Engineering Ethics Education for Social Justice: Implementation and Preliminary Data

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

J. Britt Holbrook
Department of Humanities & Social Sciences
New Jersey Institute of Technology
Newark, NJ, USA
holbrook@njit.edu

Florencia Corbo-Ferreira
Department of Environmental Engineering Sciences
University of Florida
Gainesville, FL, USA
fcorboferreira@ufl.edu

2022 IEEE Frontiers in Education Conference (FIE) | 978-1-6654-6244-0/22/$31.00 ©2022 IEEE | DOI: 10.1109/FIE56618.2022.9962711

***Abstract*—This work-in-progress paper describes a new course in engineering ethics focused on social justice and preliminary data we have collected as part of a quantitative study on its effectiveness. This course was designed using the Understanding by Design approach. Unlike traditional engineering ethics classes, it has a strong focus on social justice. It asks students to reconsider what it means to be an ethical engineer, with particular attention to listening as a core engineering skill. The course has been implemented at two institutions, the University of Florida and New Jersey Institute of Technology. We are in the beginning stages of collecting data on its effectiveness, using measures of perspective taking and moral efficacy.**

Keywords— engineering ethics, social justice, ethics education

I. Introduction

Current teaching of engineering ethics pays inadequate attention to social justice, mirroring engineering education in general [1-3]. While several authors have called for a reconsideration of the fundamental canons of engineering ethics [4-6], there has been relatively less work on teaching and developing ethics from viewpoints that highlight social justice. Our project seeks to fill this gap, focusing on curriculum design and collecting preliminary data to demonstrate the efficacy of our approach. Our goal is to address the following objectives:

- Design an engineering ethics course that revolves around social justice
- Implement this course in two distinct settings
- Collect preliminary data to show the efficacy of this course for engineering ethics education

Teaching engineering ethics in terms of social justice is potentially transformative in two ways: 1) to reorient the focus from solely professionalism to include social and cultural impacts and factors shaping where and how professional duties are performed; and 2) to integrate discussions of ethics and social justice in novel ways through the engineering context.

II. Course Description

A. Course Design

Our course design followed the Understanding by Design (UbD) process as described by Wiggins and McTighe [7]. 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 [8], according to Wiggins and McTighe understanding is a necessary first step. Essential questions are the deep questions that define the field and lead learners towards understandings. Thus, they describe the stages of curricular design as 1) Identify desired results, i.e. enduring understandings and/or essential questions; 2) Determine acceptable evidence; and 3) Plan learning experiences and instruction.

We conducted iterative cycles of identifying essential questions. The authors independently created a set of questions, and those questions were then discussed, refined, and consolidated. The refined list was then provided to the project advisory board, which made additional suggestions. Once the essential questions were identified, we used the same process to identify learning objectives associated with each question. The final list of learning objectives and questions is:

- Can ethics be taught?
  - Recognize that there are multiple ways to approach ethical decision making.
  - Recognize that a well-reasoned argument does not necessarily lead to a correct decision.
  - Recognize that correct ethical decisions can be made in the absence of an argument.
  - Recognize that ethical decision making occurs with a social, cultural and historical context.
- What is the nature of ethical expertise?
  - Be able to question your own expertise.
  - Know that there are limits to expertise.
  - Be able to identify other ethical perspectives/viewpoints of key stakeholders.
- How do we make a well-reasoned argument?
  - Identify the premises and conclusions of arguments.
  - Restate others' arguments in your own words.

Support was provided by the U.S. National Science Foundation through grants DUE-1933652 and DUE-1933657.

- Construct your own argument.
- Construct sample arguments for a variety of stakeholders.

- How do we make ethical decisions?
  - Describe at least three different approaches to ethical decision making.
  - Apply the engineering codes of ethics to cases of professional ethics.
  - Construct an argument in support of an ethical decision using different approaches to ethical decision making.
- Whose knowledge counts?
  - Understand that listening is important.
  - Understand that there are multiple types of knowledge and expertise.
  - Identify whose knowledge counts and why
  - Identify what knowledge is absent, ignored, or hidden and why.
- How do engineering decisions affect society?
  - Recognize the ethical issues present in engineering decisions.
  - Recognize the presence of environmental injustice.
  - Understand the impact of "un-intended consequences".
  - Identify what values engineering decisions carry and how they may or may not match the users/society's values.

