Challenges and Opportunities: Faculty Views on the State of Macroethical Education in Engineering

Dr. Nathan E. Canney, Seattle University

Dr. Canney teaches civil engineering at Seattle University. His research focuses on engineering education, specifically the development of social responsibility in engineering students. Other areas of interest include ethics, service learning, and sustainability education. Dr. Canney received bachelors degrees in Civil Engineering and Mathematics from Seattle University, a masters in Civil Engineering from Stanford University with an emphasis on structural engineering, and a PhD in Civil Engineering from the University of Colorado Boulder.

Ms. Madeline Polmear

Madeline Polmear is a PhD student and research assistant in the Department of Civil, Environmental, and Architectural Engineering, College of Engineering and Applied Science at the University of Colorado, Boulder. She is interested in studying how ethics are infused into curricular and co-curricular settings in engineering.

Dr. Angela R. Bielefeldt, University of Colorado, Boulder

Angela Bielefeldt is a professor at the University of Colorado Boulder in the Department of Civil, Environmental, and Architectural Engineering (CEAE), where she serves as the ABET assessment coordinator. Professor Bielefeldt is the faculty director of the Sustainable By Design Residential Academic Program, a living-learning community where interdisciplinary students learn about and practice sustainability. Bielefeldt is also a licensed P.E. Professor Bielefeldt's research interests in engineering education include service-learning, sustainable engineering, social responsibility, ethics, and diversity.

Dr. Daniel Knight, University of Colorado, Boulder

Daniel W. Knight is the Program Assessment and Research Associate at Design Center (DC) Colorado in CU's Department of Mechanical Engineering at the College of Engineering and Applied Science. He holds a B.A. in psychology from Louisiana State University, an M.S. degree in industrial/organizational psychology and a Ph.D. degree in education, both from the University of Tennessee. Dr. Knight's research interests are in the areas of retention, program evaluation and teamwork practices in engineering education. His current duties include assessment, team development and education research for DC Colorado's hands-on initiatives.

Dr. Christopher Swan, Tufts University

Chris Swan is an associate professor in the Civil and Environmental Engineering department at Tufts University. He has additional appointments in the Jonathan M. Tisch College of Citizenship and Public Service and Center for Engineering Education and Outreach at Tufts. His current engineering education research interests focus on learning through service-based projects, ethics, and the entrepreneurial mindset in engineering education. He also researches the development of reuse strategies for waste materials.

Ms. Elizabeth Simon, Seattle University

Elizabeth Simon is a civil engineering student at Seattle University, a Jesuit institution located Seattle, Washington. She moved to Seattle from Chicago, Illinois where she attended Saint Ignatius College Prep. Previously, Elizabeth spent a year at Loyola University Chicago's John Felice Rome Center, located in Rome, Italy, where she studied art history and obtained a minor in the subject.

Challenges and Opportunities: Faculty Views on the State of Macroethical Education in Engineering

Abstract

The meaningful inclusion of ethics in engineering education often seems to be a challenge in programs which are already packed full of technical content. Most often the ways in which ethics are included into engineering education relates to microethical issues such as ethical codes or personal professional conduct in the office. Macroethical topics, such as the profession's ethical obligations around climate change or sustainability, are less common and the ways in which macroethics are included in engineering courses has not been well studied. Two surveys were developed to explore the ways in which faculty teach students about macroethical issues; one focused on curricular settings and the other on co-curricular settings. Participants were asked to describe general topics that they covered in their respective settings and then to describe in detail the ways in which they include the societal impacts of engineering in a single course or co-curricular activity including specific topics, educational approaches and assessment tools. At the end of the survey, participants were asked in a free-response question to share their thoughts about the education of engineering students regarding broader impacts and ethical issues. This paper focuses on faculty response to this question. There were 406 responses to the open-ended question. These responses were coded using emergent, thematic coding. Inter-rater reliability was established for frequently-identified themes. The analysis of these themes highlighted four main themes: current practices, topics, challenges, and goals/opportunities. In talking about current practices, some faculty focused on engineering service opportunities or experiential learning as effective approaches. Examples of topics that were discussed include justice and community development contexts. Examples of challenges that were discussed include faculty having a limited knowledge or training about how to teach ethics or that ethics education is currently taught in ways that are too black and white and more nuanced topics should be included. Some goals or opportunities that faculty talked about indicate that students should receive a broader exposure to the societal impacts of engineering and that students should learn how to identify and negotiate work related ethical dilemmas. Some differences were found in the frequency that challenges and goals/opportunity-related themes were used between gender, tenured/tenure-track (T/TT) vs. non-T/TT, and institution types. The paper provides an interesting view of faculty perspectives on teaching ethical issues.

