

Students' Perceptions of the Social Responsibilities of Engineers

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Abstract—Engineering social responsibility is the responsibility of engineers to evaluate the broader impacts of their work on public welfare. Despite the central role of social responsibility to the engineering profession, social responsibility does not seem to be adequately emphasized in engineering curriculum. This study seeks to understand how students understand the social responsibilities of engineers. Interviews with ten students and three professors in engineering were analyzed with thematic analysis. The results from this study indicate that students are aware of ways that engineers can both benefit and harm society. When asked what influenced their views on social responsibility, students identified personal and extracurricular experiences, not engineering courses. Engineering programs are encouraged to incorporate more explicit instruction about the social dimensions of engineering to support the development of socially responsible engineers.

Keywords—social responsibility; professional responsibility; engineering ethics

I. INTRODUCTION

Engineering social responsibility can be understood as the professional obligation of engineers to consider the broader impacts of their work on society [1]. Social responsibility can come from an engineer's recognition of their ability to serve others with their professional skills [2]. The expertise and specialized competencies of the engineering profession uniquely position engineers to reflect on the broader impacts of their work [3,4]. Though the engineering profession values social responsibility, studies have shown that engineering programs may not be adequately cultivating students' dispositions towards social responsibility within the engineering profession [4,5,6,7].

Canney and Bielefeldt developed a framework for studying the development of social responsibility in engineering students, called the Professional and Social Responsibility Development Model (PSRDM) [2,8]. The PSRDM describes the development of personal and professional social responsibility in three realms. The Personal Social Awareness realm concerns the development of social responsibility within students' personal lives, separate from their professional identities as engineers. Within this realm are three dimensions: the awareness of those who are in need (awareness), the recognition that one can help those who are in need (ability), and the obligation to help others (connectedness). The Professional

Development realm comprises the development of students' professional abilities and recognition that their professional abilities can be used to serve others. Within this realm are three dimensions. Base Skills refers to the technical and professional skills needed to act with social responsibility. The Professional Ability dimension refers to an understanding that engineers can help others. The Analyze dimension refers to the ability to "examine social issues from a professional perspective." The Professional Connectedness realm focuses on students' feelings of obligations to use their professional skills and abilities to help others. Within this realm, the Costs/Benefits dimension characterizes the costs and benefits of socially responsible action and how they influence an engineer's decision to act.

This work-in-progress study uses the PSRDM to understand how engineering students understand the social responsibilities of engineers. This study builds on previous studies to further understand and articulate the ways in which engineering students understand the responsibilities of engineers towards society. An understanding of students' perceptions of social responsibility can help inform educational efforts to support the development of socially responsible engineers. This study addresses two research questions:

RQ1: What are engineering students' perceptions of social responsibility in engineering?

RQ2: What are implications for teaching social responsibility in undergraduate engineering programs?

II. METHODS

A. Data Collection

Data were collected at a large, public research institution in the Midwest. Engineering students were invited to participate in an online survey; the survey is not described in this paper [9]. At the end of the survey, students could volunteer for interviews. Individual interviews with ten undergraduate engineering students were conducted to collect qualitative data about their perceptions of social responsibility. The interview format was semi-structured; most of the interview questions were pre-determined, and participants were prompted with follow-up questions when appropriate. For example, participants were asked, "How would you define social responsibility," and "What people or experiences have

influenced your thinking about social responsibility?” The duration of the interviews ranged from thirty to forty-five minutes. Students were recruited from emails sent to academic advisors in engineering departments. Table I summarizes the backgrounds of the ten students interviewed.

Interviews were also conducted with three engineering professors as a source of secondary data to understand their views on how social responsibility manifests in undergraduate engineering education. Professors were recruited by emails to department heads to send to faculty in their departments. The interview format was semi-structured. The duration of the interviews was thirty to forty minutes.

B. Data Analysis

Interviews were transcribed verbatim for analysis. To analyze the student interviews, an initial coding scheme was developed from the dimensions of the PSRDM in the Professional Ability and Professional Connectedness realms.

Inductive codes emerged from the data through thematic analysis [10]. Thematic analysis was used to analyze how students defined social responsibility and the role of engineers in society. Codes emerged to distinguish whom students believed were affected by engineering. Codes were also developed to describe influences on students’ views of social responsibility. Faculty interview data were analyzed for evidence related to the themes from the student interviews.

C. Limitations

The validity and generalizability may be limited for the following reasons. The students who participated in this study were all from the same institution, so the results may not be generalizable to broader populations of engineering students. The sample was chosen out of convenience; all students who volunteered for an interview were included in the sample. Students who would volunteer their time for an interview may have had a strong interest in social responsibility. Only three professors were interviewed. Their views cannot be assumed to represent the views of faculty within their departments or all engineering faculty at large. Finally, the interviews were coded by only one coder, so no inter-coder reliability could be established.

