Macroethics Instruction in Co-curricular Settings

The Development and Results of a National Survey

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***Abstract*— Ethical awareness and decision-making are important skills for graduating engineers transitioning into professional practice and for engineering education accreditation. Ethics instruction can target microethics which focuses on individual projects and topics such as safety, and macroethics which covers larger ethical topics in the field of engineering such as sustainability. While much research has addressed microethical concerns, fewer studies have addressed macroethicial issues.**

Ethics instruction takes place in a wide variety of settings, both curricular in for-credit classes and co-curricular settings such as clubs and societies. The present work-in-progress paper presents a National Science Foundation supported investigation into macroethics education in co-curricular settings that gathered information via a survey of instructors and mentors of these activities.

Preliminary results from the on-going survey are presented, including the settings for co-curricular macroethics instruction and the ethics topics that are discussed. Also, assessment methods used to determine outcomes will be discussed.

Keywords—macroethics; ethics instruction; ABET

I. INTRODUCTION

Ethics instruction is an important topic in engineering education for the purposes of developing principled professionals in the workplace, as well as satisfying the requirements for ABET accreditation. [1] The topic of ethics instruction in engineering can be delineated into microethics and macroethics instruction. Microethics covers the day-to-day ethical considerations such as safety in a specific design project and macroethics covers larger ethical concerns that impact the engineering profession as a whole such as sustainability, poverty and underdevelopment, security and peace, social justice, bioethics, nanoscience, and social responsibility. [2-3]

The present study is concerned with macroethics education in co-curricular settings, such as student clubs. Data were gathered via a national survey of co-curricular engineering instructors and mentors. This study is part of a larger research project funded by the National Science Foundation investigating macroethics instruction nationally at the undergraduate and graduate levels. The project started in the fall of 2015 and has begun with a broad national survey of ethics instruction in both macro and microethical contexts and then the study will narrow to a targeted investigation of successful macroethics programs.

This work-in-progress paper targets a portion of the first phase of the project related to the development of a national survey to assess the range of ethics instruction in co-curricular settings. The paper will cover the preliminary results from the national distribution of the co-curricular survey.

II. BACKGROUND

Skill at ethical decision making and appropriate professional practices are important outcomes of any engineering education and ethical codes of conduct have been developed, incorporated in accreditation practices and taught to students across the range of engineering disciplines. [4] Yet, many of these codes and curricular initiatives can be classified as microethics instruction because they are mostly focused on the day-to-day decision-making and projects of individuals. The present study is focused more on issues that can be termed macroethics instruction. Macroethics takes into consideration the "collective, social responsibility of the engineering profession and societal decisions about technology," and includes topics such as sustainability, social justice and bioethics. [5]

Although ethics instruction is consistently valued in engineering programs, finding a place in the curriculum is a challenge within the context of a crowded four-year degree pathway. One solution is to focus on ethics instruction in co-curricular settings which are also sometimes known as extracurricular organizations and informal learning settings and include a variety of organizations that are not organized for academic credit such as clubs, professional societies, design competitions and undergraduate research programs. For the present study, the term "co-curricular" will be used to cover the range of these types of organizations [6] Although these co-curricular initiatives are promising venues to build additional engineering skills, fewer studies have investigated the impact of this type of instruction via assessment of outcomes or attempted to distinguish between micro and macroethics issues in co-curricular settings.

The present investigation delves further into ethics instruction in co-curricular settings as part of a larger NSF funded mixed-methods project investigating macroethics instruction in engineering education. For this WIP, the focus is on two research questions:

(1) How are macroethics taught in co-curricular engineering settings?

(2) How are macroethics assessed in co-curricular engineering settings?

III. Method

The construction of the co-curricular survey was attentive to best practices for usability, reliability and validity in survey design. [7] The survey design process began with a review of the literature for the purpose of targeting categories and items important to the assessment. This led to the generation of a pilot survey using Qualtrics (http://qualtrics.colorado.edu), a survey design software. The pilot survey was tested locally via administration and interviews with faculty associated with the project PI's three home universities and a variety of revisions were included into the final survey. The survey was approved by the lead PI's IRB. For additional details on the development of survey, please refer to an associated paper from ASEE 2016. [8]

The national co-curricular surveys were targeted to potential respondents based on membership as a mentor/instructor/director in a variety of co-curricular organizations including various societies, service groups, design competitions and undergraduate research sites. Some co-curricular groups sent email to their lists of faculty mentors; in other cases, we self-compiled a contact list of individual names from institutional websites. Table 1 depicts the groups who received survey invitations.

