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Learning to be Public Welfare Watchdogs: A Master's Level Course to Enhance Engineers' Recognition of and Responsiveness to their Public Welfare Responsibilities

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Abstract

Engineering professionals have a societal and moral obligation to protect the safety, health, and welfare of the public. Although public welfare concerns are touted by engineering leaders and educational institutions as important in the abstract, engineering students are often inadequately prepared to recognize their public welfare responsibilities, let alone to act when issues arise. To address this gap, we designed and piloted a one-credit course for Master's and upper-division undergraduate engineering students. The course had three learning goals: (1) teach students to recognize their public welfare responsibilities, (2) motivate students to act on public welfare issues, and (3) equip students with intervention strategies (e.g., understanding whistleblowing protections, writing an op-ed) to confront issues they may encounter in their future professional work. In this paper, we provide a detailed description of the course and present data from pre- and post-class surveys and open-ended reflections to illustrate how the class produced notable changes in students' (a) recognition of their public welfare responsibilities, (b) motivation to take action, and (c) familiarity with intervention strategies. These results suggest the viability of engineering education courses to not only increase students' knowledge of their public welfare responsibilities (the typical approach of ethics and professionalism courses), but to better equip them to uphold their responsibilities as public welfare watchdogs.

Introduction

Formal engineering education is one of the only institutional spaces with the explicit goal of training neophytes to become responsible members of the profession [1]. Once they graduate, engineering students are unlikely to receive effective public welfare responsibly training in their workplaces or professional societies [2]. Yet, due to curricular challenges like ever-expanding technical content that crowds out other topics and cultural ideologies in the professional culture of engineering that devalue non-technical considerations [3-7], engineering education programs often de-emphasize public welfare responsibilities compared to technical skills and can even foster *disengagement* with public welfare considerations as students learn to be engineers [8].

As part of a broader project on engineers' recognition of their public welfare responsibilities, we developed a one-credit course to teach Master's and upper-division undergraduate students to recognize their public welfare responsibilities, equip students with strategies to intervene (e.g., bring issues to the attention of team members, use organizational hotlines, report to federal agencies, work with journalists), and prepare students to act.

The goal of this paper is to provide an overview of the course's goals, content, and assessments. We then use data from pre- and post-class surveys and open-ended reflections to illustrate how the class produced significant changes in students' recognition of their public welfare responsibilities, their motivation to take action, and their familiarity with intervention strategies.

Course Goals

The purpose of the Public Welfare Responsibility and Intervention Training (PubWRIT) course was to guide students toward a multi-faceted understanding of their professional responsibilities as engineers. Those responsibilities include both their accountability to people and society, as well as their duty to be vigilant to the ways the burdens of socio-technical systems may be disproportionately shouldered by certain groups.

The PubWRIT course had three learning goals: (1) teach students to recognize their public welfare responsibilities, (2) motivate students to act on public welfare issues, and (3) equip students with intervention strategies to confront issues they may encounter in their future professional work. The course included a mix of lectures, group discussions, and reflection assignments, and it demanded more of students in terms of engagement and sophistication in the readings and assignment than typical lower-division courses. The detailed learning outcomes listed on the class syllabus are included in Fig. 1.

The one-credit course was aimed at upper-division undergraduate and master's students in the Electrical Engineering and Computer Science (EECS) and Mechanical Engineering (ME) departments at the University of Michigan. This is an important constituency of students who are about to head into the labor force to participate in and possibly lead design teams and many have already had experience in the engineering workforce through internships; yet this group of students is typically not the targetsof ethics and public welfare training.

We piloted the PubWRIT course in Fall 2024 at University of Michigan. The course modules and assignments are described in the next section.

