

A graduate-level course module to introduce electrical engineering master's students to public welfare responsibilities

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Abstract — This is a full Innovative Practice paper. Engineering professionals are increasingly called on to serve as “public welfare watchdogs” by paying heed to ways in which complex technologies can impact society and intervening when ethical issues arise. Though it is a goal of engineering education to train engineers to recognize and understand their responsibilities to the safety, health, and welfare of the public, research suggests that students are inadequately prepared to address such issues in practice. To address this concern, we designed and piloted a course module for electrical engineering master's students to help them better address their public welfare responsibilities. In this paper, we provide a detailed description of the course module, including reflection prompts, in-class presentations, breakout group activities, discussion prompts, and post-class assignments. We also present results from our pilot, including a summary of student responses to the reflection and discussion prompts and an overview of students' course feedback.

Keywords—graduate education, course design, student experience, professional skills, public welfare responsibility

I. INTRODUCTION

This paper presents findings from a graduate-level course module on engineering ethics. The engineering profession has the power to shape many key elements of public life [1-3]. Because of this significant authority and the technical inaccessibility of engineering work, the public is reliant upon engineers to protect collective health, safety, and welfare, a responsibility that is formally written into the codes of professional organizations such as the Institute for Electrical and Electronic Engineers (IEEE) [4].

As much as it is the goal of many engineering educators to impart a sense of responsibility to students, however, previous research suggests that students may not be aware of or may not feel prepared to fulfill this responsibility in practice. For instance, some students may not view public welfare as part of their professional responsibility [5-7]. Or, even if they do recognize this responsibility, they may be unwilling or unsure of how to intervene if they identify a concern [8-10].

Ideologies of depoliticization and meritocracy common in professional engineering culture are thought to discourage engineers from viewing commitments to the public welfare as being related to their professional responsibilities [11]. Without intervention, these normative ideas are likely to be self-

perpetuating and may encourage educators and students to focus on developing what are seen as more employable skills at the cost of attention to other professional responsibilities [1].

Educators have long been concerned about promoting engineers' public welfare responsibilities [12, 13], and there has been growing research on ways to teach engineering students to understand and value their public welfare responsibilities [14-18]. However, more research is needed to understand what methods are most effective. It is also notable that most previous work has focused on undergraduate-level training, with little attention to graduate-, particularly master's-level, training [19].

In an effort to better understand engineering students' current knowledge about—as well as to (re-)familiarize them with their public welfare responsibilities—we developed and piloted a course module for graduate students in the University of Michigan's electrical engineering program. The module comprised two sequential one-hour class sessions with pre-class assignments, in-class activities, and post-class assignments for each session. We piloted the module in an introductory course for electrical engineering master's students. In this paper, we describe our Public Welfare Responsibility and Intervention Training (PubWRIT) module, present results from our pilot, and offer thoughts for future work.

II. THE COURSE MODULE

In the Fall 2021 semester, the Electrical Engineering and Computer Science (EECS) Department at the University of Michigan offered a 1-credit course in which we piloted our two-session PubWRIT module. The course, “Skills for Success in Graduate Studies,” was primarily intended to assist first year electrical engineering master's students in transitioning to graduate school. Fifty-minute weekly class sessions were held for each of 14 weeks. The course covered topics such as time management, student life on and off campus, mental health and stress, oral communication and presentations, research basics, tips for writing, imposter syndrome, bystander intervention, and career planning. In addition, two sequential class sessions (during weeks 12 and 13 of the semester) were devoted to our PubWRIT module that addressed engineers' responsibility to public welfare.

A total of 47 students enrolled in the course. Typically, four to five students attended each class session in person, 15-20

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participated synchronously by zoom, and roughly half of the students watched the recorded videos later. Each class session typically comprised an ungraded, pre-class assignment as well as a graded, post-class assignment due the following week. Our two-session PubWRIT module included one pre-class assignment prior to Day 1 of the module, in-class activities during the first class session, a post-class assignment after the first day (which also served as the pre-class activity for Day 2), in-class activities during the second class session, and a final graded assignment.

A. Day 1: Pre-class assignment

Before the first class session of our PubWRIT module, students were asked to complete a two-part pre-class assignment. First, they read and reflected on an op-ed published in the American Society for Engineering Education (ASEE) Prism magazine [20]. This piece discusses the importance of engineering students and practitioners recognizing their responsibility to public welfare and highlights the role that institutions can and should play in supporting that learning. Students then completed a brief survey about ethics training they received previously. The survey items were based on the PIs' pilot survey of employed engineers about their prior exposure to public welfare-related training (see [21] for more details).

