Bringing in "The Social"

Resisting and Assisting Social Engagement in Engineering Education

Skye Niles*[1], Santina Contreras[2], Shawhin Roudbari[3], Jessica Kaminsky[4], and Jill Harrison[1]

[1]Department of Sociology, University of Colorado Boulder
[2]City and Regional Planning, Knowlton School of Architecture, The Ohio State University
[3]Program in Environmental Design, University of Colorado Boulder
[4]Department of Civil and Environmental Engineering, University of Washington
*Corresponding author: niles.skye@colorado.edu. Department of Sociology, University of Colorado Boulder

I. Abstract

This paper explores how students experience the integration of social knowledge into engineering education. Engineering for peace requires going beyond purely technical engineering towards an integrated social and technical understanding of how engineering can promote community development and societal good. This study focuses on student experiences at two major engineering for community development programs that are actively integrating social and technical knowledge in engineering education, with the goal of training more socially-engaged engineers. We find that knowledge of the social context and implications of engineering creates tensions and conflicts with established technocentric norms of engineering knowledge and practice. This makes the adoption and integration of these concepts challenging for students engaged in these fields. We conclude that integration of "the social" requires more than shifts in educational content and is also reliant on changes in engineering culture and student support both inside and outside of the classroom in order to challenge normative, technocentric conceptions of engineering identity, knowledge, and practice. This has important implications for peace engineering, because understanding how students are integrating knowledge of "the social" in engineering education is key to the development and support of future peace engineers.

Keywords— sociotechnical knowledge, engineering education, community engagement, engineering culture, peace engineering

II. Introduction

Peace engineering requires an integrated social and technical understanding of how engineering can promote societal good, and involves critical inquiry into the social, political, and ethical impacts and possibilities of engineering. However, researchers of engineering education have found that dominant practices in engineering education include a reductionist way of thinking that excludes more complex problems, and the value of technical and mathematical knowledge over social and cultural knowledge [1], [2], [3], [4], [5]. Traditionally, engineering education has been characterized by a hierarchal and dualistic sense of knowledge, in which scientific and mathematical laws are used to both define and prove what is truthful, and in which more reflective, personal, or ideological knowledge are deemphasized and discouraged [2], [3], [4], [5], [6], [7]. This has important consequences for peace engineering, as it limits the ways in which engineers understand their responsibility for the detrimental social impacts of engineering practice, as well as the possibility of engineers to engage in meaningful efforts to promote peace and societal good [7], [8], [9], [10].

This presents an interesting dilemma. The stated purpose of engineering is to serve public welfare [11]; however, the technocentric focus of engineering education curtails the ability of engineers to actively engage in and imagine transformative practices to promote global social welfare and peace. As Cech [7] argues, due to the marginalization of knowledge of the social and political impacts of engineering, students in programs with a more explicit focus on social welfare may be forced to grapple with conflicting messages about the value of these topics and relevance to their roles as engineers. Furthermore, Bejerano and Bartosh [12] argue that the "hidden curriculum" in education— the processes through which norms, values, and beliefs systems are taught unintentionally or implicitly—also plays in important role in reproducing norms in engineering. Their study focused on how masculine norms are reproduced in STEM through the hidden curriculum, but this can also be extended to technocentrism and positivist epistemologies. This means that even implicit messages can reinforce dominant practices in engineering and inhibit change towards socially-engaged learning focused on integrating community knowledge and perspectives.

