Supporting Engineering Students' Identity Work Regarding their Career Trajectories for a More Humanizing Engineering Future

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Abstract

Undergraduate engineering schools are working towards supporting students to see engineering as a sociotechnical field. As a response to the effort, students vocalize their aspirations for a more humanizing, equitable, and justice-oriented engineering, one that works *with* communities, not *on* them. However, when considering their future career, many of them expressed their concern about the engineering industry being technocentric, capitalist, neglectful of issues of justice, and unattentive to its impact on the communities. The students have to navigate the tensions between their emerging professional engineering identities and their sense of engineering industry culture.

Through the analysis of in-depth interviews with 6 engineering students, I studied the nature of the tensions students experience as part of the identity work they do to figure out their positions in engineering and imagine their future in engineering. I identified 4 themes in these tensions: misalignment in the mission of the work, challenges to finding a role that makes an impact, differences in epistemic commitments, and absence of support in navigating career possibilities.

This study will serve as a foundational step for institutions like engineering schools to make space and design ways to support students' identity work. It also calls for the engineering industry to listen to the voices of to-be engineers and construct a more equitable and humanizing future together with them.

Introduction

> "... while I was off for a year, I was working at [robotics company] and one of the things that they build is like warehouse robots that will basically like displace workers and stuff like that. When I think of engineering, I think heavily about what it is that… like I want out of engineering. Because there are some jobs where, like morally, I'm just like, why would I ever want to work at [defense contractor] and like, make weapons, you know? So there's a lot of stuff with engineering where I'm like, wow I... like really hate. " [Ross, 4th-year Mechanical Engineering student]

Undergraduate engineering schools aim to prepare their students to join the engineering workforce and to see themselves as engineers [1], [2], [3]. In engineering schools, students not only acquire the knowledge and skills necessary for the workforce but they also begin participating in the engineering culture [4], [5], [6]. Students do "identity work" to position and reposition themselves as a certain kind of person in engineering by taking action and forming relationships [7]. Figuring out what kind of career trajectories they want to pursue after university is an important part of their identity work as future engineers. Career considerations require them to engage with the values they construct regarding what engineering is and how they want to participate.

Especially with the increasing emphasis on the sociotechnical aspect of engineering in the curricula [8], [9], [10], students are vocalizing their aspirations for a more humanizing, equitable, and justice-oriented engineering, one that works *with* communities, not *on* them [11]. However, through the contact points with the industry, the industry continues to project images of engineering as technocentric, capitalist, neglectful of justice issues, and unattentive to its impact on the communities [3], [12]. These images leave students to experience tensions between their identities and the industrial culture, as manifested in the above quote of an undergraduate engineering student. They appear to develop a critical eye for the ethical dimensions of different engineering professions and these are often in contrast and conflict with the values students construct while preparing to become an engineer.

In this study, I aim to characterize the tensions engineering students experience when doing identity work related to their future careers. The study is based on a thematic analysis of in-depth interviews with 6 engineering students at a private university in New England. The interview protocol was developed to explore their identity work in engineering school. I seek to understand the nature of engineering students' identity work when they consider their career trajectories and offer engineering schools recommendations for making space and designing ways to support this identity work. I also call for the engineering industry to listen to the voices of future engineers and to construct a more equitable and humanizing future with them, together.

Engineering as a sociotechnical field

Traditionally, engineering has been constructed to be a technical field that is apolitical, and independent from social justice issues [3], [13], [14]. However, due to the historical lack of interest in social justice issues, many engineering designs are created based on assumptions about users, leaving marginalized and oppressed communities to be misrepresented, or even harmed by the designs [11], [15]. Recently, research has demonstrated that engineering practices - choosing which problems to solve, defining the problem space, making design decisions to prioritize certain technical features over others, etc. - are always shaped by cultural norms. The engineers' social and political beliefs are always reflected in their practices and their work [16], [17]. Engineering as a heterogeneous practice should be aware of its entangled social justice issues and work *with* the communities when creating designs [11], [18], [19].

Engineering education is moving towards perceiving engineering as a sociotechnical field not only because of the shifting ideology described above but also because the movement can better engage students' identities, hence broadening participation in engineering [8], [20]. Because engineering has been heavily represented by middle-class White men, students of minoritized groups experience persistent challenges seeing how their identities align with engineering [21], [22], [23], [24]. Students of minoritized groups often conceal and sacrifice their cultural identities in order to navigate stereotypes associated with their characteristics such as race, gender, and class, that undervalue their academic and intellectual credibility [17], [25], [26], [27], [28]. If we are to understand engineering as sociotechnical, then we need to rethink engineering education to include more social, cultural, and historical dimensions of learning. This approach places engineering education within contexts that are personally meaningful and

community-oriented. It encourages young people to bring their cultural ways of knowing into engineering and engage their interests and identities [29], [30], [31], [32].