The survey invitations brought in 917 completed responses as of 4/25/16. Table 1 sorts the data by type of activity. The largest number of responses were from instructors and mentors of professional societies with the smallest number of responses from engineering service groups. Respondents were 68% male and 79% Caucasian. The largest group by academic rank was full professor (34%) followed by associate professor (30%). Public universities represented 72% of responses and 80% were from doctoral granting institutions. The largest disciplines represented by respondents were civil (24%) and mechanical (23%) engineering. The survey allowed respondents to describe up to two co-curricular activities, with 42% of respondents providing data on a second activity.

TABLE I. Co-curricular organizations who were invited to complete the survey

Number	Type and Rate		
	Activities	***Overall n (range per group)***	***Response Rate, % Overall (range per group)***
1	Professional societies	570 (3-58)	19 (11-43)
2	Honor societies	193 (0-70)	19 (0-27)
3	Engineering service groups	129 (6-61)	34 (30-38)
4	Research Experience for Undergraduates Sites (REU)	217	19
5	Design groups	144 (6-21)	24 (15-33)
6	Other	22	14

IV. Results and Discussion

Preliminary results from the on-going survey will be reported in this WIP according to types of co-curricular activities where ethics are taught, the ethical topics that are discussed by specific type of activity, the learning methods used discussed by specific type of co-curricular activity and information related to the assessment of these activities. Table 2 depicts results of this analysis of activities by topic.

Across types of co-curricular activities, respondents were able to select from 20 different ethical topics ranging from the topic of bioethics to the topic of war, peace, and/or military applications of engineering. For each activity, the majority of the 20 ethical topics were selected as pertaining to each activity with the only two activities failing to record all ethical topics, student design competitions (18/20 topics selected) and engineering service organizations (19/20 topics selected). Professional practice topics were most frequently selected across activities appearing in four of five co-curricular categories. Societal impacts of engineering & technology was the second most chosen topic appearing in three out of five categories. Within categories, engineering and poverty was a topic discussed in 87% of engineering service groups and responsible conduct of research was discussed in 80% of REU groups. Across activities, bioethics (4%) and nanotechnology ethics (3%) were the least frequently chosen topics.

Participants were also asked to select from different types of learning methods used in co-curricular settings. They were

able to choose between design projects, lectures, discussions, and working with a community.

TABLE II TYPES OF CO-CURRICULAR ORGANIZATIONS AND THE ETHICAL TOPICS ASSOCIATED WITH EACH ACTIVITY

Number	Type and Rate	
	Type of co-curricular activity	***Top 4 topics and percentage***
1	Professional societies	Professional practice issues 72% Societal impacts of engineering & technology 45% Safety 37% Sustainability and/or sustainable development 35%
2	Honor societies	Professional practice issues 49% Societal impacts of engineering & technology 35% Engineering code of ethics 35% No topics related to societal impacts of tech or ethics 29%
3	Engineering service groups	Engineering and poverty 87% Sustainability and/or sustainable development 85% Societal impacts of engineering & technology 78% Safety 76%
4	REU Sites (REU)	Responsible conduct of research 80% Safety 58% Professional practice issues 50% Societal impacts of engineering and technology 41%
5	Design groups	Safety 72% Engineering decisions in the face of uncertainty 65% Professional practice issues 54% Risk and liabilities 53%

Results by co-curricular activity are presented in Table 3. Across activities, all learning methods were used, but the percentages vary by co-curricular activity. Design projects were used extensively across engineering service groups and design competitions while societies, both professional and honor made use of lectures. REU sites tended to rely on discussions to teach macroethics. Across activities, the lowest score was for the use of design projects in honor societies (6%).

Turning to the assessment of co-curricular activities, survey participants were asked if they assess students' knowledge of the societal impacts of technology and/or ethics in this co-curricular setting with only 12% indicating in the affirmative.

TABLE III TYPES OF CO-CURRICULAR ORGANIZATIONS AND THE ETHICAL LEARNING METHODS ASSOCIATED WITH EACH ACTIVITY

Number	Type and Rate	
	Type of co-curricular activity	***Method and percentage***
1	Professional societies	Design projects 33% Discussions 50% Lectures 73% Working with a community 40%
2	Honor societies	Design projects 6% Discussions 36% Lectures 43% Working with a community 40%
3	Engineering service groups	Design projects 92% Discussions 75% Lectures 54% Working with a community 88%
4	REU Sites (REU)	Design projects 47% Discussions 71% Lectures 58% Working with a community 20%
5	Design groups	Design projects 93% Discussions 46% Lectures 26% Working with a community 21%

Results of this question by type of co-curricular activity are displayed in Table 4. Across types, REU's had the largest percentage engaging in assessment while professional societies reported the smallest engagement.

