This is an accepted version of a manuscript. The published version is available at Schiff, D. S., Logevall, E., Borenstein, J., Newstetter, W., Potts, C., & Zegura, E. (2021). Linking personal and professional social responsibility development to microethics and macroethics: Observations from early undergraduate education. *Journal of Engineering Education*, *110*(1), 70–91. https://doi.org/10.1002/jee.20371

Linking personal and professional social responsibility development to microethics and macroethics: Observations from early undergraduate education

Daniel Schiff [1], Emma Logevall [2], Jason Borenstein [1], Wendy Newstetter [3], Colin Potts [4], and Ellen Zegura [2]

[1] School of Public Policy, Georgia Institute of Technology, Atlanta, GA
[2] School of Computer Science, Georgia Institute of Technology, Atlanta, GA
[3] Department of Biomedical Engineering, Georgia Institute of Technology, Atlanta, GA
[4] Office of Undergraduate Education, Georgia Institute of Technology, Atlanta, GA

Abstract

Background: Developing social responsibility attitudes in future engineers and computer scientists is of critical and rising importance. Yet research shows that prosocial attitudes decline during undergraduate engineering education.

Purpose: Influenced by the Professional Social Responsibility Development Model (PSRDM), this study explores the connection between undergraduate *personal* social responsibility attitudes and the development of *professional* social responsibility attitudes. We consider a wide range of college and pre-college influences and inhibitors.

Design/Method: We conducted and analyzed 21 semi-structured interviews of second-year undergraduates, predominantly in engineering and computer science. The interviews form the first collection of qualitative data for a multi-year mixed methods study which has followed a cohort of students since they entered college.

Results: We find preliminary evidence that social responsibility attitudes tend to be conceptually separated for early undergraduates along two lines: personal and professional considerations, and micro-level and macro-level concerns. This leads some students to assume that social responsibility obligations can be considered as a 'weekend project,' may 'fall into place' later in one's career, and can generally be deprioritized compared to technical education and career pursuits. Candidate explanations for this divide include early influences from parents, religious values, collegiate social interaction, students' limited familiarity with their future profession, and a social/technical divide and meritocratic ideology in engineering culture.

Conclusions: This study provides qualitative evidence to advance the conceptual understanding of professional social responsibility development. The findings highlight key individual and institutional influences and barriers for scholars and practitioners interested in nurturing prosocial attitudes among engineering students.

Keywords: Social responsibility, Student moral development, Qualitative research, Undergraduate education, Professional social responsibility, Engineering ethics

1 INTRODUCTION

Engineers hold profoundly important roles as professionals. They are the architects of the "complex technical systems pervading post-industrial society," and their work impacts lives and communities around the globe (Cech, 2010, p. 1). As technology advances, the associated risks deepen and extend to new areas (Bairaktarova & Woodcock, 2017). An engineer's influence is not always beneficial; incidents involving unethical, illegal, or well-intentioned but ultimately harmful engineering practices are unfortunately commonplace (e.g., Grigg, 2017; Mansouri, 2016; Sgobba, 2019). In short, an engineer's unique and increasingly powerful role in society carries with it significant ethical responsibilities, ranging from more narrow forms of compliance with professional rules to broader notions of social responsibility.

It is clear that university engineering programs need to produce graduates with robust senses of professional social responsibility (Cech, 2013b). The Accreditation Board for Engineering and Technology (ABET) states as a criterion for accreditation that engineering students must have "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" (ABET, 2020). Upon completing their education, engineers "are not only expected to have technical knowledge, skills, and abilities, but also a foundation in professional and ethical practices" (Bairaktarova & Woodcock, 2017, p. 1130). Educators and their institutions can play a key role in promoting a prosocial orientation by, for example, introducing future engineers to social justice concerns (Leydens & Lucena, 2018; Riley, 2008).

Educators have tried many strategies to advance the ethical development of students (National Academy of Engineering, 2016). Scholars have reviewed the importance of multiple pedagogical and delivery methods and activities, identifying elements which appear conducive to student growth. They have also considered case-based, interactive, and reflective learning; the nature of the instructional content itself; educator characteristics; the extent to which an educational program is sustained or embedded, and how moral development is assessed (Antes et al., 2009; Watts et al., 2017). While the case study approach in particular has a long history in engineering ethics education, other approaches, including problem-based learning (Harrell, 2019) and real-world engagement with stakeholders outside of classroom environments (Hess & Fore, 2018), have also been implemented. Though critiques have surfaced in response to some forms of community engagement (Schneider et al., 2009), many characteristics of such activities are relevant to student moral development, including robust and sustained collaboration with communities (Delve et al., 1990; Ward & Wolf-Wendel, 2000) and critical reflection (Eyler, 2002).

Yet despite ethics education and other efforts including community engagement, nurturing prosocial behavior and a sense of social responsibility in science, technology, engineering, and mathematical (STEM) students has proven difficult (Bielefeldt & Canney, 2016). Cech (2013b) has identified what she refers to as a culture of disengagement in undergraduate engineering education. Her longitudinal study of engineering students' attitudes across four universities found that public welfare concerns actually *declined* over the course of their undergraduate education. These declines occurred regardless of student gender, race/ethnicity, family income, or the school's cultural and pedagogical structure, suggesting that the problem is pervasive

(Cech, 2013b). These findings generate a need to understand the causes of, and potential remedies for, this problem.

Within this context, our research team is engaging in a five-year, NSF-funded, mixed methods study at a large public institution, the Georgia Institute of Technology. The aim is to explore factors that influence the development of student social responsibility attitudes and suggest avenues for future research and practice. Our study's quantitative approach involved adapting the Engineering Professional Responsibility Assessment (EPRA), a validated survey (Canney & Bielefeldt, 2016), for a broader student population. The instrument we developed, the Generalized Professional Responsibility Assessment (GPRA), both assesses social responsibility attitudes and considers potential influences such as extracurricular activities that may influence these attitudes (Borenstein et al., 2019). We sent the GPRA to the entire entering fall 2017 undergraduate student class at an engineering university at the start of their education. These students are the project's primary cohort. The tool was administered to the cohort a second time at the midpoint of their career, in the summer of 2019. The students will be surveyed again near graduation, providing multiple time points to review attitudinal changes and factors associated with increases or decreases in professional social responsibility.

The quantitative portion of the study is complemented by a longitudinal qualitative design, which follows a subset of the student cohort to examine their attitudinal development and influences more deeply. Here we report on the findings from the first administration of the qualitative portion of our study: semi-structured interviews of 21 second-year undergraduates predominantly from engineering and computer science majors. At many universities, computer science is part of engineering, but at our institution, it is separate. Yet for the purposes of this paper, the term "engineers" will typically encompass computer scientists.

2 CONCEPTUAL FRAMEWORK

Cech's work provides an important starting point as a potential explanation for the identified decline in social responsibility attitudes. Cech offers three candidate explanations or "ideologies." First, a technical/social dualism embedded in engineering culture and education encourages students to "bracket social considerations" (Cech, 2013b, p. 48) and prioritize technical competencies or the "nuts and bolts" of engineering (Faulkner, 2007). Second, Cech suggests that an ideology of depoliticization actively fosters the notion that "pure" engineering work should be free from the biases of "soft" social considerations. Indeed, a laser focus on mastery of mathematics and sciences in engineering education has existed since the mid-1900s (Litchfield & Javernick-Will, 2015; Lucena et al., 2010).

Moreover, socio-technical dualism and depoliticization are not only reflections of engineering *content*; they influence an individual's professional *identity* as well. Engineering problem solving, arguably the "core knowledge content of engineering curricula," demands a sharp boundary between work and self, "where work is dedicated wholly to solving bounded mathematical problems" (Downey & Lucena, 1997, p. 40). This sharp separation involves setting aside non-technical skills, interests, and concerns and thus "[weeding] out a part of themselves as persons" (Downey & Lucena, 1997, p. 40).

Third, Cech (2013a) describes a meritocratic ideology that casts systematic inequalities in society as the result of individuals not working hard enough to achieve greatness, and therefore not the responsibility of engineers to address. This ideology can be further understood in relation to the view of engineering as a mechanism for increasing national productivity and competitiveness, a view popularized during the Cold War (Downey & Lucena, 1997). Beginning in the 1980s, engineering education was conceptualized as a pipeline through which intelligent, hard-working students become professional engineers by demonstrating mastery of technical skills and a readiness to contribute to national goals of productivity and competitiveness. Despite critiques that a pipeline metaphor over-simplifies complex environmental and individual dynamics (Lord, Ohland, et al., 2019), it persists, and engineering students today may continue to experience a version of the meritocratic ideology firsthand.

Collectively, these three ideologies, and their infusion into the engineering curriculum, potentially explain, according to Cech, the decline in student social responsibility attitudes. Indeed, the career identities, social roles, and responsibilities of engineers have been contested topics as the broader engineering profession has evolved (Layton, 1986; Noble, 1977). Cech's work suggests a need to continue scrutinizing the ideologies as they manifest in engineering education.