Many engineering schools started to make efforts to support students in approaching engineering as a sociotechnical activity. For example, Ozkan and Akowa [33] reported on an introductory engineering course where students were asked to wrestle with "real-world problems" and considered the social and technical dimensions of these problem spaces. Baillie and Armstrong [34] studied workshops where engineering students debated about the meaning of words such as "globalization" and "poverty" to make sense of how these concepts affect their engineering work. These efforts seem to have provided a great starting point for engineering students to include their lived experience and reframe engineering as a sociotechnical field.

At the same time, the engineering industry projects itself to be more reluctant to shift to this reframing [11], [12]. There is frequent news in the media about large technology companies prioritizing benefits over the safety of minoritized users, the welfare of their employees, and the well-being of the planet [35], [36], [37]. While the news does not represent the whole engineering industry, it can influence how engineering students perceive what the industry values. This image of the engineering industry being built within a capitalist system [38] and being inattentive to social justice issues begs the question of how engineering students are making sense of their career trajectories as they come to see engineering as sociotechnical. In this study, I apply the lens of identity work to identify the tensions engineering students experience when considering their career trajectories in the engineering industry.

Identity work to negotiate tensions when considering career trajectories

According to the framework of situated learning by Lave and Wenger [39], to learn in a particular community is to engage with the practices of that community and to develop one's identities as a participant in that community. One seeks cues to figure out the narratives of the community, what practices are valued, and what ethical values the community holds [12], [40]. How one develops relationships with the practices and ethical values of the community affects how one's identities align with the community, and how engaged one is with the learning in that community [12], [41], [42]. When one feels that their identities misalign with the narratives of the community, they may negotiate the tension in the misalignment to find their belongings in the community [6]. They do "identity work" to reposition themselves as a certain kind of person in that community by taking action and forming relationships [7], [43], [44].

Identity work helps us characterize the tensions engineering undergraduate students experience when considering their career trajectories. These tensions emerge when the students imagine themselves entering new communities in the engineering industry and trying to figure out what is valued in those communities. The tensions emerge from the identities that the students are developing in engineering school with beliefs that engineering is sociotechnical, and their sense that the culture of the engineering industry disregards social justice issues. I study the nature of engineering students' identity work regarding their career trajectories by characterizing these tensions to contribute to the literature on students' career considerations. I provide implications on how engineering schools can support this identity work, and how the engineering industry should make changes to construct a more equitable future with young people. The study is

guided by the research question: *What is the nature of identity work that engineering students engage with when considering their career trajectories?*

Research methods

Research setting and participant

This study is situated within a larger study aimed at understanding students' identity work in engineering schools. In the larger study, I conducted in-depth semi-structured interviews with 10 engineering students at a middle-sized private university in New England. The interviews included questions such as "What is your relationship with engineering?" and "What do you plan to do after graduation?" During these interviews, 6 out of the 10 students shared the tensions they experienced when thinking about careers. We analyzed the responses of these 6 students and the students were assigned pseudonyms.

The study participants were all recruited from a pool of research assistants and teaching assistants affiliated with engineering education research at the university. Their demographics are documented in Table 1.

Name	**Major**	**Year**	**Gender**	**Race**
Ross	Mechanical engineering	4	Male	White
Samantha	Mechanical engineering	4	Female	White
Sarah	Mechanical engineering	4	Female	White
Andrew	Mechanical engineering	2	Male	White
Rebecca	Mechanical engineering	4	Female	White
Irene	Human Factors Engineering	3	Female	White

Table 1. Demographics of study participants

Data analysis

I first identified segments in all 10 interview transcripts where the students talked about their future careers. Within these segments, I identified the 6 students who expressed tensions they experienced. These tensions were expressed through phrases that carry heavy emotional weight such as "I don't want to," "I hate," or "I can't." I conducted inductive coding to identify topics in each of the students' responses related to these tensions. From the topics, I conducted a thematic analysis to identify 4 themes. Some themes are prominent in multiple students' responses, while others are based on an individual student's responses.

Findings

I identified 4 themes in the tensions students narrated regarding their career trajectories: misalignment in the mission of the work, challenges to finding a role that makes an impact,

differences in epistemic commitments, and absence of support in navigating career possibilities. These themes are not distinct but intertwined with one another.