Introduction

The meaningful inclusion of ethics in engineering education often seems to be a challenge in programs which are already packed full of technical content. Previous work has pointed to systemic barriers such as a prioritization of technical content, lack of emotional engagement by students, or inadequate preparation of faculty as reasons that ethics education may be sparse or ineffective in engineering programs[1,2]. Another study found that ethics education in engineering tended to vary greatly between programs in both its coverage and quality, and that, when ethics is covered, it tends to be superficial in content and not adequately focused on the ethical development of the students[3]. When asked if undergraduate and graduate engineering/computing students in their programs received sufficient education on the societal impacts of technology

and ethical issues, only 33% and 19%, respectively, indicated that education on both was sufficient.[4]

Furthermore, when ethics is covered, the focus is most often on microethical topics, such as codes of ethics or personal behavior, rather than macroethical topics, which deal with the collective responsibility of the engineering profession with respect to social issues and the social ramifications of technology[5]. Examples of macroethical topics that may be covered in engineering contexts include sustainability, climate change, poverty alleviation, and war – specifically what ethical obligation engineers and the engineering profession may hold with respect to these larger social issues. The ways and degrees to which macroethics are included in engineering courses has not been well studied. The largest study to date on ethics instruction focused on student perceptions at 18 institutions, characterizing the pedagogies, settings, and quality of instruction in courses and co-curricular experiences;[6] the focus appears to have been primarily on microethics.

This paper draws from results from two surveys which were developed to explore the ways in which faculty teach students about macroethical issues; one focused on curricular settings and the other on co-curricular settings.[4,7-10] Previous papers have focused on the quantitative results from the survey, looking at where and how faculty teach students about various ethical topics, and assess their learning. This paper focuses on open-ended responses to the question: "Please share your thoughts about the education of engineering students regarding broader impacts and ethical issues." Themes from responses to this question are explored in order to better understand what faculty think about the state of ethics education for engineering students, specifically related to macroethical topics.

Methods

Data Collection

In order to examine the state of macroethics education in engineering across the U.S., two surveys were developed focused on specific topics, pedagogical methods, and assessment approaches that faculty use in both curricular and co-curricular settings. The surveys were developed through a pilot process which included local distributions at each of the authors' home institutions and follow up cognitive interviews with faculty to improve the survey (See [7] for more detail on the survey development). Both surveys were very similar and mainly used multiple select items, multiple choice questions, and some Likert items for participants to describe their ethics education approaches. One survey began with questions on ethics education in courses and the other began with questions on co-curricular settings. If a participant initially responded to the curricular survey, they also were given an opportunity to describe their approaches to ethics education in co-curricular contexts and vice versa. At the end of both surveys there was a free-response question asking faculty to "Please share your thoughts about the education of engineering students regarding broader impacts and ethical issues" and the responses to this question are the focus of this paper.

The survey was administered using the online platform Qualtrics and open from February through June of 2016. Many different professional groups and associations were used as the basis for sending survey solicitations, including: members of the American Society for

Engineering Education (ASEE) ethics, community engagement, liberal education/engineering & society, and educational research & methods divisions; authors of papers from peer-reviewed journals and the ASEE conference with 'ethics' as a keyword, principle investigators of NSF funded grants related to ethics; faculty advisors for student professional, honors and service societies (e.g., Society for Women Engineers, the American Society of Civil Engineers, Tau Beta Pi, Engineers Without Borders); and faculty mentors of NSF funded Research Experience for Undergraduate sites.