Along these lines, codes of ethical practice have been among the chief instruments used to educate current and future engineers about their ethical obligations. The National Society of Professional Engineers Code of Ethics for Engineers, for example, outlines essential obligations of engineers, the first of which is "to hold paramount the safety, health, and welfare of the public" (NSPE, 2019). Other codes of ethics from engineering professional organizations also emphasize the vital importance of protecting the public. Yet, while codes of ethics are a prominent source of guidance, they typically speak to relatively small scale "microethical" issues such as avoiding conflicts of interest and being honest with one's employer (Herkert, 2005). This is not to imply that such concerns are unimportant; rather, it is to say that they pertain to one's responsibilities as an individual practitioner. In contrast, codes of ethics often do not address "macroethical" issues pertaining to the broader social responsibilities of the profession (Herkert, 2005). The distinction can of course become blurred because the same concern, privacy for example, can have both microethical and macroethical dimensions.

According to Downey & Lucena (1997, p. 33), an engineer's ethical responsibility understood through the microethical lens is not to "critique the ethical dimensions of the problems they solve" but rather to behave ethically by "controlling [their] passions and impulses." Recent work on the current state of practice also suggests that engineers consider risks at the microethical scale (Vakkuri et al., 2019), a notion often reinforced through engineering courses (Loui, 2005). On the other hand, engineers and the engineering profession often do not pay sufficient attention to macroethical issues including systemic social, political, and environmental concerns (Herkert, 2004).

Our conception of social responsibility used throughout the study is consistent with a macroethical perspective. It reflects Cech's (2013b) focus on "public welfare," as well as the concept of professional social responsibility promoted by Canney and Bielefeldt (2015). More importantly, strict adherence to microethical concerns reflected in the law and employer-based rules, referred to as the "minimalist view" by Woodhouse (2001), is arguably not sufficient in terms of the ethical obligations engineers should uphold.

Another distinction of importance in terms of student development is that between *personal* and *professional* social responsibility. According to the Input-Environment-Output model, student inputs might interact with one's college environment to produce various outputs in terms of student attitudes, skills, and dispositions, or "those aspects of the student's development that the college either does influence or attempts to influence" (Astin, 1970, p. 224). Here, we view students' prior personal social responsibility attitudes as 'inputs' that students bring with them to college, and professional social responsibility attitudes as 'outputs' that college might influence (Rulifson & Bielefeldt, 2019). Conflating personal and professional social responsibility attitudes would risk assuming that both proceed along the same developmental pathway. The type of conflation ignores the ways in which prior personal social responsibility attitudes might enhance, moderate, or constrain professional ones. Therefore, in order to explain the culture of engineering disengagement and explore strategies to mitigate declines in prosocial attitudes, our five-year project seeks to address the following research questions:

RQ1. How do student professional responsibility attitudes change while in college?

RQ2. What is the relationship between personal and professional social responsibility attitudes in students?

To address these questions, we adopt Canney and Bielefeldt's Professional Social Responsibility Development Model (PSRDM) as a framework for understanding moral development in the undergraduate engineering context. The PSRDM articulates distinct pathways for personal and professional trajectories, culminating in a sense of professional connectedness (Canney & Bielefeldt, 2015). Three realms—Personal Social Awareness, Professional Development, and Professional Connectedness—make up the core of the PSRDM model.

The Personal Social Awareness realm "describes the development of feelings of moral obligation to help others separate from one's professional identify" (Canney & Bielefeldt, 2015, p. 418). Here, the PSRDM draws principally from Schwartz's work on altruistic helping behavior, i.e., how feelings of moral obligation and other elements of moral and emotional development causally influence altruistic behavior (Schwartz, 1977). In contrast, the PSRDM's Professional Development realm illustrates the development of technical and professional skills (Canney & Bielefeldt, 2015). Professional Connectedness, the third realm of the PSRDM, results from the combination of the prior two realms, iteratively developed through a cyclical process. It describes the sense of moral obligation to help others and solve social problems that arises in relation to and because of one's professional abilities (Canney & Bielefeldt, 2015). In this way, one's identity as an engineer is shaped by one's sense of Professional Connectedness, with altruism becoming a central pillar of one's self-conceived role in society as a professional.

While the aforementioned research questions guide the overarching study, they are intertwined with two research questions more specifically tied to the student interviews discussed here.

RQ3. How do college students understand personal and professional responsibility?

RQ4. Which factors or experiences shape students' attitudes toward personal and professional responsibility?

Informed by the PSRDM, these research questions involve an examination of the lived experiences of undergraduate students, primarily from engineering, in order to better understand how personal and professional social responsibility attitudes develop, separately or in tandem. We therefore consider a myriad of pre-college and college influences that might shape student senses of personal and professional social responsibility. This includes paying attention to micro- versus macroethical conceptions of social responsibility, and how students describe their professional identity.

3 METHODOLOGY

3.1 Overall study design

As the study developed, we recognized that beyond understanding (quantitatively) which student experiences or characteristics appeared to influence social responsibility attitude development, we also needed to identify which aspects of those experiences mattered, and how various influences and student characteristics intermingled. For this reason, we incorporated a multistage qualitative component of our research to complement the multistage quantitative component. We determined that a semi-structured interview of students would provide the appropriate flexibility to address important concepts from the PSRDM and emphasized in the GPRA survey instrument. The first set of interviews took place between the first administration of the survey – just before the primary cohort began their undergraduate program – and the midpoint administration of the survey, after students completed their second year of studies. Given our longitudinal research design, the aim is to interview the same students a second time prior to graduation.

[Suggested Figure 1 location]

This strategy produces a sequential and explanatory embedded design (Ivankova et al., 2016), presented in Figure 1 above. An embedded mixed methods design refers to a design where a second method supports the first to enhance the overall design (Schoonenboom & Johnson, 2017). In this case, the qualitative component is embedded in a quantitative pre-post survey design and adds explanatory depth to the original research questions. It allows us to not only draw on our conceptual framework as conceived of in the initial quantitative instrument, but also to identify elements in the qualitative portion of the study which we have used to strengthen the survey instrument for a future administration and towards eventual mixed methods analysis. The explanatory embedded design is particularly useful for cases like ours where theoretical frameworks are still nascent and in need of more systematic development (Creswell & Plano Clark, 2018).

Our theoretical approach focuses significantly on the "experiences, meanings and the reality of participants" (Braun & Clarke, 2006, p. 81). Our analysis approach is thematic and involves identification of "the necessary contextual conditions for a particular causal mechanism to take effect and to result in the empirical trends observed" (Fletcher, 2017). Given our study's underlying theoretical assumptions, we employ a directed coding technique, deriving codes initially from the conceptual framework underpinning both our quantitative and qualitative instrument, but allowing them to evolve (Hsieh & Shannon, 2005).

3.2 Semi-structured student interview design

The embedded and sequential approach encouraged us to draw on concepts from the PSRDM and our adapted survey instrument, the GPRA. The approach also allowed us to expand on these concepts based on other theoretical constructs and influences relevant to students' lives. Our research team engaged in multiple rounds of iteration and refinement of the interview protocol during the fall of 2018. This included pilot interviews with four undergraduate students followed by open-ended cognitive debriefing (Desimone & Le Floch, 2004) to determine problems in the articulation of our interview questions and to identify important categories missing from our survey instrument. Table 1 below provides an overview of the instrument design (see the Appendix for the complete interview protocol).

[Suggested Table 1 location]

3.3 Research Participants

Given our embedded approach, our participant pool was drawn from our primary cohort, undergraduate students who started at our institution in the fall of 2017. Interviews with a subset of the cohort took place in the spring of their second year. To derive more balanced generalizations about social responsibility development, we determined that it was important to draw on a broad range of students (Becker, 2008). We therefore sought to recruit a diverse group across gender, race/ethnicity, and major.

First, given the possibility of participants with heightened interests in social responsibility self-selecting into our study (Bielefeldt & Canney, 2014), we worked to recruit students with different levels of exposure to community engagement and social responsibility issues. This involved identifying a required first-year English course as an imperfect proxy for how much the students were learning about community engagement. The course was taught by a variety of instructors who each designed a unique variation, such as Science Writing or Digital Humanities. With assistance from campus administrators, we identified four instructors who indicated they had a prominent community engagement focus in their course, and four who did not indicate that focus. Each instructor taught three sections of the English course with around 20 students per section. This constituted our primary sampling frame, though this aspect of our sampling strategy did not seem to be a meaningful factor in terms of the interviewees' responses.

Next, while engineers and computer science students constitute the large majority of our sample (18 of 21), we deliberately included perspectives outside of engineering and computer science as a basis of comparison. Students who pursue majors or minors outside of engineering and computer science fields, or who leave them altogether (Meyer & Marx, 2014; Rulifson & Bielefeldt, 2017) can shed light on important individual and institutional influences, including potentially the role of social responsibility in shaping decisions about major and career. We believe that this contrast was important to better contextualize the experiences of the engineering and computing students, allowing us to examine whether student experiences were similar or distinct across disciplinary lines. Nevertheless, all of the students in our sample attend a large public engineering university, and are exposed to engineering in a variety of ways, including

through a required computing course, the technological focus of even non-engineering courses, and the broader academic and social environment.