Citing the ways in which engineering falls short of its ability to make widespread positive impacts on society, many engineering educators are advocating for more integration of "the social" in engineering education, including emphasis on public welfare, peace, and social justice (e.g. [3], [5], [13]). These efforts require epistemological shifts in engineering to include more in-depth understandings of the social context in which engineering takes place, and the impacts of technology on society. While there are many ways to define "the social" in engineering education, in this study we focus on social context, integrating community perspectives, and the social impacts of engineering, as this is how "the social" was most commonly identified in the programs we studied. Although there is no single way to increase student knowledge of and engagement with the social impacts of engineering, we list several prominent methods:

- Interdisciplinary training and “multiliteracies” (i.e. economics, law, ethics, politics, sociology, history) [14], [15], [16], [17].
- Emphasis on learning reflexivity, positionality, and reflecting on systemic inequalities [3], [16].
- Understanding of macro ethics in addition to micro ethics (i.e. critical questions about what engineering is for, who it is for, and how benefits and costs of technology disproportionately distributed in society) [5], [9], [10], [18], [19].
- Focus on how engineers define problems, not just problem solving [9].
- Emphasis on the socio-technical—identifying how technology and society are inextricably linked, rather than separate domains [5], [9], [16], [20].
- Affective support in the classroom—understanding how emotions and feelings of belonging on exclusion also impact student learning outcomes and engagement [16].

However, while there are many examples from educators advocating for a shift in engineering education towards a greater emphasis on social context and promoting social welfare through engineering, less is known about how students are experiencing these cultural shifts within the classroom and in the broader engineering institutional context, and how students are integrating these principles of social engagement. Cech’s [7] longitudinal survey of students at four different engineering colleges found that, even in colleges with an increased emphasis on social engagement within engineering, students concern with public welfare *declined* over the course of their studies. This prompts further exploration of the processes through which this social disengagement may be occurring, and what practices may be helpful to increase student concern for public good.

Our study uses qualitative research methods including in-depth interviews with students and extensive observations of program activities, classes, and events in order to explore student experiences at two non-traditional engineering programs with explicit focus on community engagement and promoting social welfare through engineering. We explore the processes through which social engagement and disengagement occur. We examine what tensions, debates, and new ideas are produced when students engage with educational practices that challenge the technocentric focus of engineering education. We question how students resolve or address these conflicts, and what kind of program support is helpful in resolving these disagreements. Knowledge of student experiences is key to a better understanding of what factors may either hinder or facilitate the adoption and integration of social engagement and peace engineering principles among future engineers.

III. METHODS

This research included observations at 60 program-related events, and 26 in-depth interviews with undergraduate, Masters, and PhD students at two leading engineering programs emphasizing social context and the promotion of global human and environmental welfare through engineering. The semi-structured interviews averaged around 1.5 hours, and the observations at classes, program-sponsored social events, presentations, and group activities ranged from one hour to eight hours. We transcribed and coded the data using qualitative computer software in order to identify salient themes. Names of programs, people, and places were anonymized to maintain student confidentiality and minor edits have been made to quotations for grammatical clarity.

The two programs that were studied emphasize the importance of new approaches to engineering education that focus on the social context and impacts of engineering technology, and include coursework focusing on community development and social justice. These programs provide a unique opportunity to explore how students experience and integrate differing social norms of engineering education because students in both of these programs take “traditional” engineering classes (e.g. civil, mechanical, or environmental engineering), in addition to their socially-oriented engineering courses. This provides an excellent opportunity to explore how students are engaging with potential conflicts between traditional engineering cultural norms (ways of acting) and epistemologies (ways of thinking and knowing) and alternative values and perspectives in their socially-oriented, community development focused engineering courses.

IV. FINDINGS AND ANALYSIS

In our analysis, we found that students experienced a large amount of excitement and enthusiasm for the opportunity to engage more deeply with the societal impacts of engineering and the possibility to use engineering to promote global social and environmental welfare. This indicates that there is a clear desire for more socially-oriented engineering education. However, at the same time we also found that students experienced significant conflicts and confusions when engaging with knowledge and practices that challenged the technocentric focus of engineering education. These included a) justifying the value of non-technical work and relevance to engineering; b) understanding and integrating cultural perspectives and community knowledge into designs and projects; and c) addressing ambiguity in ethics and problem-solving.