In total there were 1448 responses combined from both the curricular and co-curricular surveys; survey respondents may have skipped any questions on the survey. Participants represented 418 different institutions, 42 of which were international programs. Participants were from both engineering and non-engineering home departments and represented various 'instructional appointments' including graduate students in teaching roles, departmental/college staff members, and different faculty positions. Of the responses, 406 of those included a written comment to the free-response prompt at the end related to the participant's broader thoughts about the education of students regarding broader impacts and ethical issues. The demographic breakdown of participants who completed the open response related to the larger survey are shown in Table 1.

Table 1. Participant demographic distribution for total survey response group and free-response group

Demographic	Percentage of total response population (N=1448)	Percentage of response population with write-in response (n=406)
Gender		
Male	63	62
Female	32	36
Prefer not to say	3	2
Rank		
Full professor	33	35
Associate professor	27	28
Assistant professor	17	15
Senior instructor or other full-time non-tenure track	11	12
Full-time adjunct faculty or research faculty	2	2
Part time instructor or lecturer	2	2
Graduate student with teaching role	1	1
Departmental/college staff member	5	4
Carnegie Basic Classification[11]		
Doctoral Universities: Highest Research Activity	44	41
Doctoral Universities: Higher Research Activity	22	22
Doctoral Universities: Moderate Research Activity	6	5
Master's Colleges & Universities: Larger Programs	11	11
Master's Colleges & Universities: Medium Programs	3	3
Master's Colleges & Universities: Small Programs	1	1
Baccalaureate Colleges: Arts & Sciences Focus	2	3
Baccalaureate Colleges: Diverse Fields	2	2
Special Focus Four-Year: Medical Schools & Centers	1	2
Survey focus		
Curricular	25	38
Co-curricular	19	13
Both	53	45

Some survey respondents (25%) only completed the curricular section of the survey, as they did not mentor co-curricular activities. Some survey respondents (19%) only completed the co-curricular questions on the survey, as they did not teach courses that included ethical or societal related issues. The remainder (53%) contributed responses to both portions of the survey.

Data Analysis

The answers from the free-response question were analyzed using emergent, thematic coding[12]. Initial thematic codes were developed by two of the paper's authors using 100 of the responses. Then one of those authors continued coding the remaining responses and new themes that emerged were discussed and added. The final codebook contained 60 codes separated into four themes: current practices, topics, challenges and goals/opportunities. This codebook and a randomly selected subset of 50 free-responses were shared with two other authors of this paper for inter-rater reliability analysis. Fleiss' kappa[13], which is an extension of Cohen's kappa for more than two raters, was used to assess rater agreement with a threshold of 0.6 to signify strong agreement[14]. Thirteen themes had strong agreement from the first round of coding. Seventeen were seen by at least one of the three raters in four or more of the 50 responses from the subset, but had kappa values less than 0.6. A second sub-set of 50 items was developed using theoretical sampling[15] to select responses that each included at least one of the 17 themes of interest and, collectively, had at least three responses for each theme. From this second round, seven of the 17 themes had strong agreement (kappa>0.6) and six more had moderate agreement (0.6>kappa>0.4). Potential differences in response frequencies were examined using chi-square tests, with $p<0.1$ as the threshold to infer significant differences.

Results

Four general categories of themes emerged from the coding of the free-response question regarding faculty's broad views of the education of engineers with respect to broader impacts and ethical issues: current practices, topics, challenges and goals/opportunities. The most common themes for each category are discussed and comparisons between demographic groups are presented, comparing gender, rank, Carnegie basic classification, and if the participant described a curricular activity, co-curricular activity, or both in their survey response.