Finally, we deliberately sought to recruit students from historically underrepresented race and gender groups. Students in these groups have been found in prior work to express an "equity ethic" influencing their career values (Naphan-Kingery et al., 2019). Moreover, it is common for students in these groups to feel a sense of "belonging uncertainty" (where self-perceptions and features of their background signal differences from mainstream engineering student culture), which can meaningfully influence the ways in which they experience engineering education and perceive the broader field of engineering itself (Smith & Lucena, 2016). While our aim was to achieve some balance across these stated demographics, we have not explored the impacts thereof in depth here. We decided that such questions can better addressed via the quantitative component of our study, in which we will have significantly greater numbers of students from underrepresented groups.

After receiving approval from the Georgia Tech's Institutional Review Board (IRB), we sent a series of recruitment emails, first prioritizing underrepresented race and gender groups, and eventually contacting a total of n=121 students, which is approximately 4% of overall cohort originally being followed during the larger quantitative study. Students were offered a $25 gift card as an incentive for participating in the interview, and twenty-two students (18%) agreed to participate, all of whom we ultimately interviewed. Table 2 below presents some key demographic characteristics of our student sample, which is reflective of our institution's overall student body. The data from one student have been excluded from the discussion below due to corruption in the interview's audio transcript.

[Suggested Table 2 location]

This table indicates some key characteristics of the student interviewees obtained from administrative data, including gender, race/ethnicity, major, and how many students took a first-year English course focused on community engagement. Unknown means that the student did not answer this question when asked by the campus admissions office. One student's interview was omitted from analysis due to audio corruption (that student's information is reflected in the parentheses).

3.4 Data collection

Interviews were conducted by one of two research team members, both graduate students who were part of the project. Prior to conducting the first participant interview, the two interviewers jointly administered two (of the four total) pilot interviews and discussed ways to ensure consistency and reliability in the interview approach. This included approaches for more clearly articulating questions, the use of body language and affirmative responses, the degree to which flexibility in the semi-structured interview protocol should be employed, and strategies to address possible social desirability bias (see Limitations section). The two interviewers also maintained a dialogue throughout the interview process as new findings and challenges emerged, in order to ensure that the interview technique was robust and consistent.

All twenty-two interviews, involving one student and one interviewer, were completed between the end of January and middle of April 2019. Each student signed a consent form granting permission for the interview and audio recording. Interviews took between 30 minutes and one hour, and were held on the university campus. Finally, the twenty-one interviews with sufficient audio quality were transcribed by a professional transcription service, while one was excluded from the dataset due to audio corruption.

3.5 Analysis

Prior to beginning analysis and based on a directed coding technique, the full research team developed and refined an a priori codebook based on the study's conceptual framework and the interview protocol design. The codebook included a set of high-level domains (see Table 1) and codes associated with each domain. The team then read two of the transcribed interviews to assess whether the preliminary codebook appropriately captured and usefully parsed the data. Several codes were merged when it was determined that the interviewees conceived of the topics jointly; other codes were added if they appeared important, while some codes were removed if they did not appear prominent across many interviews.

The coding team consisted of the same two researchers as the interview team. Interviews were distributed randomly between the two team members to avoid researchers only coding interviews with which they were already familiar. Next, the coding team engaged in interrater reliability evaluation through both asynchronous and synchronous coding. Using the Dedoose software package (version 8.3) (SocioCultural Research Consultants, 2019), the two coders separately coded a single interview and engaged in line-by-line discussion of their coding strategies and interpretation of the codes themselves. This process led to the team establishing further standards for general coding rules, such as capturing an entire sentence and its surrounding context for each code. It also resulted in identification of any coding inconsistencies and expanding on the definitions of each code to ensure clarity.

Subsequent asynchronous coding of a second interview resulted in improved reliability to the satisfaction of the research team. While we did not feel that strict quantitative testing of reliability was the most appropriate method (Hallgren, 2012), each coder also prepared a test for the other using approximately ten interview excerpts via Dedoose's inter-rater evaluation feature. The process took approximately one month and the coders reached 79% and 85% reliability, respectively, using Cohen's kappa. The final codebook included 41 codes across six major categories: Major and Profession, Prior Influences, College Influences, Community Engagement Experiences, Social Responsibility Impacts, and a Miscellaneous category.

After coding each of the 21 student interviews (approximately 263 pages in total), the two coders also developed 21 five-to-seven page student memos. The rationale for creating memos using students as the unit of analysis is that it helped to contextualize each student's overall story in the broader setting of our study, and allowed us to draw clearer contrasts between students. Our discussion of results draws largely on themes identified in the student memos complemented by single-code and cross-code analysis. For the purposes of upholding student anonymity, race/ethnicity is clustered into the two categories of "White" or "Non-White."

4 RESULTS

4.1 Family values shape personal, not professional attitudes

The students were asked about numerous possible precollege influences on their attitudes towards social responsibility, including family, friends and peers, classes and teachers, extracurricular activities, and community engagement activities. Additional influences that might not strictly fit these categories (such as exposure to news media or independent research on the Internet) were also explored. The single most common influence on social responsibility beliefs identified by students (14 of 21 interviewees) was family. For example:

> I would definitely say my dad has been a big influence before college on like some of my views on social welfare. Because he's kind of been a big prominent figure in my life, pretty much all my life. So I've had that benefit of him there to teach me. Guide me. And tell me what he thinks is right and wrong [*White male, computer science*].

Students described how parents instilled in them a general sense of appropriate behavior in terms of being kind towards others, "treating people the same, being nice to people… that sort of thing" [*White male, chemistry*]. It is notable, however, that students emphasized parental influence in terms of personal and general prosocial attitudes, not on professional activities and one's career:

> It's kind of the values instilled in me from a young age. Anything from, being nice, being courteous, being kind to other people, to not wasting -- not being wasteful. Just all the good, moral things you should know […] I think they have been the biggest influence [*Non-White male, mechanical engineering*].

While personal values derived from family were clearly important to students, the absence of emphasis by their family on *professional social responsibility itself* likely serves as an important background explanation in terms of how students determine their professional goals and identities. Indeed, when exploring student motivations for pursuing their major and/or future career, students were overwhelmingly motivated by intellectual interest in the subject rather than social responsibility concerns. Typical responses discussed a mix of subject interest and personal skill and perhaps a high school course, teacher, or club that helped to solidify that interest.

> Since I was a young boy, I always liked the more science-y-math-y type parts of school, and I think it really kicked off for me […] probably from eighth grade I tried to look more into computer hardware, and after I built my first computer, I was like, 'Oh, snap, this is pretty cool' [*Non-White male, computer engineering*].

> And in high school, I wasn't really sure what I wanted to do. I was just sort of like I like physics, I like math. People say that that's like an engineering thing. So I was like what's the broadest mechanical, like what's the broadest discipline. And so that's why I applied [*White female, mechanical engineering*].

Overall then, our discussions with these second-year college students strongly support two common findings: 1) unsurprisingly, students in their early academic path felt it was important to be a generally good person, but 2) for most students, selection of one's major and career path were largely about interest and fit (Rulifson & Bielefeldt, 2019), whereas social responsibility concerns did not appear to be a decisive factor. This aligns with the PSRDM's identification of

personal responsibility and professional development as bifurcated tracks (Canney & Bielefeldt, 2015). It is also suggestive of an emerging socio-technical divide (Cech, 2013a), beginning even prior to college, in which selection of academic discipline is primarily a 'technical' choice. Without a strong prior orientation toward professional social responsibility, it is likely that proactive influences in college are necessary to bridge this gap.

4.2 Social interaction and interpersonal morality in college

We also explored a variety of influences on social responsibly attitudes that may have taken place during college, including friends/peers, teachers and classes, community engagement activities, and student clubs. The interviewees consistently articulated that their peers are a key influence. In particular, exposure to student diversity was a significant factor, especially for students from relatively homogenous (i.e., white, rural, working class) hometowns who had little exposure to differing political viewpoints prior to college. Roommates, students in one's fraternity or sorority, or classmates might share reflections about their political values, challenges in their country of origin, or how they were negotiating their career choices:

> [The university] is pretty culturally diverse compared to where I came from. You know, there's a large population of Indian, Spanish, Chinese, Japanese, Middle Eastern [students]. It's a melting pot and it's unlike anything that I saw in [hometown]. And, it's amazing to see just the vast difference in outlooks on things [*White male, chemistry*].

Hearing these diverse viewpoints from fellow students helped interviewees to identify new views or even determine that a viewpoint aligned with values they felt they already held:

> Sometimes, you know, you're going to think about that on your own. But sometimes you're not unless someone brings it up. And I feel like I have had people that have caused me to think about that in my life [*White female, undeclared engineering*].

> I think just being around such diverse group of people is almost made me be like, oh, you should probably take more of an interest… And that also applies like people from different backgrounds I think […] it definitely opened up my eyes. My roommate at freshman year was from Puerto Rico and that was like right as the hurricanes were happening as well. And so I think just sort of hearing her experience has definitely influenced me […] it sort of helps realize like, yes, you were already concerned about this [*White female, mechanical engineering*].

Peers and friends influenced the interviewees in a variety of other ways. Some were encouraged by friends to join extracurricular activities that later developed into social responsibility interests. Spending time with friends served as a motivation to participate in community engagement activities, "because it's kind of like, wake up on a Saturday. Do you want to go do volunteer work by yourself? Or do you want to go do it with like a group of people you get along with? Of course, you're going to want to do it with people" [*White male, computer science*].