Fig 1. Learning Outcomes of PubWRIT Course

Technical and non-technical skills students will acquire through the course

- Recognize public welfare concerns in engineering
- Identify strategies engineers can take to address public welfare concerns
- Practice taking action to address public welfare concerns
- Read and reflect critically
- Engage in respectful dialogue about challenging issue
- Express complex ideas in writing and through presentations

Technical and non-technical educational outcomes

By the conclusion of the course, students will …

- Be able to articulate the full range of engineers' professional responsibilities, including both technical and societal ones
- Consider public welfare-related considerations as central to their professional roles
- Increase their understanding of how the technical/social dualism and depoliticization manifest in engineering
- Be equipped with intervention strategies (e.g., take action within their organization, report to federal agencies, or work with journalists) to use when facing threats to public welfare
- Be motivated and prepared to take action when faced with public welfare concerns

We evaluated the course by administering detailed pre- and post-class surveys to students the first and last day of class and reflection exercises throughout the course. Achievement of learning outcomes is illustrated in evidence of students' more expansive understanding of their professional responsibilities, their deeper commitment to taking action, and their greater knowledge of tactics for intervening.

The PubWRIT course was structured as a one-credit class that met in person two hours per week for the first seven weeks of the term. This half-term structure allowed for deeper engagement with the topics and material than a one hour class meeting once a week for the full term would likely have provided.

The course consisted of three modules: Module 1: Engineers' responsibilities to public welfare, Module 2: Roadblocks to recognizing, strategizing about, and taking action to address public welfare concerns, and Module 3: Intervention strategies. Each module included pre-work, in-class discussions, and (in most cases) a reflection exercise or follow up assignment and each spanned two weeks of course meetings; the seventh week was reserved for class presentations and final assessments.

Module 1: Engineers' Responsibilities to Public Welfare

Week 1. Traditional conceptualizations of engineers' public welfare responsibilities
Week 2. Deeper investigation into public welfare responsibilities

The goal of this module was to introduce students to the full range of their public welfare responsibilities as professional engineers. We began with a discussion of codes of ethics, which many students had heard of but were not especially familiar with. We used the IEEE code of ethics [9] as our focal example, both because the class was comprised of many electrical engineers and because the IEEE code covers a wider range of issues than many other articulations of the engineering code of ethics. Through lectures and in-class discussions, we emphasized that engineers' professional responsibilities not only include health, safety, and security concerns for clients and end users, but they also encapsulate considerations of inequality of access, comparison of risk and benefit, issues of monitoring and control, and the fair and non-discriminatory treatment of one's colleagues. We emphasized that engineers not only have a responsibility for their own behavior, but they have a duty to speak up if they believe the welfare of the public is at risk by the actions or decisions or their employing organizations or within areas of expertise.

For pre-work in this module, students read examples of ethics statements from large technical companies (e.g., Amazon Web Services and Google) and defense-related companies (e.g., Lockheed Martin and Palantir Technologies). In class, they discussed patterns they noticed in those ethics statements, as well as gaps between these corporate ethics statements and the more expansive IEEE codes of ethics. Students also read op-eds from engineers making the case that ethical practice is vital for technical success [10].

Finally, we led students in an in-class reflection exercise about times when they had encountered things that concerned them ethically (e.g., in the company they worked for before graduate

school, in a lab where they were a research assistant, in organizations where they interned), and ways they handled those situations.

Module 2: Roadblocks to Recognizing, Strategizing About, and Taking Action to Address Public Welfare Concerns

Week 3. Institutional and workplace roadblocks to addressing public welfare concerns
Week 4. Cultural and identity-based roadblocks to addressing public welfare concerns

For many students, Module 1 was the first time they had been exposed to what the "social contract" of engineering ethics means for engineering practice. Scholars in fields such as engineering education and science and technology studies (STS) have written for decades about the institutional and cultural factors that serve as roadblocks to engineering students' and professionals' serious engagement with these public welfare considerations. The goal of Module 2 was to educate students about such roadblocks.

Here, we drew on literature from engineering education, social science, and STS to discuss factors that devalue and constrain considerations of public welfare responsibilities in engineering. We taught students, for example, about curricular challenges in engineering education like technical content crowding out training in public welfare responsibilities and other professional skills [1, 4, 6, 11, 12] and corporate interests that pressure workplace ethics training to emphasize avoiding litigation [13-15]. We also discussed cultural and ideological factors in engineering education and engineering practice that devalue considerations of public welfare as less relevant or even threatening to "real" engineering work [8, 16].