Current Practices

Themes that pertained to current practices tended to focus on where ethics is taught in the curriculum (e.g., senior design or introductory courses), pedagogical approaches (e.g., case studies, engineering service, or current events) and general comments about the state of ethics education (e.g., "Ethics is rarely covered at my institution in engineering"). Only three themes related to current practice were present in 15 responses or more and had kappa values greater than 0.4 and these are shown with example quotes in Table 2. These open-ended responses are generally supported by the multiple-select parts of the survey. For example, 55% of the respondents indicated that they taught "professional practice issues" in their course,[4] perhaps similar to the engineering practice theme. Among respondents who described the course where they believed they most effectively taught students about ethical/social issues, 67% used case studies among their teaching methods. There were no significant differences in the response frequencies for any of these three themes by gender, rank, institution type, or survey response.

Table 2. Most prevalent themes relating to current practice in educating engineering students on ethics and the broader impacts of engineering

Theme	Description	Example	Frequency (out of 406)	Fleiss' Kappa
Engineering Practice	Discussions of typical workplace situations or workplace dilemmas as a way to teach ethics	"However, the situations that the students will likely encounter when they enter the workforce will likely be more nuanced with little to no media coverage. Helping students navigate these types of challenges is more important but difficult to do pedagogically."	44	0.80
Case Studies	Using case studies to teach ethical issues	"I have asked them to review case studies and gather data from various state Boards. But there is a real lack of interest in the industry to address issues like plan stamping and lobbying for work. There is a real lack of understanding that engineers must be part of the community."	20	1.0
Senior Year Only	When it is noted that ethical issues do not become part of curriculum until senior year	"…I don't believe there are many places that students really get exposure to these topics in depth. They may 'come up' in other courses but often it's not until capstone design that students really have to wrestle with these issues (and sometimes not even then)."	15	0.79

Other themes related to current practice were identified in the data set, but moderate or higher inter-rater reliability was not established (likely due in part to low representation in the sub-set of responses coded by multiple raters). Examples of these themes and their frequency are: experiential learning (n=17), differs by major (n=13), in humanities and/or social science courses (n=12), not formally taught (n=10), learn on the job (n=10), engineering service (n=8).

There was a minority of responses that discussed how ethics or the broader impacts of engineering are too common in engineering education and that these topics should be covered less often (3 suggesting that the current level is already sufficient and 8 commenting that there should be less ethics education than the current practice). One example is "They spend too much time on it and not enough on technical aspects of engineering" and another is

> "I believe that undergraduate exposure to these topics must be limited in scope and duration. They will not have a foundation to apply these concepts until after they work for a few years. We should make sure they are aware of NSPE [National Society of Professional Engineers] and other codes of ethics, open their eyes to the broader topics of engineering in a global society and instill in them that we only gave them a glimpse of what they will encounter. Let's stop kidding ourselves that we can 'prepare' them for what is coming."

While responses like this were a minority among this sample population, they do highlight important dissenting voices that may be more representative of the larger engineering community than this sub-population who willingly responded to a survey about how they teach ethics to engineers – a sub-population that likely is already invested in ethics education.

Topics

Several responses mentioned specific topics that faculty discussed in their curricular or co-curricular contexts with respect to how they teach ethics or the broader impacts of engineering to students. Sustainability (n=8), social justice (n=11), engineering development contexts (n=3), and ethical theories (n=9) were some of the topics that were discussed, but topics in general were very infrequently discussed in this sample set. One reason may be that earlier questions in the survey asked respondents to indicate which among 18 different topics they taught in curricular and/or co-curricular settings; that data has been published elsewhere.[4,7, 9-10] There was only one theme with more than 15 responses, which was *Socio-Technical*, and had a kappa value greater than 0.4. Twenty-eight responses were coded as relating to the socio-technical topics. One example response with this theme is:

> "My university has a project-learning based undergraduate system. All students complete a junior year project on the societal impacts of technology on diverse stakeholder groups. This is an excellent and unique way of teaching about ethics and responsible engineering."

Comparing demographic groups showed no significant differences in response frequency by gender, rank, or institution, but participants who only described curricular activities in their survey response were more likely to discuss socio-technical issues than the other response groups ($\chi^2 = 6.825$, $p = 0.078$). Eleven percent of the curricular participants' responses were coded as have a socio-technical topic as opposed to 4% and 5% for the co-curricular and both survey groups, respectively.