Peers and friends also served as examples of positive and negative behavior. One student discussed how Greek organizations, student clubs, and friend groups helped him to realize the importance of kindness and sensitivity in interpersonal interactions:

> I've been part of like friend groups: one friend group which is very socially responsible, one friend group which is not as much. And the difference is really stark to me and […] so that's like a very, very clear contrast […] like how being socially responsible or just like being more considerate of others can help not only you but also others like everyone [*Non-White male, industrial engineering*].

We see this as consistent with a microethical focus (Herkert, 2004), here applied to personal, not professional, issues. Perhaps as a result of the heightened visibility of social interaction and its importance to overall student development, a number of the interviewees (around one third of the sample) discussed social responsibility in terms of interpersonal microethical behaviors. When prompted to consider professional social responsibility explicitly, they began to define it similarly, in terms of interpersonal behavior and professionalism. The same student offered that:

> The decisions I make, even if they don't affect anyone else but myself, I still hold them to a high standard for me […]not manipulating results, not promising outwardly ambitious results which deep down you know are not true […] being honest with the client, being responsible for the decisions and suggestions that you make.
>
> So they don't connect as much to my career, but they do affect how I make my decisions in terms of what I consider is ethical, what I consider is unethical, what I consider is socially responsible, what I consider is socially irresponsible, what I consider to be disrespect to others […] And that has influenced the way I carry myself, the way I live my life but -- and it will also definitely result in the way I have professional interactions with people but, as of now, it hasn't really affected my career direction [*Non-White male, industrial engineering*].

These statements are consistent with a microethical focus that one might see expressed in a professional code of conduct (Herkert, 2005). The student appears to focus on interpersonal behavior at work, but bracket or "weed out" (Downey & Lucena, 1997) broader macroethical concerns like the choice to engage in the career altogether. Interestingly, the student even relates professional responsibility to his own personal standards for himself.

We represent these results in Figure 2, which divides micro- and macroethical foci by personal and professional dimensions (specific examples were extrapolated from student interviews). Our findings suggest that students were able to translate micro-personal ethical attitudes into a micro-professional ones, and that this process of translation was relatively straightforward. Students greatly appreciate the importance of kindness, tolerance, honesty, and similar virtues, emphasized by their upbringing and reinforced during college socialization. In turn, the interviewees plan to bring these character traits into the workplace.

[Suggested Figure 2 location]

However, this interpersonal 'good neighbor' interpretation of social responsibility did not seem to extend to concerns about the broader macroethical impacts of their future professions. While students were perfectly capable of *identifying* important public-oriented professional social responsibility concerns, the more microethical concerns learned through interpersonal interaction were simply more salient to their understanding of social responsibility. Moreover, students

typically identified *distinct* macro-personal (for example, student mental health or social inequality) and macro-professional concerns (for example, aviation safety or pollution). As a result, a link was drawn between micro-personal and micro-professional ethics, but no such link was drawn between, for example, a macro-personal and macro-professional ethic.

4.3 Sufficiency of small acts and religious professional social responsibility attitudes

Several students emphasized how "finding small things to do can even be, like, more meaningful" [*White female, undeclared engineering*] than grand gestures. For example:

> We had one really great day that we put on like a charity concert and that was, that came out really successful we raised a lot of money and that went to charity too. So, I think that's influenced me a lot. It's shown me that all your actions no matter how small you know it does leave an impact [*Non-White male, mechanical engineering*].
>
> You know, it doesn't have to be any grand like you're going to roll out and decide to give every single person you see outside a sandwich or something. But it can be something small. It doesn't have to be, you know, that grand gesture where you're trying to improve the world, improve everything in the world in one day [*White male, computer science*].

Canney & Bielefeldt's work draws on a feminist lens and Delve's service learning model, theorizing that relationships built through smaller actions and community engagement should help foster professional social responsibility attitudes (Canney & Bielefeldt, 2013; Delve et al., 1990). In that sense, these students' expressions could reflect a more realistic sense of their current scope of impact and leave room at a later time for movement towards more robust social responsibility attitudes.

However, we found that the sentiments often translated into preference for personal and microethical thinking and a narrowed scope of professional and macroethical responsibility. This was particularly true for students who emphasized their Christian religious values (n=10), possibly co-mingled with political values:

> You don't necessarily have to be like 100 percent of my career has to give back to everybody, has to be good for public well-being, public welfare. That's where, you know, volunteering outside of work can kind of help you [*White male, computer science*].
>
> I'm a Christian, and I think that […] you can do something small and still be helping other people. Even if you don't feel that your career directly impacts people, you can, I believe that, like, you can do small things just to, like, show people love and serve other people [*White female, undeclared engineering*].
>
> For me, like, the more societal impact is not something that I'm looking for in the workplace because, I mean, I know that wherever I end up working, I can find a church in there. I can get engaged with the community there…and sort of have an impact with that…so, I'd say that something that--like I do want to have a societal impact but that's not something I'm looking for in the workplace or through the workplace [*White male, chemical and biomolecular engineering*].

Instead, several students articulated that they could best realize their religious values through socializing in one's church or "spreading faith" [*Non-White female, literature*]. These findings indicated a striking disconnect between personal and professional values. By emphasizing small acts and expressions of religious faith rather than large public welfare concerns, some students tend to not view one's profession as the pathway to actualize their religious values and obligations. While a full explanation of this phenomenon is beyond the scope of this paper, American values of individualism and personal responsibility may be contributing factors and notions that are reinforced through engineering's meritocratic ideology (Cech, 2013a).

4.4 Social/technical divide in early STEM education

Engineering students at our institution are required to receive some form of ethics education to satisfy ABET requirements. The specific type of ethics offering varies by major; some departments develop major-specific ethics courses, while other departments suggest a roster of eligible university-wide courses. The students in the study were in their second year, and thus typically had not yet completed the ethics requirement. It is most commonly done during a student's third or fourth year. Moreover, many engineering students in their first two years normally focus on general technical coursework rather than major-specific courses. For this reason, their actual engagement with their major and profession can be limited during early undergraduate education. Nevertheless, these early years constitute a foundational component of "professional development" shaping students' ultimate professional social responsibility attitudes (Canney & Bielefeldt, 2015; Rulifson & Bielefeldt, 2019).

Coursework can affect student social responsibility attitudes by exposing students to new social issues, i.e., building 'personal social awareness' (Canney & Bielefeldt, 2015). However, these issues were typically not tied to a student's discipline or career. One interviewee described an awareness-building experience as meaningful but "definitely" not connected to her major, as most of her major courses are "very technical-based" with "not a lot of regard to social concern." She stated that:

> I guess class-wise, I did take a public policy class in my freshman year […] we looked into the effect of like runoff from like farms […] [that] farmers are allowed to like use up the runoff water like divert the wrong water to the stream, that stream ends up going like to the ocean and it causes like so much algae growth which impacts-- it killed the fish […] And so I think that also definitely helped me appreciate like the overall impact [*White female, mechanical engineering*].

When students were exposed to social issues that might foster social responsibility attitudes, this was almost entirely outside of their foundational engineering and computer science coursework:

> Not in my technical classes that I can think of, my CS. In my business classes, we also talked about UN sustainable goals and we work on product development right now for people with needs […] So I'm really enjoying that right now. So most of the social [responsibility topics] have been in business, history, sociology. None of the technical classes have had a social focus [*White female, biomedical engineering*].

On the other hand, students agreed that their engineering and computer science coursework was "pretty technical" [*White male, aerospace engineering*]. This coursework seemed to actively deemphasize or "weed out" (Downey & Lucena, 1997) social dimensions of engineering in favor of the dominant problem-solving orientation. For example:

> I think just […] how we're sort of taught to address certain topics […] it's basically about like designing products […]for an end goal, and sort of the things we're taught to look at is... the engineering specifications and translating like the customer needs […] but it's not necessarily target[ted] at improving specific groups of people's lives. It's just like targeting the specific problem [*White female, mechanical engineering*].

This is highly resonant with prior work on the social/technical divide in engineering education (Cech, 2013b) and the ideology of depoliticization (Cech, 2013a; Cech & Sherick, 2015). Together, these findings raise the concern that even students who do develop "personal social awareness" may do so outside of their own disciplinary context, and therefore fail to develop "professional connectedness" (Canney & Bielefeldt, 2015) or professional social responsibility attitudes.

Another possibility is that future ethics or discipline-specific coursework might address social issues better, "saving it for later classes when they really start kind of being career-focused, career-driven" [*White male, computer science*]. However, a music technology student with experience in both technical and social science courses questioned the model altogether. She noted that placing computer science ethics education into a single, required course created certain expectations, perhaps even limiting student moral development:

> There is a CS ethics course, to be fair […] So, I imagine that's like that's the time to be like… there is ethics and it does matter, but I think […] having the social implication[s] come up more often and frequently would be better training for computer science majors to be aware of what's going on. Because […] I'm not aware of all the implications. I don't think anyone truly is […] I feel like if you talk about it once or twice or like even just in semester, it's just like I'm checking this box […] I really do believe that with the right environment, the education could be so much better [*White female, music technology*].