TABLE I. DEMOGRAPHIC INFORMATION OF INTERVIEWED STUDENTS

<i>Pseudonym</i>	<i>Year</i>	<i>Major (engineering)</i>	<i>Engineering internship experience</i>
Ariana	Sophomore	Materials	None
Dave	Senior	Materials	Healthcare
Hugo	Freshman	Materials	None
Kim	Freshman	Industrial	Manufacturing
Kyle	Sophomore	Materials	None
Natasha	Junior	Electrical	National lab
Sam	Freshman	Aerospace	None
Sara	Senior	Materials	Healthcare
Sean	Senior	Materials	Semiconductors
Sophia	Senior	Materials	Semiconductors

III. RESULTS

A. Students interpretations of social responsibility

During the interviews, students demonstrated an awareness of the impacts of engineering by describing ways that engineers could benefit and harm society. Some students conveyed social responsibility as an obligation, either to contribute positively to society or to protect against harm. Students’ perceptions of the social responsibilities of engineers were categorized under the four statements shown in Table 2.

Students recognized that engineers have the capabilities to serve and help others, exemplified in this statement by Dave: “We have the skill set to do something good for other people.” While Dave spoke generally about the abilities of engineers, Sophia and Kyle mentioned specific skills. Sophia mentioned engineers’ approach to solving problems: “I think engineers can give a unique problem solving perspective to a lot of social problems.” These statements demonstrate students’ recognition that engineers influence peoples’ lives and can make an impact on social problems.

Some students expressed that engineers have not only the ability but also a professional obligation to make positive contributions to society with their work. These students stated that the role of engineers is to design technologies and products to improve the lives of others. Sam felt that engineers should focus on projects that can benefit people: “Engineers do have a lot of power because they can change the world around them. So I think they should focus on things that would help people.” Sam believed engineers can choose work that benefits others, which to him is the socially responsible path.

Students recognized that engineers can harm society. Some students discussed how engineers harm society when they neglect to consider the impacts of their work on the environment and on people. Kim observed from her internship experiences that engineers can neglect the welfare of workers in their work:

When we’re designing products or something, we don’t think about how it’s going to be manufactured or the dangers inherent in manufacturing or the precautions we have to take, or be mindful of. (Kim)

Some students expressed that engineers have a responsibility to protect against the harmful consequences of the technologies and products they develop. Students emphasized the importance of considering the needs of society when developing engineering solutions and the effects of the product or technology on society. Sara acknowledged that these consequences can be difficult to foresee:

I think sometimes we create things and we don’t realize the effects. I think sometimes we get caught up in innovating that we forget that we should also start thinking about what the potential consequences of those innovations are. (Sara)

Sara implied that social implications are often left as an afterthought in the design process. She argued that potential social consequences should be considered from the start of the design process.

TABLE II. STUDENTS' VIEWS OF SOCIAL RESPONSIBILITY

	Responsibility of engineers to	
	<i>Do good</i>	<i>Prevent harm</i>
Awareness	Engineers can benefit society	Engineers can harm society
Obligation	Engineers should benefit society	Engineers should prevent harm to society

Natasha also expressed difficulties in foreseeing the consequences of technological developments, but she maintained engineers had a responsibility to try:

I don't think it's possible for any one human or any group of humans to predict the consequences of some engineering project. But you owe it to yourself and to your society, and to humanity and the Earth and maybe eventually the galaxy, to try. And if you fail, well okay, good faith effort was made. (Natasha)

Natasha asserted the difficulties of predicting consequences do not excuse engineers from failing to consider the social implications of their work. Like other students who discussed engineers' responsibilities to prevent harm, Natasha did not suggest concrete ways that engineers could mitigate the social consequences of the technologies they develop. Natasha suggested that good intentions may be sufficient, given the difficulties associated with foreseeing and addressing social consequences of engineering projects.

B. Influences on students' views of social responsibility

Students mentioned influences from college and in their personal lives. Many students indicated that their engineering courses did not emphasize social responsibility. According to Kyle, "You could go four years and never have to examine the social responsibilities of engineers." Some students identified courses that influenced their understanding of social responsibility, but these courses were often outside of the required curriculum for their majors.

Students mentioned some ethics instruction, but did not cite it as being a particularly influential experience for them. Ariana said, "I feel like classes wise, I don't see it that much. There's only the one ethics class, and we're kind of done with it." Ariana acknowledged that she had been exposed to engineering ethics instruction, but that it had been cursory and did not significantly affect her understanding of the social responsibilities of engineers.

Outside of courses, students expressed that their engineering programs influenced their views on social responsibility through exposure to engineering projects with social impacts and meeting people on campus. Sara said, "I think in a lot of ways, it's not really the curriculum itself. It's more the people that I interact with... You meet people who are doing really important things, and you realize that there's a sense of responsibility that you should have."

