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Efficacy of Macroethics Education in Engineering

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Efficacy of Macroethics Education in Engineering

Abstract

There is a need for engineering education to prepare students to address macroethical issues. Macroethics refers to the broader ethical obligations of the profession such as those embodied by social responsibility and sustainability. The extent to which students graduate with an understanding of macroethical issues is unclear and in need of organization. The goal of this new research project is to evaluate the various ways in which macroethics is taught in engineering, examining variations in pedagogy and topics, as well as examining differences between disciplines and institution types. This paper describes the first phase of the research, to develop surveys that will reveal a national picture of engineering macroethics instruction. Survey development began based on a review of the literature. One survey was targeted to deans and department chairs, aimed at identifying the names of faculty at their institutions who are involved in ethics instruction. A second survey was aimed at faculty who teach macroethical topics in courses for engineering students. A third survey was aimed at faculty who mentor co-curricular activities where students may learn about or engage with macroethical issues. Pilot versions of the three surveys were distributed to selected faculty at three institutions: a large public research-intensive university, a private research-intensive university, and a Christian-affiliated, private Baccalaureate university. Approximately 30 responses indicated a breadth of courses where faculty infused a wide variety of macroethical topics. It also revealed the challenges associated with encouraging faculty to respond to surveys. A handful of faculty participated in follow-up interviews, giving feedback to help improve the surveys. The surveys were revised, with national dissemination in spring 2016. The dissemination plan includes ASEE list serves and a targeted list of individuals who have publications and have received grants related to macroethics education. Some national survey results should be available in time for the poster in June 2016.

Introduction

The broad vision of this research project is to transform the knowledge and attitudes of engineering students and faculty with respect to macroethical issues. Macroethics refers to the broader ethical obligations of the profession, such as those embodied by social responsibility and sustainability.[11] To catalyze this change, programs and instructors must have a better understanding of the national landscape of macroethics education, as well as access to best practice models for instruction and assessment of learning outcomes. The goal of this research is to investigate the various ways in which macroethical issues are examined in engineering education, exploring variations in both pedagogy and content. The first step toward achieving these research goals will involve a national survey of ethics instructors. This background section presents the underlying motivations for the research and a review of relevant engineering education literature.

Ethics in Engineering Education

In order for engineering to reach its full potential to benefit society, students must be prepared to engage in broad considerations of the macroethical issues that face our profession. The engineering profession has established codes of conduct to describe standards for professional

behavior [6,9,10,31,40], but these largely relate to individual actions associated with individual projects, and therefore can be characterized as microethical considerations. Engineering falls short of its societal duties if it ignores macroethical challenges. Macroethics considers the "collective, social responsibility of the engineering profession and societal decisions about technology."[28] Macroethics can include issues such as sustainability, poverty and underdevelopment, security and peace, social justice, bioethics, nanoscience, and social responsibility.[5,17,28]

An understanding of professional and ethical responsibility by students is required for accreditation of engineering degrees in the U.S.[1] and globally. The New Zealand and UK accreditation requirements have a greater emphasis on macroethical issues, such as a stand-alone requirement for sustainability.[20,32] Engineering disciplines have similarities and differences in their ethical requirements. The American Society of Civil Engineers (ASCE) is trying to increase the ethical capabilities of students via the ABET civil engineering program criteria (CEPC), and recently changed the requirements "prepare graduates to analyze issues in professional ethics."[8, p. 24]

Ethics instruction takes place via a broad diversity of methods and courses.[24,38] The literature is rich with different examples of ethics instruction; over the past 10 years there have been 283 papers presented at the American Society for Engineering Education (ASEE) Annual Conference that focused on ethics (2006-2015).[7] Ethics is frequently integrated into first-year introductory engineering courses.[13,18,42] Ethics are incorporated into a variety of courses from standalone 3-credit to infusions in a variety of courses such as Capstone Design.[16,19,30,33,41] While ethics are taught in various contexts, it remains unclear the proportion of content related to micro- versus macroethical issues. Only 30 ASEE conference papers returned from a search on "macroethics", suggesting that macroethics is less commonly taught in courses and/or co-curricular activities.

Ethical instruction methods in courses have been categorized into multiple types: ethics across the curriculum; professional codes of ethics; humanist readings; ethical problem-solving heuristics; groundings in theoretical ethics; case studies; debate; role-playing; and service-learning.[27,29] Many programs teach ethics through a number of these methods. For example, Catalano[16] at SUNY-Binghamton describes ethics integration that includes theory, case studies, and humanist readings. Two studies suggest that one of the most effective teaching methods is grounding in theoretical ethics, supported by instruction in professional codes of ethics, humanist readings, and/or ethical problem-solving heuristics.[12,38]

The largest survey of ethical instruction in engineering to date appears to be the SEED project with 19 partner institutions and results from 4000 students.[23,26] Their model for ethical behavior included institutional culture and individual student experience in both formal courses and co-curricular environments. The survey attempted to measure the quantity and quality of students' ethical experiences paired with the level of students' ethical development. This included nine pedagogies, setting of occurrence, and cognitive depth (Bloom's taxonomy). Faculty (n=110), administrator (n=36), and student (n=123) perceptions of ethics instruction were also characterized by focus groups and interviews. However, the study did not distinguish between macroethics and microethics, and seemed to focus primarily on microethical issues.