B. *Course Content*

To address these questions and learning objectives, each class takes a similar overall approach, with some differences. At both institutions the students prepare for class by doing an assigned reading and then responding to a blog prompt. Some of the readings are the same, while others reflect the unique needs of the class. For example, the UF course is specifically for environmental engineers, so that course has a section on environmental ethics that includes readings in topics such as environmental justice and sustainable design.

One important commonality is the focus on listening [9] as a means to combat the phenomenon of the "hero-engineer" [10]. The Flint Water Crisis is used as a paradigm case to show what happens when decision-makers ignore community voices, particularly in ways that perpetuate environmental injustice. To give students experience with listening they are assigned a field experiment to talk in groups to someone in the community about an engineering-related ethical issue impacting the community (e.g., environmental injustice in Newark's Ironbound neighborhood). The goal of the exercise is for them to go into the conversation without any preconceived notions and gain an understanding of the issue from that person's perspective. In order to focus their attention on listening they are not allowed to take notes or record the conversation. Students find that focusing on understanding that person's perspective can take the conversation in surprising directions. One group at NJIT intended to talk about traffic problems in their city. The woman they talked to turned the conversation to the poor state of the sidewalks, which she saw as a more important problem. Students have described the focus on listening as "transformational".

III. Data Collection Methodology

To determine the effectiveness of an ethics course focused on social justice, we are collecting data on students' moral efficacy and perspective taking using a pre-/post-test control group design. At each institution there are two control groups: a traditional engineering ethics class and an engineering class with no ethics component. The measures of moral efficacy and perspective taking have been adapted from existing instruments [11-13]. Both instruments use a Likert-type scale on a range of 1-5. We are also collecting demographic data. At the time of this writing we have only collected one round of pre-test data.

IV. Preliminary Findings

Table I shows the survey response rates. For all but two classes the response rate was over 80%. For most of the classes a member of the research team attended the class (either in-person or virtually) to recruit participation. One exception was the UF traditional engineering ethics class. Due to course scheduling we were only able to recruit through an email to the students in the class, and as a result the participation was below 20%. For the NJIT non-ethics class the instructor solicited participation instead of the research team, and the response rate was also low. We surmise that the instructor simply mentioned the survey and did not discuss the project or the reason for participation in any detail. It appears that active involvement by the research team in recruitment is needed to get high participation. For the full data collection in the 2022-23 academic year we will ensure that a member of the research team attends the classes.

TABLE I. Survey Response Rates

Course Title	Number of Responses	Enrollment	Response Rate
UF Social Justice Ethics	56	63	88.9 %
UF Traditional Ethics	39	196	19.9 %
UF Non-Ethics	41	46	89.1 %
NJIT Social Justice Ethics	14	17	82.4 %
NJIT Traditional Ethics	48	59	81.4 %
NJIT Non-Ethics	8	28	28.6 %

Demographic data comparing the samples at the two institutions are shown in Tables II-VI. These tables shown clear differences in the samples from the two institutions. In particular, NJIT has more students older than the traditional university age of 17-22, and higher proportions of male and Asian students, while UF has a higher proportion of white students. These differences may reflect the character of the institutions; UF is a highly selective public university while NJIT is a public polytechnic university that attracts a large number of working and commuter students. Also, the UF social justice class is only for environmental engineering students,

which may explain the high proportion of women in the overall sample.

TABLE II. AGE OF SURVEY RESPONDENTS

Age (years)	UF	NJIT
17-19	18.9%	36.7%
20-22	71.7%	44.9%
23-25	8.5%	12.2%
25-30	1,9%	6.1%
30-40	0%	4.1%

TABLE III. GENDER OF SURVEY RESPONDENTS

Gender	UF	NJIT
Male	45.3%	89.8%
Female	51.9%	10.2%
Other	2.8%	0%

TABLE IV. SEXUAL ORIENTATION OF SURVEY RESPONDENTS

Sexual Orientation	UF	NJIT
Straight	83.0%	93.9%
Gay	9.4%	2.0%
Other	7.6%	4.1%

TABLE V. RACE OF SURVEY RESPONDENTS

Race	UF	NJIT
White	84.9%	55.1%
Black	2.8%	0%
Asian	8.5%	26.5%
Native American or Alaska Native	0%	4.1%
Native Hawaiian or Pacific Islander	0%	2.0%
Mixed or Other	2.8%	12.2%

TABLE VI. ETHNICITY OF SURVEY RESPONDENTS

Ethnicity	UF	NJIT
Hispanic or Latinx	29.3%	22.5%
Non-Hispanic	69.8%	77.6%

Our original data analysis plan was to pool the data from both institutions and conduct a two way ANOVA with location (UF, NJIT) and treatment (social justice ethics class, traditional ethics class, non-ethics engineering class) as the independent variables. Given the clear demographic differences, we now plan to treat each institution as a separate case, and conduct one way ANOVAs on each set of data with treatment as the independent variable.