Thus, the very act of placing ethics into a single course appears to send the message that ethical thinking can be "bracketed" (Cech, 2013b). If so, pinning hopes on later-term ethics courses to bridge personal and professional values may be misplaced.

The same student articulated additional ways in which technical and social science courses differed. The contrast was not just in the coverage of material, but even in how technical courses were structurally and pedagogically less likely to encourage student growth and provide a supportive environment:

> Those [technical] classes just feel like you're there to sit down and like learn the information and if you don't, it's like too bad […] You'll just have to retake the class […] it doesn't feel like I'm learning to grow myself. It feels like I'm in there to complete the work to get the degree […] Some professors have this superiority complex... in my CS

> classes or it's like, we know everything kind of deal. You know, then it makes it feel like you can't ask questions or have discussion […]I would say, CS students fare worse...whether it be due to the larger lecture halls or because the professors are really here for research. There just isn't a lot of leeway for students to have a personal life or any understanding you need accommodations [*White female, music technology*].

This suggests to us that the aspects of engineering culture that lead to social disengagement go well beyond topical focus or curricula. Instead, structural aspects like lack of positive student-teacher interaction, large class sizes, and a survival-of-the-fittest mentality may play important roles in the failure to nurture professional social responsibility development. We see these as manifestations of what Cech calls the ideology of meritocracy (Cech, 2013b). Students are expected to sink or swim and learn to "weed out" aspects of their interests and identity outside of the technical work (Downey & Lucena, 1997). As a result, one student reflecting on the connection between her future profession and social responsibility offered that:

> Maybe some other careers […] [you] can just focus on social welfare […] but for CS I think it's something you have to do on your own to figure out [*Non-White female, computer science*].

Overall, STEM coursework appears to be a negative influence on social responsibility attitudes, often reinforcing the technical nature of STEM careers to the exclusion of social concerns. Our findings also suggest that topical absence of social issues in engineering and computer science curricula (the socio/technical divide) is not the only factor influencing students. Instead, *structural* aspects of engineering and computer science education may be just as important, such as the nature of student-teacher interaction, openness, compassion, and an emphasis on student personal growth rather than merely getting through a degree program. These structural elements, related in part to the competitive and meritocratic ideology of engineering, may constitute key, underexplored influences in social responsibility attitude declines.

4.5 Professional social responsibility as a loose boundary constraint or delayed goal

The interviewees uniformly viewed themselves as good people and as holding altruistic intentions. As discussed, however, they often did not connect personal social responsibly attitudes to professional ones. Even students who could articulate public welfare issues pertaining to their profession often described a completely distinct set of unrelated issues as their personal social concerns. Personal social responsibility might entail having compassion, being there for friends in need, and being sensitive or tolerant, while their conceptualization of professional social responsibility often relates to product safety, waste, or efficiency. Yet the interviewees rarely discussed topics pertaining to macro-professional social responsibility.

One case in which students did move beyond micro-professional values relates to how they might avoid working at clearly socially irresponsible industries or companies. As one student noted, "I'd be very hesitant to work for a company that I see is like socially irresponsible…like that would definitely be a huge red flag" [*White male, chemical and biomolecular engineering*]. However, some interviewees seemed to assume that their professional choices would meet their own standards of socially responsible behavior quite readily:

> So I think by a broad definition it's hard for anything I'm likely to do with my expertise to not involve some degree of social responsibility simply because my hope and goal and I think really anything that I'm going to be doing will in some way advance humanity's capability for flight, which I feel is, in whatever small way I contribute to it, a valuable thing for, really, mankind as a whole [*White male, aerospace engineering*].
>
> For example, like I applied to Johnson & Johnson. And obviously they're kind of very philanthropic like healthcare organization. So being able to work for them through efficiency in their business is also, you know, as a whole, you know, making the world a better place [*White female, biomedical engineering*].

By this minimal standard, nearly every profession contributes to some social good. On this view, avoiding 'irresponsible' companies or industries might not constitute a particularly clear and meaningful constraint.

Several interviewees also seemed to expect or hope that their social responsibility activities would fall into place eventually in one's career and life. In the meantime, academic success and career growth appear to be the clear priorities:

> At least the little bit of exposure that I've had, it's geared more towards gaining skills rather than being ethical […] about it. And I'm not saying that this is not a topic of like of concern. It's just there are a lot of priority at this point for like most students to gain skills [*Non-White male, industrial engineering*].
>
> I've tried a little bit, but, I mean, this is my first job internship. I just really am looking for a place that I can just start somewhere, you know? And, I have my dream job, my dream goals, and then I am working towards them. But, you got to start from baby steps, right? [*Non-White male, mechanical engineering*]

This deprioritization minimizes the importance of professional social responsibility. Students may hope that, by serving their employers "faithfully and professionally, it will somehow all work out in the end" (Catalano, 2007, p. 2). However, one interviewee, reflecting on a professor's advice about volunteering during a keynote speech, worried that a personal/professional divide was instead a 'trap' that would limit her long-term professional social responsibility behavior:

> I was just thinking how this guy is a professor. Like he has so much expertise and the years and years of experience under him. But even his mode of making a difference is to tell his students to go and […] volunteer and teach at [local] schools […] But like we're all going to be professionals, right? Like isn't the point of these years that we're sinking into learning something to use that something for some like greater purpose? I was just thinking about how we tend to like, we commit to a profession and then you see all these people who, I don't know, like they volunteer at the Red Cross or something. And the rest of the time they're investment bankers. But if you're an investment banker, 40 hours a week, then why don't you figure out a way to use investment banking to change the world in some way? And I'm really scared of falling into that trap [*Non-White female, chemical and biomolecular engineering*].

These students' undergraduate experiences do not seem to have bridged the divide between personal and professional values, and may have even reinforced the initial conception that these

are distinct spheres. Moreover, Rulifson and Bielefeldt (2018, 2019) have found that professional internships, important developmental experiences during later undergraduate education, can further deprioritize social responsibility as a priority. Without efforts to change a student's ranking of priorities and conception of career responsibilities, social responsibility concerns appear to take a backseat, serving as either a very minimal constraint on job choice or an aspiration that students are willing to defer to a later point in time.

5 DISCUSSION

5.1 Building on the engineering education literature

Our study offers several key findings of interest to engineering educators and other scholars. Foremost, our research build on work by Cech and Sherick on engineering disengagement, Canney, Bielefeldt, and Rulifson on professional social responsibility development, and Herkert on micro- and macroethics. Cech's work importantly emphasized the culture of engineering disengagement and offered several explanations for it, including the socio-technical divide and accompanying 'depoliticization' of engineering education (Cech & Sherick, 2015), and the interviewees' experiences provide further evidence that these ideologies (Cech, 2013b) *do* encourage students to ignore or undervalue the social dimensions of engineering, including their own social responsibility concerns.

Bielefeldt and Canney advanced this line of research through constructing a conceptual framework and survey instrument to better understand professional social responsibility development. Their research has identified various student demographic characteristics, community engagement experiences, and internships as factors influencing student social responsibility development. We extend this work by looking deeply into the distinction between personal and professional social responsibility. Our primary contribution is the identification of a new barrier to professional social responsibility development – the divide between micro-and macroethics.

In particular, our results indicate that many students at this important development stage, during their second year of college, are strongly influenced by their interpersonal interactions, especially with peers. In turn, students develop microethical personal attitudes that emphasize values like compassion, tolerance, or honesty in small-scale social settings. However, our findings indicate that *a focus on personal microethics may translate only into professional microethical views, while failing to translate into macroethical development*. Moreover, even when students are encouraged to build their personal macroethical awareness, this may fail to translate into a clear sense of professional macroethical awareness if the topics of concern are conceptually dissimilar.

Our study offers a few other findings of interest. First, we find that a 'sufficiency of small acts' mentality, related in part to religious or political values, may encourage microethical social responsibility activities that are outside the sphere of their future profession. This may thereby act against professional macroethical development. Second, students' social responsibility attitudes appeared to be shaped significantly by experiences and influences prior to college, raising the concern that their attitudes are relatively fixed. Third, the results raise additional features of the meritocratic ideology of engineering and computer science education that may shape student social responsibility, such as teacher-student dynamics, a [low] level of tolerance

for student failure, and a ‘check-the-box’ mentality to degree completion. Finally, student responses indicate that students may begin their professional career under the “fatal premise” (Myers et al., 1997) that they and their future employers are probably ‘ethical enough,’ and that it may be safe to defer social responsibility concerns until later in one's career.

5.2 Implications for educators and administrators

Given that students largely determined their academic path because of intellectual interest, and that few have a robust understanding of their future profession, universities and educators are likely to inherit an uphill challenge of helping students connect intellectual interests with moral obligation and personal values with professional ones. This is all the more difficult if students have little direct guidance on what career pathways to pick, which are socially responsible, and what options students have to infuse social responsibility in their profession. Our study thus urges the need for action and innovation by practitioners in higher education, including administrators and engineering educators.

Because fostering student personal social responsibly attitudes may fail to translate into professional ones, practitioners should consider adopting discipline-based social responsibility strategies. A variety of strategies have been fruitfully applied to foster professional social responsibility attitudes, including interdisciplinary team teaching (Walsh et al., 1975), discipline-specific case studies (Alpay, 2013), and a global challenges strategy (Vanasupa et al., 2006). Educators should also develop creative new strategies which aim to leverage students’ personal social responsibly attitudes and the importance of peer interaction to foster professional responsibility development, for example, by creating venues for peer dialogue about career choices and bringing in recent graduates to speak.