Assessment of Moral Reasoning and Ethical Knowledge

It is important that ethics instructors have a valid assessment instrument in order to measure impact of instruction. ABET self-study reports indicate how programs teach students about ethics and how they document this learning outcome. ABET self-study documents generally do not distinguish between micro- and macro- ethical issues; however, the use of the FE exam as an outcomes assessment method by many programs implies a focus on microethical issues.

A number of rubrics have been developed and applied to assess engineering ethics. Rubrics allow the direct assessment of students' knowledge. Ethics rubrics are typically used in courses that rely heavily on case studies.[46,49,50]

Ethics education quality may also be assessed by standardized instruments. Kohlberg's[33] ideas were used as the basis for Rest's Defining Issues Test (DIT, DIT2), which have been widely used in engineering.[25-26,43-44,48,51] Two other instruments that are similar to the DIT but use scenarios more specific to engineering are the Engineering and Science Issues Test (ESIT)[14] and the Engineering Ethical Reasoning Instrument (EERI).[53] Different instruments have been used to assess macroethical issues, including a sustainability value instrument[36] and the Commitment to Social Justice instrument.[25,39]

In summary, there is substantial literature on where and how ethics is taught to engineering students. However, it has been poorly synthesized and instead is largely comprised of specific examinations of individual examples. There are also a wide range of assessment methods that have been used, such that it is difficult to compare results and distill best practices. Finally, there is a poor understanding and little record of the extent to which engineering curricula teach students about macroethical issues. This research will address these issues by providing a more complete national picture of macroethics education in engineering,

Research Goals

The first phase of the multi-year research project is aimed at developing a national picture to understand to what extent engineering students are taught about macroethical considerations in their courses and through co-curricular opportunities. The research questions that are currently being explored as part of this phase of the research include:

Overarching question A: How are macroethical issues taught in engineering programs?

- RQ1. How common is instruction in macroethical issues in engineering courses?
- RQ2. How commonly do students learn about macroethical issues in co-curricular activities associated with engineering?
- RQ3. Are there particular macroethical issues that are more commonly associated with some disciplines? For example, bioethics may be more common in Chemical/Bioengineering versus sustainable development being common in Civil and Environmental Engineering.
- RQ4. Are macroethical issues more commonly taught in upper division or introductory courses?
- RQ5. To what extent are student-centered pedagogies associated with macroethics instruction?

Overarching question B: How are macroethical issues assessed in engineering programs?

RQ6. Are instructors generally satisfied with their ability to assess students' knowledge of and attitudes toward macroethical issues?
RQ7. Are different assessment tools typically used in different contexts?

Methods

Pilot Surveys

The first step in the research was to develop online surveys that would be used to assess the state of macroethics education in the U.S. It was determined that the research would initially pilot three separate surveys: (1) a survey targeting engineering deans and department chairs to identify the names of individuals at their institution who teach students about ethics; (2) a survey targeting faculty who teach engineering students about ethics via courses; and (3) a survey targeting faculty who mentor co-curricular activities in engineering.

The surveys were each developed using Qualtrics survey software and by keeping in mind best practices of usability, reliability, and validity.[4,35] After development of the survey instruments, recruiting emails, consent statements, and follow-up interview questions, the information was submitted for approval to the University of Colorado Boulder (U3) IRB and the research was approved as exempt. The three surveys were piloted at three diverse institutions. A few of the individuals who took the surveys at each institution were interviewed about the survey. Finally, the surveys were modified (primarily to make them shorter) for national dissemination.

The first survey was aimed chairs and deans, in order to identify the names of faculty who teach engineering students about ethics via courses and/or co-curricular activities. The survey included five questions related to who in their program "teaches engineering students about topics related to ethics and societal issues in undergraduate and/or graduate courses". There were possible topic areas provided. If the respondent also felt that ethical issues were taught through co-curricular activities, the names of faculty mentors of seven different co-curricular types (including other) were requested.

The second survey was aimed at faculty who teach ethics in courses – termed the "curricular survey". The goal of the survey was to characterize where macroethics education is situated in different institutions and engineering disciplines, what macroethical issues are taught, the methods used to teach macroethical concepts, the methods used to assess student learning, and a faculty perspective on perceived effectiveness of ethics instruction. The majority of the questions were multi-select or multiple choice, with only a couple of open-ended questions. The survey also included questions to determine if the individual mentored co-curricular activities where students learned about ethics and/or the societal impacts of engineering.

The third survey was aimed at faculty who mentor co-curricular activities in engineering – termed the "co-curricular survey". After the informed consent statement, the first question asked "do engineering students learn about any of the following topics in co-curricular activities that you mentor? (check all that apply)". There were 18 response options – repeating the options from survey 2 and adding "none". Individuals who checked any of the topics were then asked to think about one co-curricular setting where students learned the most about ethics and/or the societal impacts of engineering, and characterize it into one of six types (including other with an open-

ended fill-in box). This was followed by an open-ended question "briefly describe how engineering students learn about ethical issues and/or the societal impacts of engineering in this co-curricular setting". Individuals were then asked whether or not they would like to describe a second co-curricular setting; if yes, the same two questions about the co-curricular setting were asked. Individuals were asked to supply the names of other co-curricular mentors that they recommended we contact. Then the individual was asked if they taught students about ethics and/or the societal impacts of engineering in any of their courses. These questions repeated those from survey two. The survey concluded with the same demographic items as survey 2.