Table VII shows the survey results for the pre-test conducted in January, 2022. We have not yet conducted any statistical tests on this data, so we cannot say with certainty if any of the differences between groups are significant. It does appear that UF students have higher scores than NJIT students on both perspective taking and moral efficacy. The highest score on perspective taking is from the UF social justice ethics class, while the lowest is the NJIT non-ethics class. For moral efficacy the highest score is the UF non-ethics class, while the lowest is the NJIT social justice ethics class.

TABLE VII. PRE-TEST SURVEY SCORES

Group	Perspective Taking	Moral Efficacy
All Respondents	3.82	3.16
All UF	3.87	3.18
All NJIT	3.73	3.11
UF Social Justice Ethics	3.90	3.11
UF Traditional Ethics	3.89	3.18
UF Non-Ethics	3.80	3.28
NJIT Social Justice Ethics	3.69	2.69
NJIT Traditional Ethics	3.76	3.26
NJIT Non-Ethics	3.69	3.13

V. DISCUSSION AND CONCLUSIONS

The social justice engineering ethics class we have developed is unique in its focus. While traditional ethics classes tend to focus on codes of ethics and well-known engineering disasters (e.g. the Challenger space shuttle), we ask students to consider their roles as engineers in society. Through readings, blog post reflections, and class discussion, they come to understand that engineering is inherently sociotechnical and that listening is a core practice of engineering. Our ongoing data collection is intended to test what we have seen anecdotally, namely that students leave our classes with a broader understanding of what it means to practice engineering ethically.

Engineers have the potential to benefit society in myriad ways – but more so if they engage in engineering practice in ways that see engineering as inherently a matter of ethics and societal impact. This project is developing an approach to engineering ethics education that encourages an engineering ethics-and-justice mindset to challenge the practice that "real" engineering ends with mechanical calculations, while ethics and values are merely "extra" – or extraneous – to engineering practice. By creating a course focused on engineering ethics and social justice, this project has the potential to transform engineering education and engineering ethics education by producing engineers focused on using engineering to benefit a broader and more equitable portion of society.

ACKNOWLEDGMENT

The authors thank the current and former members of the project advisory board: Wenda Bauschpies, Yanna Lambrinidou, E. Yvonne Lewis, and Michael Loui.

REFERENCES

1] E. A. Cech, "Culture of Disengagement in Engineering Education?," *Science, Technology, & Human Values,* vol. 39, pp. 42-72, 2014.

[2] 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.

[3] S. Niles, S. Contreras, S. Roudbari, J. Kaminsky, and J. L. Harrison, "Resisting and assisting engagement with public welfare in engineering education," *Journal of Engineering Education,* vol. 109, pp. 491-507, 2020/07/01 2020.

[4] D. M. Riley and Y. Lambrinidou, "Canons against Cannons? Social Justice and the Engineering Ethics Imaginary," in *ASEE Annual Conference*, Seattle, WA, 2015.

[5] C. Baillie and M. Levine, "Engineering Ethics from a Justice Perspective: A Critical Repositioning of What It Means To Be an Engineer," *International Journal of Engineering, Social Justice, and Peace,* vol. 2, pp. 1-11, 2013.

[6] G. Catalano, *Engineering Ethics: Peace, Justice, and the Earth*. San Rafael, CA: Morgan & Claypool, 2006.

[

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

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

[9] Y. Lambrinidou, "On Listening, Science, and Justice: A Call for Exercising Care in What Lessons We Draw from Flint," *Environmental Science & Technology,* vol. 50, pp. 12058-12059, 2016.

[10] Y. Lambrinidou, "When Technical Experts Set Out to "Do Good": Deficit-Based Constructions of "the Public" and the Moral Imperative for New Visions of Engagement," *Michigan Journal of Sustainability,* vol. 6, pp. 7-16, 2018.

[11] 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.

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

[13] 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.