Challenges

Many participants talked about the challenges or barriers related to teaching engineering students about ethical issues or the broader impacts of engineering. All seven of the themes that emerged for this topic are shown in Table 3. The most common theme that addressed challenges, *Theory vs. Practice*, oftentimes examined the difference between learning about ethics or ethical theories and actually behaving ethically. Many of these responses talked about the importance of including workplace situations into the education but some also mentioned that ethics education should be expected to continue beyond school and into professional lives.

Many of the challenges that were discussed focused on fitting ethics education into already full curricula. Oftentimes in these discussions, respondents also shared sentiments around technical content being prioritized over ethics and that knowledge of ethics is almost uniformly taught as separate from technical knowledge. These ideas were also accompanied by the theme pertaining to students generally receiving little exposure to ethical topics in their formal education. Two example quotes expressing these ideas were:

> "Our traditional engineering program tends to focus on technical design to the exclusion of sociocultural context. Awareness of the need to understand and reflect the needs and requirements of the client is growing, but still is infrequently taught in the classroom."

> "I think many students graduate without placing a great deal of thought on these issues. Some are under the impression that material that does not require calculations is less important."

Another challenge that was discussed focused on ethics being a difficult topic to teach, especially since most engineering faculty do not have the formal training necessary to thoroughly cover the topics. Similarly, the challenge of assessing ethics was discussed.

Table 3. Most prevalent themes related to challenges in teaching engineering students about ethical issues or the broader impacts of engineering

Theme	Description	Example	Frequency (out of 406)	Fleiss' Kappa
Theory vs. Practice	When the difference between learning ethics and ethical behavior or practice is discussed	"It is very difficult to do more than just feed them facts in class. Until they are confronted with a personal opportunity to truly reflect on the impact that their decisions can have, it is just a classroom exercise. In ethics classes, for instance, they know the answer that they should give, but it doesn't mean they would make that decision and they haven't really thought through the impact of what happens if they don't do it. Maybe the best assignment would be to write a first person narrative of what would be the effect to them if they were on the receiving end of an ethics violation."	35	0.53
Separate from Technical	When it is discussed that ethics is taught separate from technical content or in way that makes it difficult for students to connect the ethics education with their technical education	"These topics tend to be relegated to HSS departments, which means that students do not necessarily make the leap of how ethics pertains to their technical majors. They (faculty and students!) have not yet discovered that ethics is a part of engineering, not ancillary."	29	0.60
Full Curriculum	Discussions of challenges of incorporating ethics into engineering education due to an overly full curriculum	"Few other opportunities in the standard curricula for these opportunities."	28	0.94
ABET	When the accreditation body of ABET is discussed	"ABET reviews are not sufficient. Still look at basic engineering education."	27	1.0
Faculty: Limited Knowledge	Discussions of limitations in faculty knowledge	"I suspect the limitation is what faculty are prepared for in terms of exercises or projects."	24	0.85
Students: Limited Exposure	When the need for more exposure is discussed	"Engineering students need to be exposed to the issues and encouraged to think critically about them. "	20	0.39
Assessment	When challenges of assessing ethical understanding are discussed	"Making formal assessment of their understanding of such issues is not always easy and does not always happen, but I do make the effort to introduce the material and provoke thought and discussion within the class."	17	0.70