Dissemination of Pilot Surveys

Deans, chairs, and faculty from three pilot institutions were invited to take the initial versions of the three surveys. The solicitation process, demographics and response rates at each institution are described in the following paragraphs.

Seattle University (U1) is a small private, predominately undergraduate, Jesuit institution. Initially, four departmental chairs and one dean were invited to take the deans/chairs survey in mid-November 2015. The goal was to see which faculty names they would provide, and then email invitations to survey 2 and survey 3 to those individuals. Two of the four invited chairs and the dean participated in the pilot survey. Four faculty names (including one of the researchers) who taught ethics in courses were provided and five names for co-curricular advisors, with several of the names being given by two or all three of the respondents. All three of the curricular faculty members were emailed and responded. One of these participants was a full professor, one was an associate professor and one was an adjunct lecturer. Four of the five co-curricular advisors were emailed (the five co-curricular advisor was also one of the curricular names given) and three completed the survey. One of the co-curricular advisors was a full professor, two were associate professors, and one was an assistant professor.

Tufts University (U2) is a private institution, classified by Carnegie as RU/VH.[15] The six chairs and three members of the dean's office were invited to take the deans/chairs survey in mid-November 2015. In addition, nine instructors of courses in which ethics is taught were invited to take the survey 2 on curricular efforts. There were four responses (44% response rate) in the deans/chairs survey with all four respondents being male. Three responses (33% response rate) were completed for curricular efforts - responses came from two assistant and one full professor; two respondents being male and one being female. One of assistant professors from this cohort agreed to be interviewed.

The University of Colorado Boulder (U3) is a large public institution, classified by Carnegie as RU/VH.[15] Invitations to the three surveys were sent to targeted lists of individuals in mid-November 2015 via Qualtrics. The deans/chairs survey invitation was emailed to the associate dean for education, the chairs of 8 relevant departments/programs, and associate chairs for 3 departments (12 individuals in total). Survey 2 to faculty who teach courses with ethics and/or macroethical content was sent to a list of 40 faculty who were believed to teach students about ethics and/or the societal impacts of technology; snowball sampling from names recommended by other faculty on the survey added two more faculty.

The individuals who were invited to participate in the survey represented all of the main engineering departments at the institution (Table 1), but were primarily faculty from the Department of Civil, Environmental, & Architectural Engineering (the home department of the project PI who sent the survey invitation email). Interestingly, the individuals believed by the PI to be potentially engaged in teaching ethics and/or macroethical issues were largely instructors (43%), over-represented compared to 28% instructors among U3 engineering faculty. Further, 38% of those invited to take the curricular faculty survey were women, higher than the 21% of the engineering faculty overall. For survey 3 on co-curricular activities, the names of faculty who mentored co-curricular engineering groups were mined from U3 websites. These 13 individuals included 62% instructors and 54% women, again over-representing these groups compared to engineering faculty at U3 overall.

Results and Discussion

This section will summarize the results obtained from the dissemination of the three pilot surveys at the three institutions. The implications of these results in terms of modifying the survey instruments prior to national dissemination will be discussed.

Deans/Chairs Survey

Overall there were 13 responses (4 partial, 9 completed) to the survey. U1 responses accounted for 4 responses (3 completed) from among 5 invitations. U2 accounted for 7 responses (6 completed). For U3, there were 2 partial responses. The Qualtrics mailer tracked the 12 email invitations that were sent to the associate dean and chairs at U3. Of the 12, only 50% of the emails were opened, only two individuals started the survey, and none completed it. Overall across the three institutions, this represents a *partial or fully* completed response rate of 50%. Informal conversations with individuals about why they failed to take the survey included that some felt they lacked sufficient knowledge (based on the invitation email) or were reluctant to supply the information. One also indicated that they were intimidated by the survey "introduction" which sounded overly formal (so they did not complete the initial survey "consent" question).

For question 1, there were 17 different ethics/macroethics topics listed (see Table 2), and individuals were asked to supply the names of individuals in their program and/or institution who taught engineering students about these issues via courses. There were 6 individuals who listed one or more names for one or more topics. The remainder failed to supply any names. The broadest response was an individual who provided names for 10 topics. The results indicated that perhaps two general open-ended questions might be more effective: who in your program teaches engineering students about ethics (such as codes, ethical theories, etc.); who in your program teaches students about the societal impacts of technology (macroethical issues such as sustainability, bioethics, environmental impacts, safety, poverty, etc.). The "such as" lists can be adjusted. But this style would likely be less intimidating and just as effective.