A. Justifying the value of non-technical work and relevance to engineering

Some students expressed having to grapple with defining—and defending—their role as engineers and their work as “real engineering.” As Meyers et al. [21] and Stonyer [1] establish, claiming an engineering identity is a central part of integrating into the engineering community, and we argue that it is also key to legitimizing alternative engineering practices. For students, establishing an identity as engineers involved navigating a dualism that frames engineers as highly technical people and that deems anything outside of the "technical" to be either of lesser value, or outside the scope of engineers and engineering. One student echoed this kind of sentiment by expressing that she does not want to be "just an engineer"; whereas other students justified and established their identity through critiquing traditional engineers as "more like robots" than people. Other students described how engineers in the socially-oriented engineering program had to contend with being framed as an outsider to engineering. As one student described:

> You say [socially-engaged] engineering [and] people immediately see people wearing ponchos, hugging trees, dancing around outside . . . I don't think that's what it's about. I think that that's my perception of the outside looking in.

One of the key aspects of this student's statement is that even though he did not experience someone explicitly telling him that socially-engaged engineering is only for hippies (people who are imagined to be very far removed from the technical and laboratory-focused engineer), he has developed an internal message that this is what socially-engaged engineering entails. His perspective of "the outside looking in," is that socially-engaged engineering is seen as far removed from real engineering.

This is an example of how students expressed grappling with more internalized or implicit messages about what it means to be an engineer and what is included in engineering; however, at other times students were more explicitly challenged. One student described how she had heard engineering for community development described as "community work," not engineering. Another student described an experience where, when she talked about the importance of working with communities during an interview for an internship, she was told that she "should just go be a social worker" rather than an engineer. These examples represent how students had to cope with messages that framed their work as outside of legitimate engineering, creating an additional burden for students to prove themselves as engineers.

Some students described integrating social context into engineering as "more challenging" or "more complex" than traditional engineering, using the quality of difficulty as a something that is normatively valued in engineering in order to justify its legitimacy. However, for another student, the perception that she was not doing "as technical" or "hard" engineering as other fields, along with the prevalence of women in her program, created an additional struggle for her to assert her legitimacy:

> Sometimes when I see myself in these fields that are like predominantly women, I'm like, 'Oh, I'm just following the stereotypes. I'm not doing something that's as technical, or hard, so it's not as respected or prestigious.' I think I struggle internally with that.

Although this student also expressed passion and enjoyment for her program, she also had to cope with the additional burden of gendered messages that devalued the legitimacy of her work, both because of its social focus and also because of the greater inclusion of women in her field, which she perceives as lessening the prestige and difficulty of her work.

While students were often very excited and passionate about their work and the importance of knowledge about social context and impacts of engineering, students in the programs we studied also had to engage in additional mental and emotional labor to justify their work as "real engineering" and to establish themselves as legitimate engineers. This extra work to justify their engineering identities created challenges for the adoption of socially-oriented engineering knowledge.

B. Understanding and integrating cultural perspectives and community knowledge

A central component of both programs was to teach students to consider the views and desires of the communities with whom they work. This involved challenging engineering expertise through the integration of the knowledge and perspective of non-engineers. During observations at events and classes as well as during interviews, students frequently expressed the need for knowledge about social context in understanding and addressing engineering problems. Classroom examples often focused on failed and detrimental projects where engineers had implemented projects without clear communication and consultation with the communities with whom they were working. Students described their programs as involving epistemological shifts, such as the "how to re-define problems," "a way of thinking," and "asking different kinds of questions." Understanding community perspectives were central parts of their approaches to engineering. As one student put it, "I've come to learn that really it's the engineers that are learning from the communities, not the other way around."

However, students also described tensions and conflicts when grappling with differences between traditional notions engineering expertise and community perspectives. For example, one student described his frustration when he was interning with an earthquake resiliency project in South America that was vandalized by local residents. For this student, it was "obvious" that there was a need for earthquake resistant building in this area, and he felt frustrated that the community did not have the same point of view:

> At night the community would come in, and they trashed the [work] site—destroyed all the work, all the tools . . . They did not want it, they didn't think that they needed it . . . And my first reaction was like, 'Why would you do that? That's stupid. We're here to help you' . . . Because for me, from the American, the

> Western way, the engineering way, it's common sense and it's obvious.