TABLE IV TYPES OF CO-CURRICULAR ORGANIZATIONS AND ENGAGEMENT IN ASSESSMENT

Number	Type and Rate	
	Type of co-curricular activity	***Percentage engaging in assessment***
1	Professional societies	5%
2	Honor societies	8%
3	Engineering service groups	12%
4	REU Sites (REU)	23%
5	Design groups	15%

For those few that indicated assessment of co-curricular activities, a follow-up open-ended question asked respondents to describe how they assess student learning about these topics in this co-curricular setting. Of the 917 respondents, 138 (15%) provided open-ended replies about assessment methods. Preliminary coding of the responses indicate a variety of methods used including:

- Surveys: Examples include a Likert scale on how much the students feel that they have improved and validated tools such as the Leadership Attitudes and Beliefs Scale,
- Reports/Essays: Examples include writing a technical paper and end-of-summer essays,
- IRB certification: One example is passing the CITI exam,
- Rubrics: These include design reviews, expert judging, and design competitions. An example is a scoring rubric given to the judges for each category at the actual competition. Part of the rubric involves student comprehension and design decisions with respect to sustainability and social parameters,
- Presentations/Posters: One example has students present at student conferences what they have learned and mentor other younger students,
- Journals: Examples include design journals and student blogs,
- Homework questions: Ethics questions are included in their homework,
- Group discussions: One example is a case study of an engineering failure that is discussed among the group. Another example is a project debrief.

V. Summary and Future Plans

To summarize, a macroethics survey was developed, piloted and administered to instructors and mentors of a variety of co-curricular activities and organizations. A main goal of the survey is to address a gap in the literature and practice of engineering education around the instruction of macroethics. This NSF supported project has garnered 917 completed responses in this on-going survey administration. Respondents were majority male, Caucasian full professors from public universities who granted doctoral degrees and civil and mechanical engineering programs.

Preliminary results reveal the largest number of responses, by far, from mentors of professional engineering societies with a smaller range of responses from engineering service groups. While all respondents discussed a co-curricular activity they mentored, 42% described a second activity as well. Across co-curricular activities the majority of 20 ethical topics presented were taught in each activity with professional practice issues the most widely taught. Within activities, the topic of engineering and poverty was taught in 87% of engineering service groups. The least taught topics were bioethics and nanotechnology ethics. A wide variety of learning methods were used for each activity with the broadest use of design projects in design and community service groups.

Turning to assessment activities, only 12% of respondents indicated they assessed ethics outcomes in these co-curricular activities with a range by organization between 5% for professional societies and 23% for REU's. These lower numbers for assessment in co-curricular settings have implications for those schools who would like to use these results for ethics outcomes in the ABET accreditation process but lack the necessary assessment data to do so. Even though the number of participants assessing their co-curricular activities was limited, a number of assessment methods were used.

Limitations of the study include the on-going nature of the data collection process. Also, some respondents indicated that a portion of their co-curricular activities were taught in a classroom setting. Future data analysis will separate completely co-curricular settings from partially co-curricular settings.

Future plans for this study include an evaluation of results for completeness in data collection across the broad range of possible co-curricular activities to answer the question of a representative data set. Also, there are plans to conduct a set of interviews with survey respondents who indicated a willingness to participate in a follow-up interview to delve deeper into results. Future plans also include targeting a few case studies of exemplary ethics instruction practices for further, in-depth investigation. Results from these additional investigations will be shared in future papers.

References

[1] Catalano, G.D. (2004). Senior capstone design and ethics: a bridge to the professional world. Science and Engineering Ethics, 10, 409-415.

[2] Barry, B.E. and Herkert J.R. (2014). Engineering Ethics. Chapter 33 in Cambridge Handbook of Engineering Education Research. Eds. A. Johri and B.M. Olds. Cambridge Press. Pp. 673-692.

[3] Allenby, B. (2006). Macroethical systems and sustainability science. Sustain. Sci. 1: 7-13.

[4] ABET. (2012). Criteria for Accrediting Engineering Programs. Effective for Evaluations During the 2013-2014 Accreditation Cycle. ABET Engineering Accreditation Commission. Oct. 27, 2012. www.abet.org

[5] Herkert, J. R. (2004). Microethics, macroethics, and professional engineering societies. Emerging technologies and ethical issues in engineering, National Academy of Engineering, Washington DC, pp. 107-114.

[6] Finelli, C.J., Holsapple M.A., Eunjong R.A., Bielby R.M., Burt B.A., Carpenter D.D., Harding T.S., Sutkus J.A. (2012). An Assessment of Engineering Students' Curricular and Co-Curricular Experiences and Their Ethical Development. Journal of Engineering Education. 101 (3), 469-494.

[7] Allen, M.J. and Yen W.M. (1979). Introduction to Measurement Theory. Belmont, CA. Wadsworth, Inc.

[8] Bielefeldt, A.R., Canney, N.E., Swan, C., and Knight, D.W. (2016). Efficacy of Macroethics Education in Engineering. ASEE Annual Conference, New Orleans, June.