The second question asked if there were co-curricular settings where engineering students learn about ethics, listing 7 options (including other). There were five individuals who provided names for one of more of the co-curricular settings. The responses indicate that it may be better to directly ask faculty mentors from these groups via list serves from organizations (if these can be

accessed, such as EWB-USA). Alternatively, the names of faculty mentors for these groups can typically be found on-line; an undergraduate student could be given this task. The PI from U3 used this process to identify mentors of co-curricular groups in departments outside her own. However, response rates were very low, perhaps due to the survey invitation. If an individual did not feel that ethics or societal impact related topics were relevant to their activity, they may have simply chosen not to respond to the survey. A better approach would be to get these individuals to concretely state this fact in a simple question at the beginning of the survey.

The third survey question asked the dean/chair to provide feedback on the survey and/or ethics instruction. There were four responses. These raised important issues. First, "I'm not sure I understand the difference between microethics and macroethics, even though you defined these terms." This is important. The PIs are debating if they can avoid the use of the term macroethics. Another response: "The survey addresses quite specific areas where ethics and engineering intersect, but not more general issues of ethics in society, equity, ethics & law, ethics & media, amoral ethical stances (Machiavellianism for example), & issues of resolving conflicts where competing ethical principles collide." We want to cast a very broad net and not leave out any of these topics. Thus, the broader approach of the two open-ended questions might be more effective, if we include a broad enough range of "such as…" examples. Another response stated: "I don't know whether you want to include computer science in engineering, or you're only interested in programs with "engineering" in the name." We are in fact interested in including computer science. So future versions of the survey introduction and questions will try to make this clear. Two individuals noted that they didn't really know which faculty members were teaching which ethical topics in their courses, and that these could vary substantially over time. This raises a broad question as to whether it is worth even trying to execute this survey. In addition, two individuals noted that they teach these areas in their own courses, so if such a survey is attempted, it may be worth including a "link" or question that allows these individuals to discuss their own ethics instruction (should they choose to do so).

Three individuals indicated a willingness to participate in an interview on the survey. Their responses were useful as modifications to the survey questions and survey invitation language were considered. These individuals were generally unaware of who was teaching specific ethical/macroethical topics and/or felt reluctant to provide their names. This, coupled with low response rates in the pilot study, led us to believe that the yield of information from this survey might be very low. Therefore, it was decided not to pursue this approach into the national study, except on an as-needed basis if direct responses to the curricular and co-curricular surveys were insufficient.

Ethics in Courses Survey

The second survey was targeted to individuals who teach engineering students about ethics (including both micro- and macro- ethical issues) via courses. Fifty-four individuals from various engineering departments and/or disciplines were invited to participate in the survey (Table 1), and 28 took at least part of the survey (26 were completed); thus the overall response rate was 52%. Of the 43 emails sent via the Qualtrics tracker, 58% were opened, and of those 84% started the survey. The majority of the 22 respondents from U3 were instructors (55% compared to 43% invited) and women were over-represented (48% of the respondents compared to 38% among invitees).

Table 1. Institutions and disciplines of individuals who participated in the curricular survey

Institution	Department	Invited among faculty*	% invited among faculty*	% response among invited
U1	Civil & Environmental	1 / 12	8	100
	Computer Science	1 / 12	8	100
	Electrical & Computer	0 / 6	0	0
	Mechanical	1 / 7	14	100
U2	Biomedical	1 / 9	11	100
	Chemical & Biological	0 / 19	0	N/A
	Civil & Environmental	3 / 28	11	33
	Computer Science	2 / 21	10	0
	Electrical & Computer	2 / 18	11	50
	Mechanical	1 / 22	5	0
U3	Aerospace	6 / 45	13	17
	Chemical & Biological	4 / 30	13	75
	Civil, Archit., Environmental	12 / 50	24	75
	Electrical & Computer	5 / 45	11	0
	Mechanical	8 / 39	21	25
	Humanities	4 / 7	57	50
	Other	3 / 11	27	67

* among total numbers of department faculty (tenured, tenure-track, and instructors based on 2015-2016 university catalog – not including emeritus)

The length of time required to complete the survey ranged from 3.8 to 125 minutes (although perhaps this long outlier was due to the person doing other tasks / being interrupted while taking the survey); the median time was 8.8 minutes (first quartile 5.9 min., 3rd quartile 13.8 min.). Therefore, the survey was generally near the 'less than 10 minute' target that was stated in the invitation email and IRB consent. Among those who described two courses and co-curricular activity mentoring (n=6), two courses (n=2), or a course and co-curricular activity (n=6) the median response time was 11.5 minutes (somewhat longer than individuals who only described one course whose median was 6.2 minutes).

The results obtained from the 26 completed surveys and 2 partially completed surveys will be summarized below. This pilot data represents a small number, but more popular responses indicate choices to retain in the full survey, and perhaps items and/or choices that could be eliminated to improve usability. In addition, three of the individuals who completed survey 3 on co-curricular activities opted to complete questions about ethics in courses that they teach. These responses are included in the results presented below. As such, the responses generally represent 29 to 31 faculty. Further, where relevant as a comparison to curricular responses, responses regarding co-curricular activities (among n=4) are presented.