B. Day 1: In-class assignment

During the first class session, the instructors reviewed the IEEE Code of Ethics [4], and students identified things that surprised them about the code. Students then individually reflected on the following questions and discussed them in small groups of three to four students:

- What type of training in the professional responsibilities of engineers (if any) did you receive as an undergraduate? In what context was the training delivered (e.g., through a dedicated course, as a module in an engineering course, as a formal part of a co-curricular activity)? What topics were covered?
- What type of training in the professional responsibilities of engineers (if any) did you receive in the workforce? In what context was the training delivered? What topics were covered?
- What type of training in the professional responsibilities of engineers has been missing?

Students recorded summaries of their group discussions in a shared online document.

C. Day 1: Post-class assignment

As a post-class assignment for the first session (and a pre-class assignment for the Day 2) students added to the in-class discussion by describing an incident where additional training in engineers' professional responsibilities would have been useful.

D. Day 2: In-class activity

During the second class session of the PubWRIT module, the instructor reviewed research findings of training for public welfare responsibilities and then asked students to discuss their responses to the pre-class assignment in breakout rooms. The session ended with the instructor reviewing examples that illustrated how the public increasingly relies on engineers to

understand complex socio-technical systems and to intervene on their behalf before then describing the final assignment.

E. Day 2: Final assignment

The goal of the final assignment for the PubWRIT module was to give engineering students practice articulating their concerns to a broader audience. Specifically, students wrote a short editorial based on the following prompt:

Select an issue related to your work or your subfield of Electrical and Computer Engineering that raises ethical or moral issues for you. Brainstorm a public outreach statement in the form of an op-ed, a social media post, or letter to the editor. In two paragraphs, (1) describe the issue, (2) explain why it concerns you, and (3) identify who should be notified and who should act.

III. RESULTS

A. Day 1: Pre-class Assignment

Sixteen students responded to the Day 1 pre-class reflection prompt. Their reflections on the Prism article [20] were largely in agreement with the authors of the piece.

I agree with the article, in a sense that engineers should be proactive in matters related to complex technologies in society, especially for public welfare.

Engineers must contribute to not only the technology enhancement but also the Public welfare.

A few students, though, offered slightly different interpretations. For instance, one student focused on the role of institutions in imparting a sense of responsibility (notably, this was not a direct claim of the piece), while another expressed concern that the article's emphasis on ethics conveyed a devaluation of technical skills.

Many engineers are unaware of their responsibilities to the public and ethics, but this is due to foundational issues in the education system.

I agree that social skills, ethics, and moral standards are important for Engineers. However, when it comes to solving problems in STEM fields, technical skills are vital, if you have no technical skills, no problem could be solved. The way the article framed as if you could only care about one skill, which to me is a false dichotomy.

A total of 17 students completed the optional, ungraded pre-class survey for Day 1. Responses offered a preliminary sense of where and when students received training about several professional responsibilities (Fig. 1). These students most often reported receiving training regarding technical skills such as verbal and written communication, identifying solutions to engineering problems, and advancing basic and technical engineering knowledge.

Almost half of the students received training on their ethical responsibilities as engineers through formal undergraduate education, with fewer obtaining this training in other undergraduate or professional settings. Only two students reported receiving no such training. This group of students was