Students identified people from their personal lives who influenced their understanding of the role of engineers in society. Sara described the influence of her parents, who are both engineers: "I think that I've tied a lot of ethics into engineering as a result of the way that my parents think and

what they believe." Sara indicated that her parents' experiences as engineers have shaped her views on engineers and their responsibilities towards society. Students' mentions of parental influences suggest that students extend their conceptions and attitudes towards social responsibility from their personal lives into their professional lives.

C. Faculty views on social responsibility

The interviewed professors had different perceptions about the extent to which social responsibility was prioritized within their department's respective curriculum. An interviewed civil engineering professor believed instruction in social responsibility was deeply embedded within his department's curriculum. Another professor felt that social responsibility was absent from his department's curriculum: "It's not part of our curriculum, I would say. There is very little discussion of social responsibility to the best of my knowledge in hardly any of our classes. In our senior design classes, a little bit." The third professor felt that while he tries to incorporate social responsibility into his courses, his colleagues do not appreciate the importance of including it in their courses. Though the interviewed professors understood the difficulties and limitations of teaching social responsibility, they did not view these difficulties as an excuse for not teaching social responsibility to engineering students.

IV. DISCUSSION

A. RQ1: What are engineering students' perceptions of the social responsibilities of engineers?

Students believed social responsibility is an important part of the engineering profession. Students' had varied perceptions of the social responsibilities of engineers. They could provide examples of ways that engineers can benefit and harm society. Students mentioned social responsibility in conjunction with issues of sustainability [1,5,11,12], social justice [5,11,12], and ethics [5,11,13,14], which are consistent with themes of social responsibility in the literature. Students' perceptions of social responsibility were consistent with the dimensions identified by Canney and Bielefeldt in the PSRDM [2,8]. Students' statements about how engineers can benefit society aligned with the Professional Ability dimension. Students' beliefs that engineers should improve society align with the Professional Connectedness dimension.

The PSRDM omits an important aspect of how students understand the ways that engineers can harm society. Students' statements indicated they recognized that social responsibility is not only about making positive contributions to society, but also about preventing harm.

B. RQ2: What are implications for teaching social responsibility in undergraduate engineering programs?

Understanding students' perceptions of social responsibility can inform effective ways to teach social responsibility. Students cited extracurricular activities, elective courses, internship experiences, and their parents as influences on their understanding of the roles and responsibilities of engineers in society. Students felt social responsibility was not taught in

their engineering courses. The faculty interviews confirmed students' perceptions that their engineering courses did not support instruction in social responsibility.

The question remains whether engineering education is the right place to foster students' attitudes towards social responsibility or if it is reasonable to expect that they will develop these attitudes once they begin work as practicing engineers. Findings from previous research suggest that graduates in engineering jobs do not experience revived interest in public welfare after college [4]. Teaching social responsibility in undergraduate education can strengthen the knowledge that engineers can draw upon in their profession.

Some scholars feel social responsibility should be taught to engineering students within the curriculum [4,5,15]. Classroom instruction can improve students' understanding of the social responsibilities of engineers [15]. Scholars have advocated for instructional methods that incorporate social responsibility into engineering curriculum without sacrificing technical content [1,16,17]. Teaching social responsibility can broaden the scope of engineering problem solving to students and challenge them to consider the broader contexts of engineering problems.

V. CONCLUSIONS

Social responsibility is at the forefront of the engineering profession. Engineers are often called upon to address social challenges, so it is important for them to consider the social contexts of their work.

The results of this study indicate that students are aware of ways that engineers can benefit and harm society. This study captures the ways students understand the ability of engineers to harm others, a finding that was not included in the PSRDM. In addition, some students indicated the obligation of engineers to use their skills to contribute positively to society and consider potential consequences of their work.

Students seem to develop their dispositions towards social responsibility outside of their engineering curriculum. Students' views on social responsibility within the engineering profession seem to be influenced by their personal views and backgrounds outside of engineering contexts. Previous studies have not addressed where students may receive messages about social responsibility outside of the classroom.

Further research is needed to understand how to promote educational efforts to teach social responsibility in engineering courses. Interviews with engineering faculty can be useful to identify the challenges of teaching social responsibility. An understanding of these challenges can inform strategies to overcome barriers to teaching social responsibility. In addition, future work can explore whether attrition rates are higher among students who have stronger beliefs about social responsibility, since students' feelings about the importance of social responsibility may decline throughout college [4].

Engineering education can be more intentional about creating learning opportunities to prepare graduates to uphold their responsibilities towards public welfare. Since education communicates to students the values of the engineering

profession, teaching social responsibility to students reinforces engineers' commitment to society. Engineering educators can empower students to create a world that is more sustainable and socially just than the world we live in today.

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