First, there was a broad range of ethics-related topics that are taught to engineering students in undergraduate and/or graduate level courses (Table 2); among the 16 topics listed, 1 to 16

individuals reported teaching the topic. Per faculty, the number of topics indicated ranged from 0 to 11, with a median of 4.5 (28 faculty indicated 1 or more topics). Three topics were taught by more than half of the faculty: engineering decisions in the face of uncertainty, professional practice issues, and ethical failures/disasters. In contrast, the most common topics covered in co-curricular activities involved sustainability/sustainable development and poverty. There were a surprisingly low number of "other" topics typed in. This indicates that it may be a good ideas to include a wide range of example topics, in order to establish the range of issues of interest for the survey. Comments indicated that faculty were generally unfamiliar with the term *macroethics*, even after it was defined (within both the consent form and the text of the survey). Therefore, asking faculty to "fill in" topics related to macroethics would probably yield minimally helpful feedback. The list was provided to faculty alphabetically, but still may be overly long as cognitive psychology research suggests research participants are best at processing about seven pieces of information.[37,45] However, the majority of those interviewed about the survey, primarily from an engineering background, indicated that they did not mind the long list.

Table 2. Topics in courses and co-curricular activities for engineering students (undergraduate and/or graduate)

Ethics-Related Topic	% Courses (N=28)	% Co-curricular (N=4)
Engineering decisions in the face of uncertainty	57	25
Professional practice issues	54	25
Ethical failures / disasters	54	0
Ethics in design projects	46	25
Safety	43	25
Sustainability and/or sustainable engineering	43	50
Engineering code of ethics	39	0
Environmental protection issues	36	0
Sustainable development	36	50
Social justice	29	25
Engineering & poverty	29	50
Ethical theories	21	0
War, peace, and/or military applications of engineering	18	0
Responsible conduct of research	14	0
Bioethics	14	0
Other	7	0
Nanotechnology ethics	4	0

The next question on the curricular survey asked individuals the types of courses where they taught students about ethics and/or the societal impacts of technology; results are summarized in Table 3. It was expected that most individuals teach multiple courses, and therefore could indicate as many of the course types as they chose. There were 8 course types from which to select; the respondents selected a median of 2 course types (ranging from 0 to a maximum of 3). Among the 29 respondents who listed 1 or more course types, the most common course types were sophomore or junior level core engineering courses and graduate-level courses. None of the respondents indicated that they taught a full course on engineering ethics, although such courses

are taught at one of the three pilot institutions. Two of the faculty members interviewed felt that more options should be provided – such as other design-focused courses.

Table 3. Types of courses where students are taught about ethics and/or the societal impacts of engineering (of n=29)

Course Type	%
Sophomore or junior level core engineering science or engineering course, where ethics/social impacts are not primary learning goals for the course	41
Graduate-level course	34
Senior capstone design	28
First year introductory course that include ethics among other topics	24
First year design-focused course that includes ethics among other learning goals	21
Professional issues course (any level; e.g. project management, communications)	14
Other	14
Full course on engineering ethics (any level)	0

At this point in the curricular survey, individuals were asked to think about one course in which they believed that they most effectively taught engineering student about ethics and/or the societal impacts of engineering. In addition, at a later point in the curricular survey, individuals were offered the opportunity to describe a second course where they taught students about ethics. The co-curricular survey also asked about course-based instruction. In total, information on 37 courses was obtained. Results for the type of courses are summarized in Table 4. As one example, a course was indicated to be an undergraduate elective, graduate required course, and a graduate elective. Most faculty reported on a course that was required for undergraduate students in one or more engineering majors. When asked to select a single additional descriptor for the course from among seven options (that included other), senior capstone design courses were most common. Interestingly, here two responses characterized it as a full course on engineering ethics.

Table 4. Courses where students are effectively taught about ethics and/or the societal impacts of technology

Type of course	N	Type of course	N
Required for undergraduate students in one or more engineering majors	19	Senior capstone design	6
		First year design focused course	5
Elective for undergraduate students in one or more engineering majors	13	First year introductory course	5
Required for graduate students in one or more engineering majors	5	Sophomore or junior engineering science or engineering course	5
Elective for graduate students in one or more engineering majors	7	Professional issues course	3
		Full course on engineering ethics	2
		Other	1

The next survey question asked faculty to indicate the methods that they used in the course to teach students about ethics and/or societal issues. Respondents could select from among 15 choices, presented in alphabetical order. Results are summarized in Table 5. For individual courses, between 1 and 9 different methods were indicated, with a median of 5 different methods for each course. The most common methods (used in 70% of the 37 courses) were: lectures, case studies, and examples of professional scenarios. However, at least two instructors used each of the 14 different teaching styles (one instructor used moral exemplars in both of the courses he described). In the future with a larger data set from national dissemination of the survey, it may be found that different types of teaching methods are more common in different types of courses or disciplines. As an illustration of that idea, the prevalence of teaching methods used in required undergraduate courses (n=19) were compared to required graduate courses (n=5). Teaching methods such as design and project based learning seemed more common in undergraduate courses; lectures, guest lectures, and reflections seemed more common in graduate courses.