This student describes the frustration and conflict that he feels when what he believes is right is different from what the community he is working with desires. He also reflects how he has developed a conception of the “American,” “Western,” and “engineering” way that is not only distinct from that of the communities he is working with, but it is in active conflict with community knowledge and perspectives. In this case, the Western “engineering way” is framed as oppositional to ways of the community and to non-Western perspectives, and creates both external conflict with the community, as well as internal conflict in the student engineer as he grapples with trying to understand a different perspective. Furthermore, his understanding of the engineering way as “common sense” and obvious” also highlights how this student’s engineering way of thinking is hierarchically naturalized in opposition to community viewpoints.

Another student expressed how she becomes frustrated as she learns about different belief systems that challenge the universal authority of Western science. She explains:

> I think the crux of the issue is that by not acknowledging indigenous beliefs, we are kind of looking down on them. And that's something that I still haven't come to terms with. Because to me . . . science is my truth. These are my guiding principles. And so, I get really angry in class [when talking about indigenous belief systems], and I have to step back and be like, ‘Okay, this is what they believe.’

Here, the student actively expresses a desire to learn about indigenous perspectives, which is key to her engineering work with indigenous communities; however, she also describes how frustrating it can be because these perspectives challenge her own deeply held beliefs in Western scientific knowledge.

These examples illustrate how, while students recognized the importance of integrating community knowledge and perspectives into engineering, they also encountered difficulties and confusions when their engineering values conflicted with those of the community. Students often expressed frustration or doubt in how to approach of problems in which their conceptions of Western scientific methods and engineering knowledge—or the “engineering way”—conflicted with community desires or perspectives. This indicates that students experienced dominant conceptions of engineering knowledge and practice as being incompatible with full integration of community knowledge.

C. Addressing ambiguity in ethics and problem solving

Another area of conflict for students was regarding how to approach ambiguous questions and ethical dilemmas. One of the key aspects of socially-engaged engineering involves teaching students about ethical dilemmas in engineering and how to understand their responsibilities for the social consequences of their work. However, because many ethical questions regarding the social impacts of engineering do not have well-defined answers, grappling with ethical questions also entailed challenging normative engineering thinking based on measurable constraints and clearly identifiable solutions [3], [4], [10], [13]. This created a conflict for many students who expressed that they just wanted to know “what to do.” As one student expressed with a tone of frustration and disengagement, “How long can you talk about it [ethical dilemmas]? It is like mental gymnastics to try to get your brain around some of these concepts.”

When asked about different ethical dilemmas that they have either experienced in their work or talked about in class, students frequently described feeling frustrated that, as one student put it, “there’s never just an answer that works for every situation.” As another student expressed:

> It is a very tiring process. Because you're constantly questioning yourself. Is this the right way to look at it? And there's no “yes” or “no” answer. I think as engineers, we love to hear “yes” or “no.” It's either right or it's wrong.

This student references normative conceptions of engineers as wanting clear-cut “yes” or “no” answers. This concept of engineering problem solving is incompatible with the more complex ethical problems and dilemmas that do not have clear “right” or “wrong” answers.

The technocentric emphasis in engineering culture emphasizes mathematical problem solving with defined parameters and clear practical applications [3], [4], [10]. The examples above demonstrate that when encountering complex ethical and ambiguous questions, many students felt frustrated that there was not a clear answer, and at times they also expressed a degree of disengagement from these topics of discussion. The contrast between dominant, reductive approaches to engineering made complex ethical problems more difficult for students to learn and integrate into their engineering knowledge.