Comparing demographic groups showed that female respondents were more likely to discuss student's having limited exposure to ethical and broader impact topics than male respondents (5% female vs. 3% male; $\chi^2 = 28.282$, $p = 0.000$); this agrees with the quantitative data from the survey where only 24% of women thought that the ethics and broader impacts education of undergraduate students in their program was sufficient compared to 34% of males. Female respondents were also more likely to discuss ABET (12% female vs. 7% male; $\chi^2 = 15.039$, $p = 0.002$). Tenure-track faculty (full, associate, and assistant professors) were more likely than non-tenure track faculty (instructors, adjuncts, research faculty, lecturers, graduate students and departmental/college staff) to discuss faculty having limited knowledge about teaching ethics (7% vs. 1%; $\chi^2 = 4.519$, $p = 0.104$) and the difference between teaching ethical theories and students engaging in ethical behavior (10% vs. 2%; $\chi^2 = 5.631$, $p = 0.060$). Respondents from small, master's granting programs were most likely to discuss the limitation of faculty knowledge (40%; $\chi^2 = 31.076$, $p = 0.009$), to talk about assessment (20%; $\chi^2 = 32.518$, $p = 0.005$) or the theory versus practice (40%; $\chi^2 = 23.619$, $p = 0.072$). Respondents from doctoral granting institutions with moderate research activity were most likely to discuss how students have a limited amount of exposure to these topics (14%; $\chi^2 = 23.742$, $p = 0.070$).

Goals/Opportunities

In addition to discussing challenges around ethics education, respondents also discussed successes, personal or collective goals around ethics education, or potential ways of improving ethics education in engineering. The six themes related to these topics are shown in Table 4. Broad statements about the need to improve ethics education or how important ethics education were the two most common themes in this data set. Several responses focused on the significant impact that engineering can have one society. There were responses that saw this impact as both a positive and motivating elements, and others that saw this as a cautionary element for why ethics education is important. One example focused on the impact of engineering was:

> "I have found the key to teaching ethics in my courses is to emphasize not only that ethics is about avoiding evil, but also that ethics is about pursuing good. Engineers want to create products that help people. They need to know their profession is intrinsically ethical, and that being a good engineer means being not only technically, but also morally good."

There were also several responses that focused on the best way to include ethics and broader impact education into engineering curricula, including incorporating these topics into existing classes, by strategically including these topics into multiple courses throughout the curriculum, or by developed stand-alone, focused courses only on these topics.

Examining the frequency of themes related to goals or potential in ethics education showed that non-tenure track respondents and female respondents were more likely to discuss the need for courses focused on ethics and broader context (6% non-tenure vs. 3% tenure-track; $\chi^2 = 13.880$, $p = 0.001$; 8% female vs. 4% male; $\chi^2 = 27.811$, $p = 0.000$). Female respondents were also more likely to discuss the need for these topics to be present in multiple courses throughout the curriculum (10% female vs. 6% male; $\chi^2 = 16.757$, $p = 0.001$). There were no significant differences between institution types or between respondents that described curricular, co-curricular, or both in their surveys.

Table 4. Most prevalent themes related to goals or opportunities for ethics or broader impacts education for engineers

Theme	Description	Example	Frequency (out of 406)	Fleiss' Kappa
Improve	When motivation to improve is noted, or when 'we need more' is stated	"I believe ethical issues are a part of most engineering curriculum, but the time devoted to them or their integration into various courses could drastically be improved overall."	69	0.64
Important	When a response says, generically, that ethics and/or societal issues is important	"It is important that the student learn and discuss the ethical dilemmas that possible will occur in their working life."	57	0.95
Engineering Impact	When the impact on communities by engineering is discussed	"I think that project work with communities in poor countries that is directed toward sustainable enhancement of the lives of family members of groups provide the students with an opportunity to use their skills and capabilities to a good human end, which is why most of the students entered engineering programs."	46	0.50
Multiple Courses	When integrating ethical discussions throughout curriculum is discussed	"I think it is better to teach this concept across the curriculum a little in every class rather than one single class. When it has a particular class, the students end up compartmentalizing the information and never try to apply it anywhere else, unless specifically told to do so. When it is everywhere, it is a topic they know they can ask about in any class."	42	0.75
Incorporate into Existing Courses	When it is recommended or encouraged that ethical topics should be incorporated into existing classes as an effective way to teach ethics	"I believe ethical issues are a part of most engineering curriculum, but the time devoted to them or their integration into various courses could drastically be improved overall."	37	0.88
Focused Courses	Discussions of need for or existence of a specific course focused on ethics	"I think these topics should be addressed in both (1) focused courses as well as (2) integrated throughout their curriculum."	15	0.85

Limitations and Future Work

A significant limitation of this study is that the response pool consisted primarily of participants who teach about ethics or the broader impacts of engineering in curricular or co-curricular settings. This may represent a biased population regarding the importance of ethics education in engineering. Among the more than 1400 survey respondents, only 28 taught no ethical/social issues in their courses or co-curricular activities. Although there were some respondents who wrote that there was already too much focus on these topics, this was an extreme minority. So, this response population should not be seen as representative of the entire engineering education community.