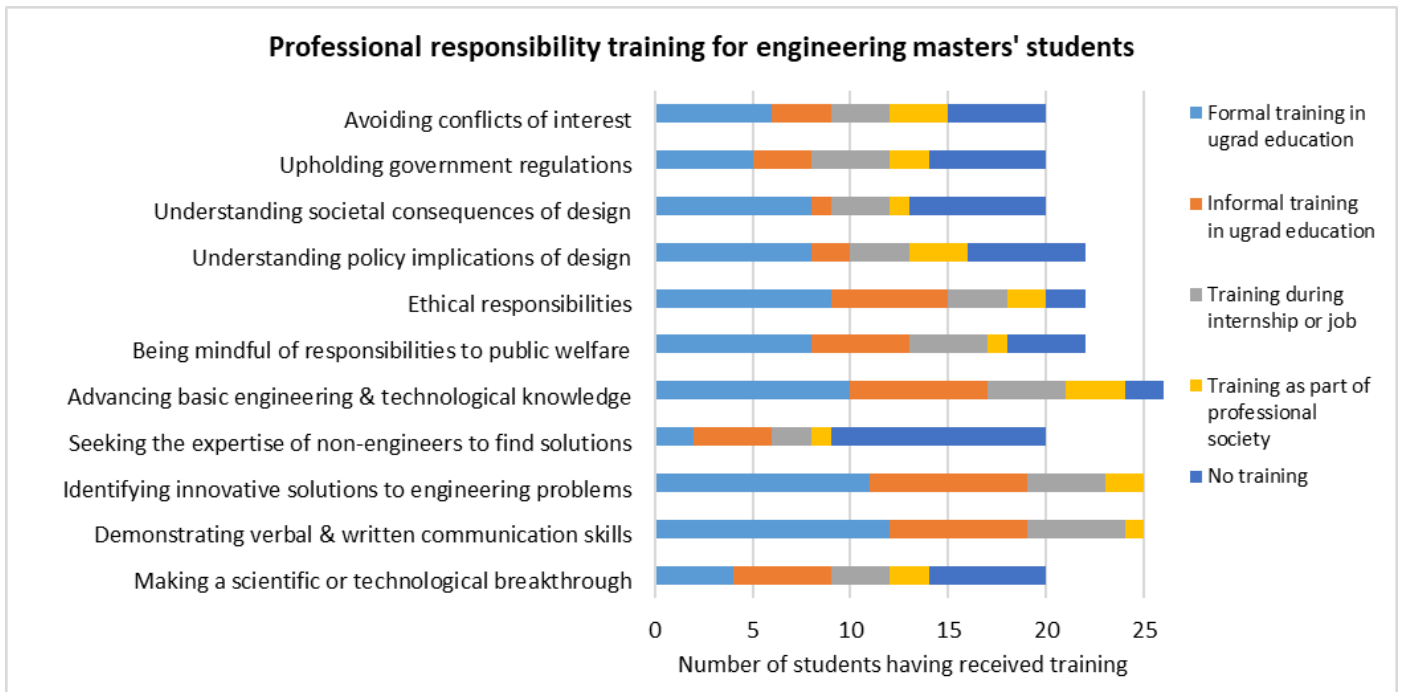


Fig. 1. List of several different factors of PubWRIT students' professional responsibility training and where this training was received, if at all.

least often trained on understanding the societal consequences of engineering design and seeking out the expertise of non-engineers to find solutions to engineering problems.

B. Day 1: In-class reflection

Thirty-three students completed the in-class reflection activity (some of whom did so when viewing the recorded session at a later date). The in-class reflection activity offered more insight into initial responses to the pre-class survey about the nature of the training received. Students who reported receiving training related to professional ethics primarily received it as a part of their undergraduate education. Several of these responses indicated that this training was limited and not typically regarded as important by their classmates.

I think responsible engineering was briefly covered during my senior design project and maybe in one other class.

I think one lecture in total was devoted to professional responsibilities of engineers. Very high level.

Some of my classes have had brief discussions of professional responsibilities of engineers. The most notable would be EECS 496, which was a professionalism seminar that had some speakers talk about things like ethics, legal issues, intellectual property, etc. I would say it wasn't treated as an integral part of our undergraduate engineering education, at least from the perspective of the students. It was seen more as a 2-credit class you just have to take as a senior, and not really as important as our technical curriculum. I've also been exposed to some ethics discussions in seminars for the engineering honors program, though I did not complete that program

Some students offered more specifics about the topics of their ethics training, which included honesty, data manipulation,

and plagiarism. Ten students who responded reported receiving no training about the professional responsibilities of engineers.

For students who had work experience as an engineer, training regarding legal matters and employee rights was most common. Few received training about their ethical responsibilities from their employer, and, as with undergraduate training, there was a sense that this was treated as a requirement rather than being something that the students felt strongly about.

Most of my internships have had some mandatory training modules for things like ethics, security, responsibility, etc. Again, I often viewed them more as something I just "had to do" and didn't value a ton, rather than a core piece of my responsibility in my job.

When asked what was missing from their training as professional engineers in either setting, students had varied perceptions. Some specifically identified that they lacked training about diversity, equity, and inclusion, and/or noted a lack of training on the societal implications of their work.

I guess one important part that's missing in some of the education today is how to integrate the conceptions into the actual technical practices. I think most of the engineers understand that their innovations would have a social impact but when it comes to the practice, engineers are sometimes confused with what specific things they can do.

Only three of the 33 students reported there were no gaps in their training. Instead, students were more likely to reflect that they did not receive enough or possibly did not value it enough.

I'm not really sure, since to me most of the "professional responsibilities" seem like common sense.

I didn't pay much attention to this before, so I think maybe, a lot?

I think, in general, what is missing is a sense of understanding that the non-technical aspects of engineering are a fundamental part of the core of engineering. It makes sense that the bulk of our education is technical, as there's a lot of stuff we need to learn. However, those discussions of professional responsibilities are often relegated to a single module in a class, or a short class that people don't take too seriously, etc. It feels more shoehorned in to check a box than something that the college/students take seriously as a fundamental part of our education.

C. Day 1: Post-class assignment

Thirty-five students completed the post-class assignment for Day 1, and they shared a variety of instances in which they felt greater training would have been helpful to them. Several students expressed feeling unsure of whether they should act, or how to act when they experienced a concern.

I was working at a company with a culture that was different then what I had been prepared for while in college. The people at the company had as a top priority the appeasement of a financial benefactor to the company and this individual made working for the company difficult. As a result of external expectations, there was a sense of urgency put employees lacking experience which resulted in dishonest work being done. I am not sure how the situation was resolved because I left but I do not think [much] real work or progress was actually accomplished.