For pre-work, students read news articles about companies like Google reversing direction on previously robust support of ethics research [17] and the structural features of tech startups that make public welfare considerations more difficult to incorporate into early decision-making [18]. Students also read a summary of our team's research findings on the absence of widespread, effective public welfare responsibility training in engineering education, workplaces, and professional societies [2].

In class, we engaged students in structured discussions where they identified other institutional and cultural blockades to serious consideration of public welfare responsibilities, and brainstormed how engineers could overcome them.

Module 3: Intervention Strategies

Week 5. Public-facing efforts to address public welfare concerns
Week 6. Action through whistleblowing and alerting government regulators

The focus of Module 3 was to engage students in considerations of how they would take action if they encountered threats to public welfare in their work as engineers. The first week of this module introduced options for speaking out publicly as a technical expert about an issue that concerned them (e.g., communicating with journalists, working with professional societies, using

social media platforms). The focal activity guided students to conceptualize and draft an op-ed on an ethical issue in their subfield that raises ethical concerns for them (e.g., the lack of regulation of generative AI, algorithmic bias, use of conflict minerals).

As pre-work, students read several examples of op-eds raising awareness of public welfare threats of technology [19]. In class, we gave them a primer on writing effective op-eds [20] and had them "reverse engineer" these example op-eds for key pieces of effective op-ed argumentation (e.g., a strong lede, supporting evidence, addressing counter arguments, ending with a call to action). We then asked them to outline an op-ed on their own in class using the same format. Students submitted a completed op-ed as one of the three major assignments for the course. Students were given the assignment instructions listed in Fig. 2.

Fig. 2: Op-Ed Assignment Instructions

For this assignment, you will identify an engineering issue that raises ethical concerns for you and advocate, using evidence, for how to improve the situation. Specifically, you will write a public outreach statement – an op-ed (opinion/editorial piece) – to express your opinion about the issue, support your point with references, summarize probable counterarguments, and offer a solution. Your op-ed should consider the impact of engineering work on global, economic, environmental, and/or societal contexts, and should make the case for *what concerns you, why it's a problem, and what we should do about it.*

Your op-ed should be ~750 words not counting citations (about five to six paragraphs), and it should:

(1) Describe an engineering issue that you think has (or might have) negative consequences for society, and explain why it concerns you. Provide a compelling hook that makes a single point about why there is an issue.
(2) Include supporting facts. Support your point with evidence in the form of a brief summary of the literature on this topic and include three to five references.
(3) Identify counterarguments. Identify 1 – 2 arguments against your point your opposition might raise.
(4) Advocate for a solution. Provide a call to action by identifying who should be notified and what they should do.

For the second week of Module 3, we introduced the topic of whistleblowing more formally. As pre-work, students read an article that discussed engineers' responsibility to act as whistleblowers [21] and several real-life cases of whistleblowing [22]. In class, we provided formal definitions of whistleblowing, brainstormed avenues for speaking up (e.g., bringing issues to the attention of supervisors or team members, using organizational hotlines, going to local or federal regulatory agencies), and discussed personal and professional risks, legal protections, and whistleblowing regulations for engineers in different employment contexts. In groups, students were given several examples of public welfare wrongdoing and asked to brainstorm plans for how they would approach whistleblowing in each instance.

Wrap-Up

The final week of class was dedicated to group presentations. Like the op-ed assignment, pairs of students were instructed to identify an engineering issue that concerned them ethically and create a presentation raising the alarm for key stakeholders or decision-makers. They were given the prompt listed in Fig. 3.

Fig. 3: Final Presentation Assignment Instructions

> For this assignment, you and a classmate will create a new op-ed together and deliver a short (4-5 minute) presentation summarizing it. Imagine that you have the opportunity to make a short presentation to a group of legislators, the leader of a professional society, a group of CEOs of tech companies, a group of academics, or other relevant constituencies. This is your chance to make the case for *what concerns you, why it's a problem, and what we should do about it.*
>
> Similar to the op-ed assignment, your presentation should have the following components:
>
> (1) Describe an engineering issue that you think has (or might have) negative consequences for society, and explain why it concerns you.
>
> (2) Include supporting facts. Support your point with evidence in the form of a brief summary of literature on this topic.
>
> (3) Identify counterarguments. Address 1 – 2 arguments against your point your opposition might raise.
>
> (4) Advocate for a solution. Provide a call to action by identifying who should be notified and what they should do.