Table 5. Methods that faculty use to teach students about ethics and/or societal issues in their courses

Teaching Method	N	% of 19 required undergraduate courses	% of 5 required graduate courses
Lectures	26	58	100
Case studies	26	79	80
Examples of professional scenarios	26	74	80
Engineering design	17	53	20
Project based learning	16	47	20
Reflections	15	32	60
In-class debates	13	16	60
Guest lectures (e.g., philosophers, social scientists)	13	32	60
Service-learning, community engagement, and/or learning through service	7	21	20
Think-pair-share	6	16	20
Humanist readings	5	0	20
Problem solving heuristics	5	11	20
In-class role plays	4	11	20
Moral exemplars	3	11	0
Other(s) [fill in = In-class discussion; exam questions on NSPE code of ethics]	3	11	0

The next question on the curricular survey asked faculty how they assessed students' knowledge of ethics and/or societal impacts of engineering in the course. The survey presented nine options from which respondents could select multiple choices; results are summarized in Table 6. For each course, 0 to 4 of the assessment methods were indicated, with a median of two. The most common assessment methods were individual reflective essays and individual assignments graded with a rubric. The options that the survey provided for this question proved to be the least comprehensive, with 6 respondents (21%) indicating "other". Two of these write-in options may

be added to the revised survey before national dissemination (do not assess; in-class discussions). No individuals in this survey were using an individual standardized assessment method; the lack of use of these instruments may point to the fact that many instructors may not be aware of these instruments, perhaps due to lack of formal training in ethics instruction. Alternatively, it may reflect the difficulty of creating standardized instruments that measure students' knowledge and/or attitudes toward macroethical issues and/or a lack of faculty confidence in such instruments. These results related to assessment merit a deeper inspection on the national surveys.

Table 6. Methods used to assess students' knowledge of ethics and/or societal impacts of engineering

Method	**N**
Individual critical and/or personal reflective essays	16
Individual homework assignment, essay, and/or papers that are graded with a rubric	9
Group-based written assignment	7
Test questions	7
Other (fill-in = 2 do not assess; 2 in class reflections / discussions; paired oral exams; blog postings)	6
Team ratings	3
Individual homework assignments where questions have fairly straight forward right and wrong answers	1
Individual standardized assessment method (DIT, etc.)	0
Surveys	0

[+] *Among a total of 29 courses described.*

The final survey questions that related to specific courses asked faculty to characterize their level of satisfaction with their ability to assess the outcomes of ethics instruction in the course, using a Likert-type scale from 1 to 7; results are summarized in Table 7. The most common response was neutral (4), neither satisfied nor dissatisfied. The majority of the respondents (54%) described varying levels of satisfaction with their ability to assess ethics education outcomes. There was a moderate correlation between the total number of assessment methods used and the level of satisfaction with ability to assess the outcomes of ethics instruction (Spearman's correlation coefficient 0.411, 2-tailed sig. 0.012).

Table 7. Level of satisfaction with ability to assess outcomes of ethics instruction in the course

Satisfaction level:	1 Very dissatisfied	2	3	4 Neutral	5	6	7 Very Satisfied
N of 37 courses	0	2	2	13	6	11	3
Overall Percentage	0%	5%	5%	35%	16%	30%	8%

The curricular survey course-based questions concluded by asking faculty to provide their opinions on sufficiency of ethics instruction (both micro- and macro-) for both undergraduate and graduate students at their institution; results are summarized in Table 8. For undergraduate education, the most common response was "no, not enough" (38%); only 21% believed students

received a sufficient amount of education on both micro- and macro- ethical issues. For graduate students, the majority of the respondents (50%) felt they did not have enough information to judge (or in the case of U1, there may not have been graduate degrees associated with the program). Instructors at many institutions teach primarily undergraduate courses, so they may feel insufficiently informed to judge the education of graduate students. Of those who commented on the sufficiency of graduate education, 73% felt that there was not enough instruction on ethical issues. These faculty represented a number different engineering programs across the three institutions.

Table 8. Number of faculty with various opinions on the sufficiency of ethics education in their programs

Rating	Do undergraduate engineering students in your program receive sufficient education on ethical issues (both micro and macro ethics)? (n=29)	Do **graduate** engineering students in your program receive sufficient education on ethical issues (both micro and macro ethics)? (n=30)
Yes, but too much; time could be better spent on other topics	0	0
Yes, a sufficient amount	6	2
A sufficient amount of microethics, but insufficient macroethics	3	2
A sufficient amount of macroethics, but not enough microethics	1	0
No, not enough	11	11
Unsure, not enough information to judge	8	15

The curricular survey then continued to ask questions about co-curricular activities that they mentored that incorporated ethical and/or societal impacts. Responses to this question will be discussed in concert with the survey 3 results below. The survey also asked individuals to provide the names of other macroethics instructors at the institution that should be contacted; this was an attempt at snowball sampling. At U3, three faculty provided other names; four had already been invited to participate in the survey and two were invited individually.