I had coworkers discuss an issue that they were dealing with that was unethical. Instead of taking it to their manager or my manager I just did nothing assuming it would get sorted out. Nothing was done and it ended up being a huge issue for the company.

To be better able to handle such concerns in the future, many students indicated that training related to professional integrity and “appropriate conflict escalation behavior” would be helpful. Others reflected that they could benefit from further training on social matters.

I think the main reason why the data isn't well balanced is that the engineers who design them never thought of these issues which may affect people when they are used. Sensitivity, foresight and awareness about ground-level issues is needed.

I was missing the skill to differentiate between having different opinions or points of views versus being disrespectful and intimidating.

Skill to identify the bias and to treat all persons equally.

Less than one third of the respondents (11 of 35 students) suggested training should be offered in the workplace, though the majority of students felt these topics should be taught through formal education. There were some disagreements in students' ideal timelines for teaching, however. For some it was important that professional responsibilities were taught to students as soon as they entered college, while others felt these subjects were more appropriate for senior undergraduates or graduate students; concern was still expressed for how students would react to such coursework, though, were it made an additional requirement.

I would like to see topics like this integrated closely with technical courses. I think shoving it all into a single seminar-like class could easily give it a reputation of just being an annoying class you have to get through to graduate, rather than being a meaningful part of the undergrad education. If it were to be its own course, I would want to see lots of resources/efforts going into making it a well-run and well-organized course, like some of the other major courses which tons of students take...The closest existing analog ... was very poorly run, confusing, and disorganized when I took it, and as a result it ended up not taken very seriously at all by anyone I knew in it.

Mandatory class would be okay but would suck to give so many presentations or something. Having a 1-1 with a mentor/faculty member is also a stretch beyond belief. So Maybe a class or program that's optional but advertised in classes.

D. Day 2: Post-class assignment

Thirty-nine students completed the final assignment for the two-session PubWRIT module, and their submissions reflected students' broad interests and experiences. Matters related to artificial intelligence, particularly as it concerned autonomous vehicles, were the most often discussed, followed by military use of new technologies. The op-eds touched upon concerns over privacy, environmental health, safety, and discrimination. There was little consensus about where responsibility lies for reporting and responding to these concerns, however. Some students suggested that the companies should be pressured by the public or regulated by governmental bodies, while others seemed to feel that engineers shoulder the responsibility to act and/or to withhold labor.

...Ring [a home security video surveillance system] needs to switch to a locally-based processing/storage solution instead of a remote one. This will keep all footage from ever leaving the customer's home, preventing widespread leaks or access. This is not only completely possible, but is already being done by other companies such as Apple, Logitech, and Eufy. Send a Tweet at @Ring with #UnsafeRing to tell them we want our video to remain OURS!

...To be honest, I don't think there is an individual we could report and solve the issue. The best we could hope for is that every engineer working in the organization/company would be honest to themselves, and speak up to their superiors when they find it necessary. If that does not work, the other option (albeit is not ideal) is to turn to the media.

...We can't expect these money-hungry corporations to make moral decisions, as they are more concerned about profits than lives. However, the second group, engineers, can make a difference here. Without our talents and work, these companies cannot continue to kill. By choosing not to work for murderous companies like these, and by speaking up when our peers are, we can affect positive change. We can starve these companies of the talent they need to continue their murder-for-profit schemes.

...Therefore, the government should issues specific rules or laws to limit the use of computer vision technologies and the

collections of biometric data to balance the privacy issues and public safety, and avoid any types of discriminations.

IV. DISCUSSION

The assignments and class discussions which comprise our two-session PubWRIT module offer several insights into student perceptions of their responsibilities and into the related training they receive. Some responses reflected scholars' concern that students do not view public welfare responsibilities as being clearly related to their technical responsibilities and that the latter are more important to the profession than the former are. Students described their training on engineers' social responsibilities offered in a formal institutional setting as brief and lacking guidance on how to apply and act on this thinking in practice. It is also unclear if this training consisted primarily of conversations about personal ethics (e.g., plagiarism, data manipulation) or of broader responsibility to the public (e.g., considering equity and inclusion). As such, students generally expressed feeling disconnected from these teachings and feeling unable to confidently take action in workplace situations.

Yet, many students' responses revealed an interest in and motivation to better understand their professional responsibilities to public welfare, to learn tactics for intervening effectively, and opportunities to practice engaging in outreach. As electrical engineering master's students, many had nuanced understandings of existing and near-term threats to public welfare and offered practical warnings when given the opportunity to express them.

V. CONCLUSION

We hope that this study contributes to efforts to better prepare engineering students for their public welfare responsibilities as professionals. We plan to continue this work through future iterations of the course and further research.

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