D. Supportive practices for socially-engaged learning

However, despite these difficulties and conflicts in integrating social engagement into engineering education, we also found that there were some key mechanisms through which students were able to better resolve with these frustrations and establish engineering identities and practices of socially-engaged engineering work. Many of these key sites of learning occurred outside of the classroom, in informal social settings, or through more individualized faculty mentorship. Students spoke about the importance of individual conversations with faculty members that helped to spur their interest and retain engagement in the field of socially-engaged engineering. Additionally, many students also talked about the importance of social groups (both program-sponsored social meetings and events as well as informal social groups) as central sites where students could share about their frustrations, but also share interests and excitement, and cultivate a sense of community belonging within engineering.

These findings lend some support to theory cited by Stonyer [1], that a critical part of the learning process is assimilation into educational "communities of practice." Student relationships with faculty, involvement in program activities, leadership roles, and developing relationships outside of classes were critical parts of student learning experiences and creating new engineering communities. Affective support [16] was also shown to be an important part of the learning process, as many students discussed how critical it was to develop social networks and faculty support in order to both cope with frustrations, and also to explore questions and ideas in more depth.

Lastly, although many students still took classes that were *either* focused on technical learning *or* social context and impacts of engineering, many students reported that when classes integrated scientific, technical skill-building with learning on social context and considerations, these classes felt increasingly relevant and engaging. In support of positions advocated by researchers and educators such as Downey [9] fully integrated classes may help resolve tensions between the competing values of the "social" and the "technical," as students may come to understand engineering as sociotechnical.

V. CONCLUSION

Engineers have great capacity to impact society, and training engineers to understand and take responsibility for the social implications of their work is a critical challenge of engineering education today. However, research has found evidence of declining interest in the public good among engineers [7]. This study explored student experiences within two engineering programs that are integrating a central emphasis of social context, community knowledge, and social impacts of engineering in order to explore how this disinterest in social welfare may occur. We examined some of the conflicts and challenges that students encountered in engineering programs that challenge the technocentrism of engineering and incorporate learning about social context and impacts of engineering in the curriculum.

We found that when engineering programs emphasize social context and implications of engineering, students are forced to contend with conflicting norms about engineering knowledge and practice. In particular, we outlined three main areas where students expressed difficulty: 1) justifying their identities as engineers and their work as legitimate engineering; 2) integrating community or cultural knowledge into their work, and 3) coping with ambiguity and complex ethical problems. The ways that students described their frustrations in these areas highlighted the ways that normative concepts of engineering knowledge and practice conflict with engineering based upon social engagement and welfare.

The data show that hierarchical dualisms in engineering and normative characteristics and conceptions of engineering were still present in student narratives, such as the desire to have clear-cut, universal answers, and referencing the difficulty of engineering as a means of legitimization. This occurred even as students expressed passion about new approaches to engineering that challenged the technocentrism of engineering, and often resulted in feelings of frustration of conflict. Feeling frustrated when learning something new is not necessarily detrimental, but without significant support to process that frustration, students may be turned off from engaging in these kinds of conversations and practices.

However, we also found that social spaces and faculty mentorship were key locations where students could seek support in resolving and coping with these conflicts, as well as establishing their identities as engineers. While we are hesitant to generalize our findings from our study of two programs too broadly to all peace engineering programs, this research indicates that affective support, social support, and the development of socially-engaged engineering communities may serve as important components of peace engineering education. In order to challenge normative conceptions of engineering and change engineering culture, broader education, emotional, and social support for students is needed both inside and outside of the classroom. This is necessary to help resolve conflicts and legitimize alternative engineering knowledge and practice.

Our findings from this study contribute to understanding of areas of resistance as well as processes of assistance regarding students' integration of socially-engaged engineering knowledge. Engineers can play a crucial role in the development of peace and improved global social welfare. Preparing future peace engineers entails not just changing educational materials to include more "social" elements, but also changing engineering culture, supporting students in developing new concepts of engineering knowledge, and helping students to establish their identities as engineers. Preparing a future generation of peace engineers is a daunting endeavor, but one that has potential to bring much benefit to the world.

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