The concluding section of the curricular survey was comprised of demographic questions; results are summarized in Table 9 (and includes the 3 individuals who provided course information on the co-curricular survey). In response to the question that asked about different disciplines of engineering where ethics are taught, zero to five categories were checked by individuals (of the 24 choices provided), with a median of 2. The common combinations were: civil and environmental (n=4), chemical and biological (n=3), and electrical and computer (n=3). These combinations are logical since these disciplines are often offered from within the same department, and therefore students in these disciplines are likely to have courses in common. The other disciplines that were typed-in were: humanities for engineers (n=2) and engineering management (n=1). The academic ranks of the respondents were primarily instructors. Eight respondents (29%) held one or two additional roles; these were most commonly ‘other’ (1 center director, 1 industry advisory board, and 1 program director). The gender of the respondents was

50% female; this is a great over-representation compared to women engineering faculty nationally at 15.2%.[52] This may be due to a combination of women being over-represented among individuals who teach ethics and societal impact issues within engineering programs, as well as the known phenomenon that women respond to surveys at higher rates than men.[47] The majority of the respondents were non-Hispanic whites, as is common among engineering faculty nationally (68% in Fall 2014 [52]). The majority of the respondents grew up primarily in the USA (86%). Only 34% of the respondents held a professional engineering license.

Table 9. Demographics of Individuals Who Provided Course information

Institution	N	**Disciplines**	N	**Academic rank**	N
U1	5	Civil	10	Full professor	7
U2	3	Environmental	6	Associate professor	5
U3	18	First-year	4	Assistant professor	4
Institution highest degree		Computer	4	Senior instructor or other full-time non-tenure track	10
Bachelor's	0	Mechanical	3	Full-time adjunct faculty or research faculty	0
Master's	5	Chemical	3	Part time instructor or lecturer	2
Doctoral	24	Biological	3	Department/ college staff member	0
Institution Type		Electrical	3	**Additional roles**	
Public	21	Architectural	3	Dean	1
Private	8	Biomedical	2	Associate or assistant dean	1
Gender		General	2	Department chair or head	2
Male	14	Engineering psychology	1	Associate or assistant department chair or head	0
Female	14	Materials	2	ABET assessment coordinator	2
Prefer not to say	0	Pre-engineering	1	Honor council or similar	0
Race (check all)		Other	3	Other (fill in)	3
White	24	**Ethnicity**		**Grew up primarily in USA?**	
Black or African American	0	Hispanic or Latino	1	Yes	24
Asian	3	Not Hispanic or Latino	26	No	4
American Indian or Alaska Native	0	Prefer not to say	1	**Hold professional engineering license?**	
Native Hawaiian or other Pacific Islander	0			Yes	10
Other	0			No	19
Prefer not to say	1				

Individuals were free to skip any demographic questions, and many of the questions included a "prefer not to say" option. Despite this, a couple of individuals voiced concern about responding to these items. In particular, they felt that the extent of information provided would allow them to be individually identified (i.e. they were the only Hispanic female in their department). For the revised survey to be distributed nationally, there will be some text added that indicates why demographic information is being requested. The form of aggregate information shown in Table 9 will be provided when publishing the results of the national survey in order to provide context

for the results; note that this aggregate reporting does not match an individual to an institution and department.

On the nationally distributed survey, the institution will be a fill-in-the-blank question. This seems more appropriate than having individuals search through a drop-down menu of over 700 institutions that have ABET-accredited engineering programs.[2] Therefore, the two basic institutional characteristics questions will allow quick sorting and statistical analyses of the national survey data.

Ethics in Co-Curricular Activities Survey

Faculty advisors of various professional societies and engineering co-curricular groups on campus were identified, resulting in 17 invited to participate in the survey. Only four responses were received, 3 were from civil & environmental engineering and 1 from electrical & computer engineering. All four respondents indicated the topics they felt students learned about in co-curricular activities that they mentored (Table 2), but only two indicated the type of co-curricular activity that they mentored. In addition, 12 individuals on the curricular survey indicated the type of activity mentored where they believed students learned about ethics-related issues. Overall, these activities were: 6 = engineering service groups such as EWB, H4H, B2P, EWH, ESW, or similar; 4 = professional society such as AIChE, ASCE, ASME, BMES, IEEE, SWE, or other; 4 = research experience such as REU or similar; 1 = design competition (mini-Baja, etc.); 1 = engineering honor society; 2 = others. The future national survey will likely ask individuals to identify the specific societies where students learn about societal impacts, in order to identify particular groups that seem to have more focus on these issues. There was some indication that not everyone understood what was meant by co-curricular; in the future, other terms may be added such as *informal educational settings* or *extracurricular activities*.

The low number of survey responses limits the ability to make any substantive conclusions about ethics in co-curricular settings based on the pilot survey data. In an open-ended question to "briefly describe how engineering students learn about ethical issues and/or the societal impacts of engineering" via the co-curricular activity" there were 15 write-in responses (median 14-word descriptions). Emergent coding identified a few common themes: lectures/presentations/guest speakers (n=6); discussions (n=5), working with community (n=3), design projects (n=2); responsible conduct of research (n=2). It is likely that these choices will be provided on the national survey, as well as including the open-ended response option.

Next Steps: National Survey Dissemination

After revision of the surveys followed by IRB approval, national dissemination of the surveys is on-going in spring 2016. The methods for dissemination and response targets for each survey are described below.