The topics of students' presentations highlighted issues such as the dangers of technological facilitation of deepfakes and fake news, sustainable manufacturing practices, discriminatory hiring practices rooted in AI, and privacy risks in medical technologies. Students were graded on their effectiveness at addressing the four components outlined in Fig. 3 as well as the clarity and organization of their presentations.

Student Characteristics

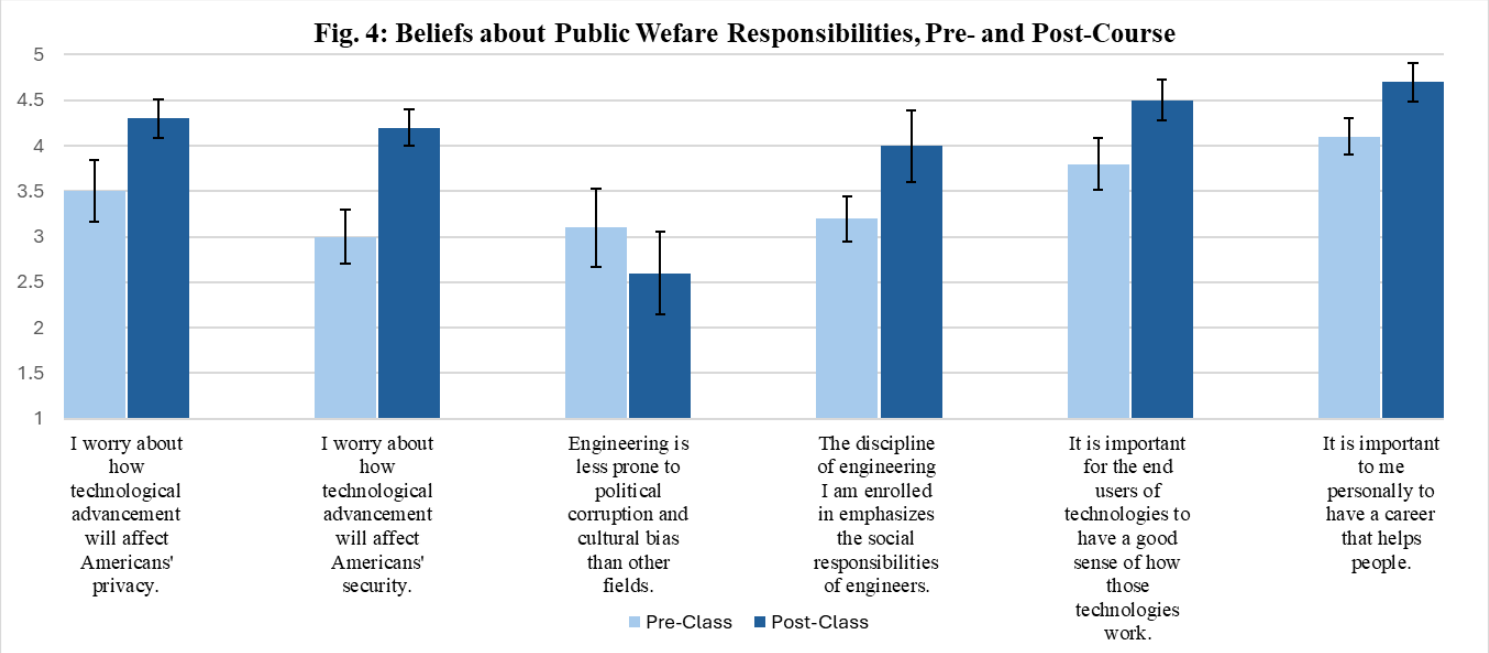
Our pilot PubWRIT course had 16 students: 11 EECS master's students and five undergraduates from EECS and ME. Although we cannot provide detailed demographic data due to the small sample size, approximately three-quarters of the class identified as men, and the majority were non-US born (primarily from East and Southeast Asia). Over three-quarters had internship experiences or other prior exposure to employment as engineers.