Yet, many universities continue to rely on a single ethics course to satisfy ABET or similar requirements. Such a dedicated ethics course, even late in a student’s academic career, is likely insufficient and ironically may even serve to reinforce the socio-technical divide by bracketing and minimizing the importance of ethics. Instead, a renewed push for ethics across the curriculum should occur (Cruz & Frey, 2003; Rulifson & Bielefeldt, 2019). This means incorporating discussion of ethics and social responsibility into arguably every course (Lucena & Leydens, 2015), even traditional courses such as Circuits (Lord, Przestrzelski, et al., 2019) to reinforce its importance and build student (and educator) awareness and skills. While instructors may have some capacity to implement classroom-level strategies, broader structural reforms will require top-down support from university administrators, regional or national government regulators, and arguably changes to certification criteria for engineering programs (Zandvoort et al., 2013).

A further challenge this study reveals is that students may settle for assumptions that avoiding the worst of the worst employers suffices to meet one’s obligations to do good for the public, or that social responsibly obligations can be satisfied ‘later on’ after achieving other career goals. Engineering educators should actively challenge this assumption and encourage students to rank social responsibility as a higher priority that should not be deferred. Educators should, for example, consider describing the difference between microethics and macroethics in order to help students reflect on how to frame their professional social responsibilities and make key career choices. This may resonate with students especially if a professor in their major

department takes the time to discuss the topic. What professors choose to cover, or not, sends a strong message about priorities.

Finally, our findings suggest that a failure to promote professional social responsibility is explained in part by the competitive, meritocratic structure of engineering education. Educators and administrators could help to reframe the structure and pedagogy of engineering by cultivating social responsibility through classroom practices, such as by creating a supportive environment and interacting with students on a personal level (see, for example, Klem & Connell, 2004; Ozaktas, 2013). Educators can look to innovations in engineering education, as well as social science, humanities, and other fields, to see how to foster group discussion, personal growth, reflection, tolerance of failure, and an overall environment more conducive to social responsibility development.

5.3 Limitations

While our results shed some light on the emerging personal and professional social responsibility attitudes of undergraduate engineers, there are study limitations worth noting. First, like any qualitative study, we cannot establish external validity with a high degree of confidence given our limited sample and possible bias resulting from our targeted sample selection process. Students at our institution and other universities may differ along a variety of factors, and the students who opted to participate in our study may differ from the broader student population. A self-selection bias may be present among those who were interviewed; for example, those who are doing relatively well socially or in their coursework might be more likely to participate.

Second, it is important to reiterate that we interviewed students during the second year of their undergraduate education. Many of the students did not have a clear professional pathway determined and most had not participated in upper-level courses (including ethics courses) or internships in their profession of interest, factors which can shape social responsibility development. Based on these facts and the students' discussion of the responsibilities in their future career, many may not have had a robust understanding of their chosen profession or had not yet been exposed to the ethical responsibilities of their profession. That students expressed a divide between personal and professional social responsibility in many cases may reflect student attitudes still in an early and developing stage. As such, it is important to keep in mind that this study aims to shed light on the emerging beliefs of early undergraduates.

Third, prior research and our own conceptual framework acknowledge that a variety of student identity categories and backgrounds may influence social responsibility development (Naphan-Kingery et al., 2019; Smith & Lucena, 2016). Due to limitations of scope and sample size reasons, our work here does not address variation by student gender, race/ethnicity, socioeconomic status (including first-generation students), international student status, or other categories. This paper also does not explore in-depth issues related to student major, such as why students select into or leave certain majors and how these different courses of study are structured. While we saw anecdotal evidence suggesting, for example, that female students were more interested in social responsibility issues, we think student variation can be treated more fully in our quantitative or mixed methods analysis, where we have a far larger sample.

Fourth, given our focus on social responsibility and students' discussion of their own values and motivations, we were attentive to the possibility of social desirability bias (Nederhof, 1985). Based on feedback from the pilot phase of interviews, the interview team identified strategies to try to minimize social desirability bias. This included: 1) adopting a friendly and honest interviewer stance rather than trying to mask the goals of our study; 2) emphasizing the importance of honest rather than 'appropriate' answers; and 3) allowing interviewees significant leeway in defining and discussing both personal and professional social responsibility. We hope this approach was successful at eliciting truthful responses, especially since the interviewees may have felt comfortable with the interviewers, themselves students. Still, we cannot rule out that student responses were influenced by the subject matter, interview style, or other factors.

Finally, our broader study is significantly interested in community engagement experiences, especially those connected to a student's discipline. This is inspired by Canney and Bielefeldt's PSRDM framework, which incorporates Delve's service learning model, and their related work which examines the influence of community engagement in detail (Bielefeldt & Canney, 2014). In particular, we posit that sustained, collaborative, reflective, and *discipline-connected* community engagement activities undertaken in the public interest should in particular serve as a key factor in the development of professional social responsibility. However, very few of the students in our sample discussed community engagement activities and none addressed community engagement related to their discipline. Given that students are at relatively early stage of their college career and may not yet have had these experiences, we chose to minimize our discussion here of community engagement, though it originally featured more heavily in our conceptual framework and research design. We plan to re-examine the influence of community engagement during the next round of student interviews.

6 CONCLUSION AND FUTURE WORK

Our study evaluates the connection between personal and professional social responsibility development for undergraduates, and factors before and during college that may influence responsibility attitudes. Using a semi-structured design and directed coding technique, we analyzed 21 interviews with a diverse sample of second-year undergraduates at a large public engineering institution, the Georgia Institute of Technology.

Study findings highlight several important directions for the duration of our larger mixed methods study and for other scholars. First, they call attention to the micro/macro divide within the personal/professional divide. Building on our conceptual framework, we think that exploring how micro-personal and macro-personal views received during engineering education do or do not translate into macro-professional attitudes is an important subject for future research. Next, the findings encourage us to look to interpersonal aspects of engineering education, such as peer interaction and the role of instructors on fostering a supportive environment. Third, we intend to explore more deeply how student conceptions of their profession's roles, identities, and responsibilities evolve in tandem.

We plan to incorporate these concepts into our next-stage student interview instrument design. Our ongoing survey work will also allow us to explore variation across student gender, race/ethnicity, and major, among other categories, adding quantitative evidence to the findings identified here. After administration of the final survey, we will be in a position to measure first-

year to fourth-year changes in professional social responsibility attitudes, correlated with student characteristics, and interpreted in the context of themes identified in the qualitative work.

Overall, our findings suggest that attempts to nurture professional social responsibly attitudes face significant obstacles. Students appear to place personal and professional values in distinct spheres, pursue academic and professional paths largely because of intellectual interest rather than societal impact, and may have limited understanding of the responsibilities tied to their future profession. Moreover, we find few clear influences that bridge this divide, as students emphasize a personal microethical perspective that does not seem to translate into professional macroethical attitudes. Some influences, such as the content and structure of STEM coursework and ethics education, may even reinforce the focus on technical aspects to the exclusion of public welfare concerns. More deliberate efforts are needed to close this social responsibility gap.

APPENDIX

Semi-structured student interview protocol

This Appendix introduces the semi-structured interview protocol that was administered to students during the study.

Student academic & career background:

- Could you tell me your full name?
- What year are you in your studies here?
- What's your major? Have you switched majors or do you intend to switch majors at any point?
    - Note: if yes, why did you/are you going to switch?
- Do you have a sense of your intended profession?
    - Note: if no, focus on major and the kind of activities/work in that major
- How would you describe the nature of that profession?
- How did you come to that view of the profession?
    - Probe: experiences, influences, classes, internships, etc.
- Why did you select that major? Profession?
    - Probe: how did you come to that decision?

Social responsibility attitudes:

- Now I'd like to talk a little bit about the role of social responsibility in that profession. How would you describe the nature of social responsibility, or concern for public welfare or public good, in the context of that profession?
    - Note: if necessary, focus on major and the kind of activities/work in that major
- How did you come to those views of the nature of social responsibility in the profession, that is, PSR?
- Did social responsibility factor into your decision to pursue that profession? (Major?)

- Prior to college, what were the biggest influences on your views of social responsibility?
    - Probe: courses, community engagement experiences, internships/work, teachers, family, other students
    - Probe: brief description. Get a sense of the key characteristics (people, motivation, duration, emotional/intellectual influence, etc.)
- During college, (briefly) what have been the biggest influences on your views of social responsibility?
    - Probe: courses, community engagement experiences, internships/work, teachers, family, other students
- To what extent do you think your views on social responsibility were set before college versus since you started college? How about professional social responsibility?

