. Post-hoc tests will be conducted on comparisons that show a significant difference in the ANOVA ($p<.05$). Note that we have contingency plans in case the data are non-parametric. The results of these tests will allow us to test our overall hypotheses (ANOVA), identify which classes are more effective than others at improving perspective taking and moral efficacy (post-hoc tests), and identify how important those differences are (effect sizes).

V. Conclusions

Our project seeks to recast engineering education to re-value engineering practice in terms of its benefits to society. Teaching ethics in terms of social justice is potentially transformative in two ways: 1) engineering ethics education rarely focuses on social justice, focusing instead mainly on engineers' professional duties; and 2) discussions of ethics and discussions of social justice are essentially segregated within the philosophical literature, and this project has the potential to bring them together in novel ways. Our ultimate goal is to transform engineering education and engineering ethics education in ways that will produce engineers focused on using the power of engineering to benefit society.

Acknowledgment

Wenda Bauchspies, Michigan State University, Yanna Lambrinidou, Virginia Tech, and E. Yvonne Lewis, National Center for African American Health Consciousness, serve as the Advisory Board for the current NSF project, and provided important guidance during the development of these courses.

References

[1] D. M. Riley and Y. Lambrinidou, "Canons against cannons? Social justice and the engineering ethics imaginary," in *ASEE Annual Conference*, Seattle, WA, 2015.

[2] W. Faulkner, "Dualisms, hierarchies and gender in engineering," *Social Studies of Science,* vol. 30, pp. 759-792, 2000.

[3] E. Godfrey and L. Parker, "Mapping the Cultural Landscape in Engineering Education," *Journal of Engineering Education,* vol. 99, pp. 5-22, 2010.

[4] D. Riley, *Engineering and social justice*. San Rafael, CA: Morgan & Claypool, 2008.

[5] E. A. Cech, "Culture of disengagement in engineering education?," *Science, Technology, & Human Values,* vol. 39, pp. 42-72, 2014.

[6] S. Niles, S. Contreras, S. Roudbari, J. Kaminsky, and J. Harrison, "Bringing in “the social”: Resisting and assisting social engagement in engineering education," presented at the World Engineering Education Forum, Albuquerque, NM, 2018.

[7] J. L. Hess and G. Fore, "A Systematic Literature Review of US Engineering Ethics Interventions," *Science and Engineering Ethics,* vol. 24, pp. 551-583, 2018.

[8] M. Davis, "Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession," *Philosophy & Public Affairs,* vol. 20, pp. 150-167, 1991.

[9] J. A. Hamad, M. Hasanain, M. Abdulwahed, and R. Al-Ammari, "Ethics in engineering education: A literature review," presented at the IEEE Frontiers in Education Conference, Oklahoma City, OK, 2013.

[10] NAE, *Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs*. Washington, DC: National Academies Press, 2016.

[11] J. R. Herkert, "Future directions in engineering ethics research: Microethics, macroethics and the role of professional societies," *Science and Engineering Ethics,* vol. 7, pp. 403-414, 2001.

[12] C. Mitcham, "A historico-ethical perspective on engineering education: From use and convenience to policy engagement," *Engineering Studies,* vol. 1, pp. 35-53, 2009.

[13] T. L. Beauchamp, "Principlism and its alleged competitors," *Kennedy Institute of Ethics Journal,* vol. 5, pp. 181-198, 1995.

[14] A. R. Jonsen, "Casuistry: An alternative or complement to principles?," *Kennedy Institute of Ethics Journal,* vol. 5, pp. 237-251, 1995.

[15] D. R. Krathwohl, B. S. Bloom, and B. B. Masia, *Taxonomy of educational objectives, the classification of educational goals. Handbook II: Affective Domain*. New York: David McKay Co., 1973.

[16] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill, and D. R. Krathwohl, *Taxonomy of educational objectives: The classification of educational objectives. Handbook I: Cognitive domain*. New York: David McKay Co., 1956.

[17] X. Tang and D. Nieusma, "Contextualizing the code: Ethical support and professional interests in the creation and institutionalization of the 1974 IEEE code of ethics," *Engineering Studies,* vol. 9, pp. 166-194, 2017.

[18] G. Wiggins and J. McTighe, *Understanding by design*, 2nd ed. Alexandria, VA: Association for Supervision and Curriculum Development, 2005.

[19] R. M. Felder and R. Brent, *Teaching and learning STEM: A practical guide*. San Francisco, CA: Jossey-Bass, 2016.

[20] D. R. May and M. T. Luth, "The effectiveness of ethics education: A quasi-experimental field study," *Science and Engineering Ethics,* vol. 19, pp. 545-568, 2013.

[21] M. H. Davis, "A multidimensional approach to individual differences in empathy," *JSAS Catalog of Selected Documents in Psychology,* vol. 10, p. 85, 1980.

[22] S. K. Parker, "Enhancing role breadth self-efficacy: The roles of job enrichment and other organizational interventions," *Journal of Applied Psychology,* vol. 83, pp. 835-852, 1998.

[23] M. C. Loui, "Assessment of an engineering ethics video: Incident at Morales," *Journal of Engineering Education,* vol. 95, pp. 85-91, 2006.