This was an elective course; while this may mean that students might have been "primed" to learn about these topics, we suspect that the elective nature of the course meant that students who selected in to the course had a higher-than-average commitment to public welfare responsibilities. This would mean that the changes we observed might be a conservative estimate of the shifts that might occur given a sample of students who were required to take the course.

Course Evaluation

We used two approaches to evaluate the PubWRIT course: pre- and post- class surveys and anonymous open-ended post-class reflections. We drew the 5-point, Likert-scale survey questions from an instrument developed we developed for an earlier part of the project to assess employed engineers' assessment of their public welfare responsibilities [2]. Due to the small sample size, the survey results preclude advanced statistical analysis. However, we found several notable positive outcomes of the PubWRIT course comparing the pre- and post-survey results.

Fig. 4 presents the means and 95% confidence intervals from the pre-class (lighter bar) and post-class (darker bar) surveys on five questions related to their understanding of engineers' public welfare responsibilities (Goal 1). The first two bars highlight students' increased recognition of the potential public welfare consequences of tech advancement, achieving significance at p=.05 level. Specifically, after taking the course, students were significantly more likely to agree that they worry about how technology advancement affects Americans' privacy and security.



Note: N=16. Light bars=means from pre-class survey; dark bars= means for post-class survey. All questions are scaled from 1=strongly disagree to 5=strongly agree. Error Bars=95% Confidence Intervals.

Although it did not reach full statistical significance in this small sample, more students disagreed after the course that engineering is less prone to political corruption and cultural bias than other fields than before the course began. This course also appears to have shifted students' belief in engineering as a depoliticized space: students agreed more strongly that their discipline of engineering "emphasizes the social responsibilities of engineers" after they took the course.

Suggesting that the PubWRIT course shifted students' motivation to engage with topics of public welfare responsibilities (Goal 2), students at the end of class had stronger agreement that it is important for the users of technologies to understand how those technologies work, and that "it is important to me personally to have a career that helps people."

While helpful for showing broad patterns, these quantitative results do not sufficiently capture the richness of how students' perspectives on public welfare responsibilities may have changed. For this, we draw on anonymous open-ended reflection questions that asked students to describe what, if anything, they learned in the course addressing Goals 1, 2, and 3.

Table 1: Sample Quotes from Students' Open-Ended Reflections on their Learning from the PubWRIT Course, by Focal Area

Greater Recognition of the Public Welfare Responsibilities of Engineers (Goal 1)
• I think I've learned a lot about just how big of a thing this is in the industry. I never imagined public welfare within engineering to be such a huge issue, and all those research and data that we got to see this semester made me realize that there's actually something that needs to be done.
• There are actually so many biases in real life due to AI algorithms.
• Yes, I learned a lot about the things I never thought about before. My perspective of seeing the relationship between engineers and social problems has largely changed.
• I used to think we engineers should consider public welfare problems but what we can do is little. After taking the class I find that we are actually responsible for being a watchdog for the technologies that might be harmful.
• At the beginning of the semester, I wasn't fully aware of the role engineers play in public welfare. Over time, I've come to understand that our work has a direct impact on society and must prioritize public safety, environmental sustainability, and ethical responsibility.
• We should be more focus[ed] on the social problems. Public safety should be put in the 1st place. Throughout this semester, I've realized that engineers must focus not only on technical solutions but also on addressing social issues. Public safety should always be prioritized in our work.
Greater Motivation to Take Action (Goal 2)
• I've started to realize that it's totally OK for me to speak up and bring in social contexts when discussing technical things. In the past, it definitely has made me feel like I'm being undervalued for bringing something up or being dramatic.
• Before the semester, I did not have a clear understanding of public welfare responsibilities of engineers, but now I realize that many small things engineers should consider, such as how the technology affects the society, how people use the technology. Also, even in some mature technology, there exists biases.
• Ensuring safety and reliability in my designs, considering environmental sustainability, ethical considerations, equity in access to technology, and long-term societal impacts are part of my responsibilities. Engineers are not just problem-solvers but also stewards of societal progress.
• The most important thing I learned in the course is that I need to take more responsibility of public engineering welfare in the future.
Improved Familiarity with Intervention Strategies (Goal 3)
• Now I know how to "be" a whistleblower. I know my role in data reliability.
• I am much more aware of my options, and I know how to effectively execute each of them, which is nice.
• We are involved in Op Ed and learn about more how the current society thinks the PWR.
• Before this course, though I know the responsibilities, maybe I won't actually execute it. But now I will follow these rules in my life.
• More awareness about regulation and safeguarding. [I] can identify wrongs in the workplace I now feel empowered to speak up if I see any wrong.
• Now I know what powers I have; [I can] identify systemic biases; [I] know how to stand up.
Specific Reflection Prompts: "Compared to the start of the semester, how has your understanding of the public welfare responsibilities of engineers changed?" "What is the thing that surprised you most about the course?" "What do you feel is the most important thing you learned in the course?"