Community engagement/experience characteristics:

- Now I'd like to talk a little bit more about the experience(s) you identified in college which influenced your views of social responsibility. Starting with the (first) influence or experience you identified, _____, could you describe that in more detail?
    - Note: start with the earliest experience/influence first.
- What motivated you to pursue this experience?
    - Probe: academic requirement, group activity, personal motivation related to SR
- Over what period of time were you engaged in this experience?
    - Probe: duration and frequency
- Was this experience related to a course you took?
    - Probe: curricular, co-curricular, extracurricular
- Was this experience related to your major and/or intended profession?
    - Probe: what was the nature of the disciplinary connection
- Where did this experience occur?
    - Probe: on or off campus, community-based or school-based
- Who determined the goals of the experience?
    - Probe: student driven, community driven, or collaborative
- How closely did you collaborate with the community?
    - Probe: did you do most of the work independently or did you collaborate regularly with the community?
- What was the final outcome or product created as a result of the experience?
    - Probe: did that outcome/product make a difference in how you perceive the experience?
- Did you engage in either formal, facilitated reflection or personal reflection related to this experience?
    - Probe: how impactful was that reflection for you?
- Did the experience affect you emotionally or would you describe the influence as more of an intellectual nature?
    - Probe: stronger identification with community, stronger identification with issue

Impact on views of professional social responsibility:

- To what extent did the experience change how you're thinking about your future professional goals?
    - Probe: how important it is to find work with SR components; how you will integrate SR into the work
- To what extent did the experience change your views of the nature of your intended profession itself?
- To what extent did the experience change your awareness of how these social issues/challenges are related to your intended profession?
- To what extent did the experience change your sense that you can impact these challenges through your intended profession?
- To what extent did the experience change your sense of obligation that you should impact these challenges through your intended profession?
    - Probe (if changed major): how did this experience relate to your decision to change your major if at all?
- Which aspects of the experience do you think had the greatest impact on your views of professional social responsibility, if any?
    - Probe: duration, frequency, setting, disciplinary connection, location, initiation, level of collaboration, final outcome/product, reflection, emotional connection
    - Note: share list above. Something like frequency might not stand out, so emphasize it
- Finally, how would you describe your current thinking about social responsibility (before today), and is that something that you've been pursuing or planning to pursue?
    - Probe: academic vs. non-academic, activities, classes, personal reflection
    - Probe: overall level of importance/salience of SR to the student currently

ACKNOWLEDGMENTS

The authors would like to thank the students who participated in the interviews. This material is based upon work supported by the National Science Foundation Cultivating Cultures for Ethical STEM Program, Grant Number 1635554. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

ORCID

Daniel Schiff https://orcid.org/0000-0002-4376-7303

Emma Logevall https://orcid.org/0000-0001-8910-2019

Jason Borenstein https://orcid.org/0000-0002-1505-4349

Wendy Newstetter https://orcid.org/0000-0001-5693-4265

Colin Potts https://orcid.org/0000-0003-4396-8399

Ellen Zegura https://orcid.org/0000-0002-4756-1759

REFERENCES

ABET. (2020). *Criteria for Accrediting Engineering Programs, 2020 – 2021*. ABET. https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2020-2021/

Alpay, E. (2013). Student-Inspired Activities for the Teaching and Learning of Engineering Ethics. *Science and Engineering Ethics*, *19*(4), 1455–1468. https://doi.org/10.1007/s11948-011-9297-8

Antes, A. L., Murphy, S. T., Waples, E. P., Mumford, M. D., Brown, R. P., Connelly, S., & Devenport, L. D. (2009). A Meta-Analysis of Ethics Instruction Effectiveness in the Sciences. *Ethics & Behavior*, *19*(5), 379–402. https://doi.org/10.1080/10508420903035380

Astin, A. W. (1970). The Methodology of Research on College Impact, Part One. *Sociology of Education*, *43*(3), 223–254. JSTOR. https://doi.org/10.2307/2112065

Bairaktarova, D., & Woodcock, A. (2017). Engineering Student's Ethical Awareness and Behavior: A New Motivational Model. *Science and Engineering Ethics*, *23*(4), 1129–1157. https://doi.org/10.1007/s11948-016-9814-x

Becker, H. S. (2008). *Tricks of the Trade: How to Think about Your Research While You're Doing It*. University of Chicago Press.

Bielefeldt, A. R., & Canney, N. (2014). Impacts of service-learning on the professional social responsibility attitudes of engineering students. *International Journal for Service Learning in Engineering*, *9*(2), 47.

Bielefeldt, A. R., & Canney, N. E. (2016). Changes in the Social Responsibility Attitudes of Engineering Students Over Time. *Science and Engineering Ethics*, *22*(5), 1535–1551.

Borenstein, J., Newstetter, W., Potts, C., & Zegura, E. (2019). *Generalized Professional Responsibility Assessment (GPRA)*. Online Ethics Center for Engineering. www.onlineethics.org/86590/GPRA

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Canney, N. E., & Bielefeldt, A. R. (2015). A framework for the development of social responsibility in engineers. *International Journal of Engineering Education*, *31*(1B), 414–424.

Canney, N. E., & Bielefeldt, A. R. (2016). Validity and reliability evidence of the engineering professional responsibility assessment tool. *Journal of Engineering Education*, *105*(3), 452–477.

Canney, N. E., & Bielefeldt, A. R. (2013). Examining the correlation between religion and social responsibility in engineering. *2013 IEEE Frontiers in Education Conference (FIE)*, 1819–1824. https://doi.org/10.1109/FIE.2013.6685151

Catalano, G. D. (2007). *Engineering, poverty, and the earth*. Morgan & Claypool Publishers.

Cech, E. A. (2010). Trained to Disengage? A Longitudinal Study of Social Consciousness and Public Engagement among Engineering Students. *Proceedings of the 2010 ASEE Annual Conference and Exposition*. ASEE Annual Conference and Exposition, Louisville, Kentucky.

Cech, E. A. (2013a). The (Mis)Framing of Social Justice: Why Ideologies of Depoliticization and Meritocracy Hinder Engineers' Ability to Think About Social Injustices. In J. Lucena (Ed.), *Engineering Education for Social Justice: Critical Explorations and Opportunities* (pp. 67–84). Springer Netherlands. https://doi.org/10.1007/978-94-007-6350-0_4

Cech, E. A. (2013b). Culture of Disengagement in Engineering Education? *Science, Technology, & Human Values*, *39*(1), 42–72. https://doi.org/10.1177/0162243913504305

Cech, E. A., & Sherick, H. M. (2015). Depoliticization and the Structure of Engineering Education. In S. H. Christensen, C. Didier, A. Jamison, M. Meganck, C. Mitcham, & B. Newberry (Eds.), *International Perspectives on Engineering Education: Engineering Education and Practice in Context, Volume 1* (pp. 203–216). Springer International Publishing. https://doi.org/10.1007/978-3-319-16169-3_10

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (Third Edition). SAGE.

Cruz, J. A., & Frey, W. J. (2003). An effective strategy for integrating ethics across the curriculum in engineering: An ABET 2000 challenge. *Science and Engineering Ethics*, *9*(4), 543–568. https://doi.org/10.1007/s11948-003-0049-2

Delve, C. I., Mintz, S. D., & Stewart, G. M. (1990). Promoting values development through community service: A design. *New Directions for Student Services*, *1990*(50), 7–29. https://doi.org/10.1002/ss.37119905003

Desimone, L. M., & Le Floch, K. C. (2004). Are We Asking the Right Questions? Using Cognitive Interviews to Improve Surveys in Education Research. *Educational Evaluation and Policy Analysis*, *26*(1), 1–22. https://doi.org/10.3102/01623737026001001

Downey, G. L., & Lucena, J. C. (1997). Engineering selves: Hiring in to a contested field of education. In N. Sakellariou & R. Milleron (Eds.), *Ethics, Politics, and Whistleblowing in Engineering* (pp. 25–43). CRC Press.

Eyler, J. (2002). Reflection: Linking service and learning—Linking students and communities. *Journal of Social Issues*, *58*(3), 517–534.

Faulkner, W. (2007). `Nuts and Bolts and People': Gender-Troubled Engineering Identities. *Social Studies of Science*, *37*(3), 331–356. https://doi.org/10.1177/0306312706072175

Fletcher, A. J. (2017). Applying critical realism in qualitative research: Methodology meets method. *International Journal of Social Research Methodology*, *20*(2), 181–194. https://doi.org/10.1080/13645579.2016.1144401

Grigg, N. S. (2017). Institutional Analysis of Drinking Water Supply Failure: Lessons from Flint, Michigan. *Journal of Professional Issues in Engineering Education and Practice*, *143*(3), 05016014. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000312

Hallgren, K. A. (2012). Computing Inter-Rater Reliability for Observational Data: An Overview and Tutorial. *Tutorials in Quantitative Methods for Psychology*, *8*(1), 23–34.

Harrell, M. (2019). Developing Engineering Students' Moral Reasoning Skills Using Problem-Based Learning. *American Association of Philosophy Teachers Studies in Pedagogy*, *5*, 123–143. https://doi.org/10.5840/aaptstudies2019121245

Herkert, J. R. (2004). Microethics, macroethics, and professional engineering societies. In National Academy of Engineering (Ed.), *Emerging technologies and ethical issues in engineering* (pp. 107–114).