For the curricular survey (survey 2 in the pilot), an invitation to the survey is being distributed via a variety of ASEE list serves (i.e. ethics, liberal education/engineering & society, community engagement, and ERM divisions). A more targeted approach is also being used. Individuals who have authored papers on ethics education are being identified. This includes authors of ASEE conference papers, FIE conference papers, the SIGCSE (Special Interest Group on Computer

Science Education) conference, and journals (Journal of Engineering Education, Journal of Professional Issues in Engineering Education and Practice, Science and Engineering Ethics, etc.). Faculty representatives that coordinate Engineering Projects in Community Service (EPICS) are also being contacted, with a goal of achieving responses representing 30% of the ~20 programs.[21] The goal is to reach knowledgeable individuals representing a broad variety of institutions and engineering disciplines. A raffle is being used as incentive for responding.

For the co-curricular survey (survey 3 in this pilot study), the goal is to receive responses from a variety of different co-curricular engineering programs at institutions around the country. Representatives from various groups will be contacted and asked to send the survey invitation to their lists (such as advisors for university chapters of professional societies). If organizational help is not received, we will compile lists of individual faculty names to the best of our ability, based on online information. Faculty representatives from EWB-USA university student chapters are being contacted, with a goal of receiving responses from 30% of the 206 chapters.[22] Faculty mentors from Engineers for a Sustainable World, Engineering World Health, and Bridges To Prosperity are also being invited to participate in the survey (there are about 50, 46, and 12 student chapters for these groups, respectively). Faculty mentors from student chapters of engineering professional societies are also being contacted, including the Society of Women Engineers (SWE), American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronics Engineers (IEEE), American Institute of Chemical Engineers (AIChE), etc; our goal is to receive responses from at least 20 university chapters of each of these societies. In addition, we will invite participation from the faculty advisors for engineering honor societies including Tau Beta Pi and discipline-specific groups. The mentors and advisors for student groups participating in a variety of engineering design competitions are being invited to participate in the study (including the solar decathlon, Shell Eco Marathon, US EPA P3, Human Powered Vehicle, concrete canoe, etc.). In addition, the PIs and co-PIs from NSF-sponsored Research Experiences for Undergraduates (REU) sites are being invited to participate in the survey. A raffle will be used as incentive for responding.

The research will target a response rate of 35% overall from each of the ABET-accredited bachelor's programs. A goal is also to have at least 20 responses from each common engineering discipline; disciplines with 50 or more ABET EAC accredited programs include: Aerospace, Bioengineering and Biomedical, Chemical, Civil, Computer, Electrical & Electronics, Environmental, Industrial, Materials, and Mechanical.[3] If these survey participation targets are not met, the research will target specific institutions and/or departments via engineering deans and chairs (in a process similar to survey 1 from the pilot study). In November 2015 a list of all ABET accredited programs was obtained via a program search from their website.[3] This resulted in a list of ~2800 four-year programs in the U.S. accredited by the Engineering Accreditation Commission, Computing Accreditation Commission, and Technology Accreditation Commission. An undergraduate student will be tasked with identifying the name and email contact information for a department chair and/or dean associated with each of these programs. These individuals will be asked to forward the survey link to the faculty they believe are involved with educating students about social impact and/or ethical issues in their programs. This will avoid having the dean and/or chair link specific individuals to specific topics, and is a more self-initiated response from the faculty as to whether or not they choose to respond to the survey.

Analysis of the data from the survey will provide a national picture on the prevalence (or lack thereof) of instruction related to macroethical issues in U.S. engineering programs. Statistical methods will be used to explore the results for potential differences between disciplines in terms of the macroethical issues, teaching methods, and assessment methods that they include. Potential differences based on institutional characteristics (Carnegie classifications of Bachelor's, Master's, Doctoral; levels of research activity; public versus private; religiously affiliated versus secular) will also be explored. Results from the national survey will initially be disseminated via a variety of national conferences. To date, there have been over 300 responses to the curricular survey and 1000 responses to the co-curricular survey.

Based on the results from the curricular and co-curricular surveys, 36 faculty representing different types of macroethics topics and instructional methods will be interviewed, as well as requested to supply syllabi and examples of student work. The interviews will result in the selection of twenty diverse and high quality macroethics instructional settings to study in more detail.

Summary

This work-in-progress described the development of surveys that will be used to provide a national picture of macroethics instruction in the U.S. Three surveys were piloted at three institutions, and the results indicated that a diversity of ethics topics, course settings, teaching methods, and assessment methods are used. Many of the respondents felt that the ethics instruction of engineering undergraduate and graduate students was not sufficient. Follow-up interviews are in progress, and these results will help to modify the surveys for improved usability, reliability, and validity. Non-response bias may present a significant obstacle in the research, particularly in regards to answering questions about the overall prevalence of macroethics education in curricular and co-curricular settings. Incentives will be used in the national surveys. Specifically, the opinions of individuals who feel that ethics and in particular macroethics instruction is not important are unlikely to respond to the survey. The future results of the national survey and case studies on ethics instruction may help others to better integrate macroethical issues into the education of engineering and computing students.

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