Although a few students noted they had a "basic understanding" of engineering's responsibilities to the public, no student said the content covered in the PubWRIT course duplicated things they had learned elsewhere in their engineering education. Each of the students in the course reported growth in at least one of the focal areas. Table 1 below provides representative quotes from students' reflections indicating growth in each area.

Beyond the content, students also expressed appreciation for the format of the course. One student noted: "I was surprised by the open and engaging discussion atmosphere, which encouraged the exchange of diverse perspectives and broadened my thinking." Such a discussion-based format was especially important for students as they grappled with complex issues like public welfare responsibilities.

Conclusion and Considerations for Future Courses

The PubWRIT course was designed to be a different kind of professionalization course: not only did we seek to teach students about the full scope of their public welfare responsibilities, but we also directly engaged students in critiques of the roadblocks that keep public welfare responsibilities from being a central concern in engineering education and engineering practice. Believing that it is insufficient to simply teach students about their responsibilities in the abstract, we designed the course to include practical ways that they could take action if they encounter potential threats to public welfare in their careers.

Although this course provided an opportunity to expose students to topics that are rarely covered in standard engineering curricula, it has a few downsides. First, it is a stand-alone, elective course, and this setting has been shown to be less influential on engineering students' ethical development than instruction that is integrated into engineering courses [23]. Addressing the culture of disengagement from public welfare concerns in engineering education will ultimately require that public welfare concerns be incorporated into what are traditionally understood as "technical" courses. Separating education on public welfare responsibilities into its own course does not challenge this division of "technical" and "social" responsibilities [24]. A first step would to make the course a required part of the curriculum, not an elective.

Second, this was a one-credit course. A course with more contact hours could incorporate more intervention strategies, a wider range of assignments, and time for guest speakers. Alternatively, the three modules discussed above could be rolled into existing courses on other topics (e.g., introductory engineering courses, senior design courses).

Third, although students demonstrated impressive thoughtfulness and reflexivity in their written assignments from the beginning of the course, many struggled at first in group and whole-class discussions about these topics. Few had had experience in prior courses participating in discussions about issues without immediate "right answers" like ethics and public welfare issues. Instituting more deliberate icebreaking activities at the beginning of class would help students develop rapport and comfort with classmates earlier in the term.

Fourth, we believe part of the success of this course was our partnership - a faculty member in EECS and Engineering Education and a faculty member in Sociology. This combination of

expertise and perspectives was advantageous in course design and greatly appreciated by students. Co-teaching is resource-intensive and not always supported by departments and colleagues, however. Such cross-college teaching is also challenging administratively. For example, Cech could not "count" the course as part of her teaching load because it was based out of a different college at the university.

Despite these challenges, we believe the PubWRIT course represents a useful approach to gearing up engineering students to be stewards of public welfare in their professional roles in the future. We encourage others to adopt and adapt these approaches at their own institutions.

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