Herkert, J. R. (2005). Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering. *Science and Engineering Ethics*, *11*(3), 373–385. https://doi.org/10.1007/s11948-005-0006-3

Hess, J. L., & Fore, G. (2018). A Systematic Literature Review of US Engineering Ethics Interventions. *Science and Engineering Ethics*, *24*(2), 551–583. https://doi.org/10.1007/s11948-017-9910-6

Hsieh, H.-F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research*, *15*(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2016). Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. *Field Methods*. https://doi.org/10.1177/1525822X05282260

Klem, A. M., & Connell, J. P. (2004). Relationships Matter: Linking Teacher Support to Student Engagement and Achievement. *Journal of School Health*, *74*(7), 262–273.

Layton, E. T. (1986). *The Revolt of the Engineers. Social Responsibility and the American Engineering Profession*. Johns Hopkins University Press.

Leydens, J. A., & Lucena, J. C. (2018). *Engineering justice: Transforming engineering education and practice*. John Wiley & Sons; IEEE Press.

Litchfield, K., & Javernick-Will, A. (2015). "I Am an Engineer AND": A Mixed Methods Study of Socially Engaged Engineers. *Journal of Engineering Education*, *104*(4), 393–416. https://doi.org/10.1002/jee.20102

Lord, S. M., Ohland, M. W., Layton, R. A., & Camacho, M. M. (2019). Beyond pipeline and pathways: Ecosystem metrics. *Journal of Engineering Education*, *108*(1), 32–56. https://doi.org/10.1002/jee.20250

Lord, S. M., Przestrzelski, B., & Reddy, E. (2019, June 15). *Teaching Social Responsibility in a Circuits Course*. 2019 ASEE Annual Conference & Exposition, Tampa, Florida.

Loui, M. C. (2005). Ethics and the Development of Professional Identities of Engineering Students. *Journal of Engineering Education*, *94*(4), 383–390. https://doi.org/10.1002/j.2168-9830.2005.tb00866.x

Lucena, J. C., & Leydens, J. A. (2015). *From Sacred Cow to Dairy Cow: Challenges and Opportunities in Integrating of Social Justice in Engineering Science Courses*. Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.24143

Lucena, J., Schneider, J., & Leydens, J. A. (2010). Engineering and Sustainable Community Development. *Synthesis Lectures on Engineers, Technology, and Society*, *5*(1), 1–230. https://doi.org/10.2200/S00247ED1V01Y201001ETS011

Mansouri, N. (2016). A Case Study of Volkswagen Unethical Practice in Diesel Emission Test. *International Journal of Science and Engineering Applications*, *5*(4), 211–216. https://doi.org/10.7753/IJSEA0504.1004

Meyer, M., & Marx, S. (2014). Engineering Dropouts: A Qualitative Examination of Why Undergraduates Leave Engineering. *Journal of Engineering Education*, *103*(4), 525–548. https://doi.org/10.1002/jee.20054

Myers, C., Hall, T., & Pitt, D. (Eds.). (1997). *The Responsible Software Engineer: Selected Readings in IT Professionalism*. Springer-Verlag. https://doi.org/10.1007/978-1-4471-0923-5

Naphan-Kingery, D. E., Miles, M., Brockman, A., McKane, R., Botchway, P., & McGee, E. (2019). Investigation of an equity ethic in engineering and computing doctoral students. *Journal of Engineering Education*, *108*(3), 337–354. https://doi.org/10.1002/jee.20284

National Academy of Engineering. (2016). *Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs*. National Academies Press. https://doi.org/10.17226/21889

Nederhof, A. J. (1985). Methods of coping with social desirability bias: A review. *European Journal of Social Psychology*, *15*(3), 263–280. https://doi.org/10.1002/ejsp.2420150303

Noble, D. F. (1977). *America by design: Science, technology, and the rise of corporate capitalism* (1st ed). Knopf.

NSPE. (2019). *Code of Ethics for Engineers*. National Society of Professional Engineers. https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/NSPECodeofEthicsforEngineers.pdf

Ozaktas, H. M. (2013). Teaching Science, Technology, and Society to Engineering Students: A Sixteen Year Journey. *Science and Engineering Ethics*, *19*(4), 1439–1450. https://doi.org/10.1007/s11948-011-9329-4

Riley, D. (2008). Engineering and Social Justice. *Synthesis Lectures on Engineers, Technology, and Society*, *3*(1), 1–152. https://doi.org/10.2200/S00117ED1V01Y200805ETS007

Rulifson, G., & Bielefeldt, A. (2017). Motivations to Leave Engineering: Through a Lens of Social Responsibility. *Engineering Studies*, *9*(3), 222–248. https://doi.org/10.1080/19378629.2017.1397159

Rulifson, G., & Bielefeldt, A. (2018). Influence of Internships on Engineering Students' Attitudes about Socially Responsible Engineering. *2018 IEEE Frontiers in Education Conference (FIE)*, 1–6. https://doi.org/10.1109/FIE.2018.8658647

Rulifson, G., & Bielefeldt, A. R. (2019). Evolution of Students' Varied Conceptualizations About Socially Responsible Engineering: A Four Year Longitudinal Study. *Science and Engineering Ethics*, *25*(3), 939–974. https://doi.org/10.1007/s11948-018-0042-4

Schneider, J., Lucena, J., & Leydens, J. A. (2009). Engineering to help. *IEEE Technology and Society Magazine*, *28*(4), 42–48. https://doi.org/10.1109/MTS.2009.935008

Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie*, *69*(Suppl 2), 107–131. https://doi.org/10.1007/s11577-017-0454-1

Schwartz, S. H. (1977). Normative Influences on Altruism. In *Advances in Experimental Social Psychology* (Vol. 10, pp. 221–279). Elsevier. https://doi.org/10.1016/S0065-2601(08)60358-5

Sgobba, T. (2019). B-737 MAX and the crash of the regulatory system. *Journal of Space Safety Engineering*, *6*(4), 299–303. https://doi.org/10.1016/j.jsse.2019.09.006

Smith, J. M., & Lucena, J. C. (2016). Invisible innovators: How low-income, first-generation students use their funds of knowledge to belong in engineering. *Engineering Studies*, *8*(1), 1–26. https://doi.org/10.1080/19378629.2016.1155593

SocioCultural Research Consultants. (2019). *Dedoose* (8.3.17) [Computer software]. Dedoose.

Vakkuri, V., Kemell, K.-K., Kultanen, J., Siponen, M., & Abrahamsson, P. (2019). Ethically Aligned Design of Autonomous Systems: Industry viewpoint and an empirical study. *ArXiv:1906.07946 [Cs]*. http://arxiv.org/abs/1906.07946

Vanasupa, L., Chen, K. C., & Slivovsky, L. (2006). Global challenges as inspiration: A classroom strategy to foster social responsibility. *Science and Engineering Ethics*, *12*(2), 373–380. https://doi.org/10.1007/s11948-006-0036-5

Walsh, W. B., Smith, G. L., & London, M. (1975). Developing an interface between engineering and the social sciences: An interdisciplinary team approach to solving societal problems. *American Psychologist*, *30*(11), 1067–1071. https://doi.org/10.1037/0003-066X.30.11.1067

Ward, K., & Wolf-Wendel, L. (2000). Community-centered service learning: Moving from doing for to doing with. *American Behavioral Scientist*, *43*(5), 767–780.

Watts, L. L., Medeiros, K. E., Mulhearn, T. J., Steele, L. M., Connelly, S., & Mumford, M. D. (2017). Are Ethics Training Programs Improving? A Meta-Analytic Review of Past and Present Ethics Instruction in the Sciences. *Ethics & Behavior*, *27*(5), 351–384. https://doi.org/10.1080/10508422.2016.1182025

Woodhouse, E. J. (2001). Curbing overconsumption: Challenge for ethically responsible engineering. *IEEE Technology and Society Magazine*, *20*(3), 23–30. https://doi.org/10.1109/44.952762

Zandvoort, H., Børsen, T., Deneke, M., & Bird, S. J. (2013). Editors' Overview Perspectives on Teaching Social Responsibility to Students in Science and Engineering. *Science and Engineering Ethics*, *19*(4), 1413–1438. https://doi.org/10.1007/s11948-013-9495-7

AUTHOR BIOGRAPHIES

Daniel S. Schiff is a PhD student in the School of Public Policy at the Georgia Institute of Technology, 685 Cherry St. NW, Atlanta, GA, 30313; schiff@gatech.edu

Emma Logevall is a recent graduate of the Georgia Institute of Technology and a former research assistant in the College of Computing, 801 Atlantic Dr., Atlanta, GA, 30332; emma.logevall@gmail.com

Jason Borenstein is a professor in the School of Public Policy and Office of Graduate Studies at the Georgia Institute of Technology, 685 Cherry St. NW, Atlanta, GA, 30313; borenstein@gatech.edu

Wendy Newstetter is a professor in the Department of Biomedical Engineering and an assistant dean in the College of Engineering at the Georgia Institute of Technology, 313 Ferst Dr NW, Atlanta, GA 30332; newstetter@gatech.edu

Colin Potts is the Vice Provost for Undergraduate Education at the Georgia Institute of Technology, 237 Uncle Heinie Way, Atlanta, GA 30332; colin.potts@gatech.edu

Ellen Zegura is a professor in the School of Computer Science at the Georgia Institute of Technology, 801 Atlantic Dr, Atlanta, GA 30332; ewz@cc.gatech.edu