The research is continuing with a series of interviews with about 35 faculty who responded to the survey (many of which also wrote in responses to the open ended question examined in this paper), selected from among the approximately 230 who indicated a willingness to participate in an interview on the survey. These interviews include questions on the institutional culture and the extent to which individual believe that other engineering and computing faculty at their institution value macroethics instruction. From these interviews, a richer perspectives on some of the themes discussed in this paper are expected to continue to emerge.

Conclusion

The results presented in this paper shed light onto the views of faculty who teach ethics and broader impacts issues to engineering and computing students regarding the state of education on these topics today. The majority of respondents spoke favorably about the inclusion of ethics and broader impacts in engineering education and most also spoke about the need and importance of incorporating more of these topics into the education of future engineers. When discussing current practices, respondents most often talked about bringing workplace situations or dilemmas into their classes, using case studies, or that ethics and broader impact issues are most often discussed in senior year classes as opposed to throughout the curriculum. The respondents saw the already crowded curriculum, the difference between teaching theory and the actual practicing of engineering, faculty having limited knowledge or formal training, student having limited exposure, and assessment as some of the most prevalent challenges toward extending the inclusion of ethics and broader impact issues in engineering education. Finally, the respondents generally voiced a need to improve the inclusion of these topics in engineering education. Some of the suggestions for doing this were to focus on the impact that engineering work can have on society, to place these topics in multiple existing courses, or to have focused courses designated solely to ethics and broader impact issues.

Acknowledgement

This material is based on work supported by the National Science Foundation under Grants #1540348, #1540341, and #1540308. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Bibliography

1 D. R. Haws, "Ethics instruction in engineering education: A (mini) meta-analysis," *Journal of Engineering Education,* vol. 90, no. 2, pp. 223-229, 2001.

2 B. Newberry, "The Dilemma of Ethics in Engineering Education," *Science and Engineering Ethics,* vol. 10, no. 2, pp. 343-351, 2004.

3 A. Colby and W. M. Sullivan, "Ethics Teaching in Undergraduate Engineering Education," *Journal of Engineering Education,* vol. 97, no. 3, pp. 327-338, 2008.

4 AUTHORS

5 J. R. Herkert, "Microethics, Macroethics, and Professional Engineering Societies," in *Emerging Technologies and Ethical Issues in Engineering,* Washington, DC, The National Academies Press, 2003, pp. 107-114.

6 C.J. Finelli, M.A. Holsapple, E. Ra, R.M. Bielby, B.A. Burt, D.D. Carpenter, T.S. Harding, J.A. Sutkus, “An Assessment of Engineering Students’ Curricular and Co-Curricular Experiences and Their Ethical Development,” *Journal of Engineering Education*, 101 (3), 469-494.

7 AUTHORS

8 AUTHORS

9 AUTHORS

10 AUTHORS

11 The Carnegie Classification of Institutions of Higher Education. Basic Classification Description. http://carnegieclassifications.iu.edu/classification_descriptions/basic.php

12 J. W. Creswell, Qualitative Inquiry & Reserach Design: Choosing Among Five Approaches, Thousand Oaks, CA: Sage Publications, 2007.

13 J. L. Fleiss, "Measuring nominal scale agreement among many raters," *Psychological bulletin*, vol. 76, no. 5, pp. 378-382, 1971.

14 J. R. Landis and G. G. Koch, "The measurement of observer agreement for categorical data," *Biometrics*, vol. 33, no. 1, pp. 159-174, 1977.

15 K. O'Reilly, Ethnographic Methods [second edition], Abingdon: Routledge, 2012.