Misalignment in the mission of the work

As quoted at the beginning of this paper, Ross who was a fourth-year Mechanical Engineering student expressed his unwillingness to work for companies that serve the mission of harming people and communities. He noticed that the work he did at a robotics company displaced warehouse workers without considering its impact on the community. This experience led him to question if his 4-year degree was "for nothing" because he "absolutely hated" his first job. Many companies in the engineering industry were using engineering to do harm, which conflicted with Ross's personal ethical commitments. Later, he interned at a university lab to create educational robots that made him feel "literally awesome." He realized that he could work as a professional engineer that does not do harm to people or communities.

Similar to Ross, Samantha, a fourth-year Mechanical Engineering student, knew that she did not want to work with defense contractors for the mission of creating weapons.

> "In my engineering classes like, I know that I, like don't want to go into defense jobs, which is like what a lot of Mechanical Engineering is. And like, those are the kinds of opportunities that are out there."

Through her experience in engineering classes, Samantha learned that a lot of what Mechanical Engineering does is related to defense, and a lot of the job opportunities for people graduating with Mechanical Engineering degrees are in defense jobs. Instead, she was also steering towards working in engineering education by "combining my technical skills with expanding access to engineering education." She was motivated by her experience in high school where "the engineering classes were not really being diverse" and wanted to support young people of diverse groups to participate in engineering.

Challenges to finding a role that makes an impact

Sarah, a fourth-year Mechanical Engineering student, wanted to work in the field of sustainability and was figuring out what role she wanted in that field.

> "In theory, something like offshore wind should be really interesting to me because it's sustainability, it's engineering. But maybe because I don't know much about it, I'm just like, eh, I don't really wanna do it."

When asked why offshore wind did not interest her, Sarah said,

> "I think I'm still getting over my anti-industry feeling. I still a bit… and I especially used to be like, I'll never work in the industry. Just because my image of it was like working for [a large IT company] and being a tiny person in this giant machine that's not actually doing anything for the world... Which I know is not a fair representation of all industries. But I feel like that's the most vocal part of it. And like, part of what you see online is that."

Sarah held an image that working in a large company means one has to follow the company's directions and work like a small gear in a large system. The work one takes on in a large company is so trivial that it is difficult for one to feel like they are contributing anything to the world. She was aware that this image emerges because of her surrounding cues, like what she sees in the online media, and it may not represent the full picture of reality. However, she still experiences tension between her desire to "use engineering to make the world a better

place" and her image of working in the industry and being unable to feel that her work matters.

At the same time, Sarah learned about a positive case of her peer interning at an engineering company. Sarah thought that in the industry, "you'd just be doing desk work if you are straight out of college." However, the company her peer worked at put his suggestions into the actual design, and "he was actually doing stuff." She was pleasantly surprised to see an example that countered her image of the industry and had hope in searching for a role that supports her to see that her work matters to the community and the world.

Andrew, a second-year Mechanical Engineering student talked about the process of figuring out what he wants to do for his career.

> "Before like my freshman year and probably even earlier this year, I just pretty much figured myself like working for a company I guess, anywhere I could, get a job. (...) And now I feel like, I don't want to do that anymore. I don't really want to work for a random company because I want to do something that would not get done if I didn't do it. You know, I want to be more consequential with what I spend my time doing."

Compared to Ross, Samantha, and Sarah, Andrew was earlier in his journey in engineering school. He has not figured out which specific field or role he wants to pursue. But he had a shift from being ok with any job as long as he has one, to forming ideas of wanting to be in a role that makes a difference. I am not attributing this shift to the education he receives. However, I wanted to highlight that in engineering school, young people may constantly be in the process of figuring out their identities and making sense of what the industry values.

Differences in epistemic commitments

Rebecca, a fourth-year Mechanical Engineering student interned at a robotics company and found that she had to adapt to the company's culture in terms of how she approaches work. In her coursework, Rebecca tends to spend more time than her peers to make sense of the mechanisms of the details of her design. She said, "I tend to, even if I do make a decision, question it and go back to and then be like, okay, I'm going to go down another rabbit hole and analyze this other option." She has an epistemological identity as a sense-maker [45]. However, during her internship, she "had a lot of trouble meeting deadlines" because she spent a lot of time trying to make sense of details in the design. At first, Rebecca hesitated to ask questions because she did not want to show her manager that she was behind. But later, she came to the realization that the manager would rather hear from her than not, and it was ok for her to take longer than more experienced engineers in the company.

Through the internship, Rebecca learned that the epistemic commitments of an engineering school and a company can be different. An engineering school is for its students to learn and spend time making sense of ideas and knowledge, while a company has its budget and priorities for what needs to be done first. A company's epistemic commitment is on how to meet its business goals and the practices in a company are oriented around that commitment. Rebecca felt tension between her epistemological identity as a sense-maker [45] and the company's priorities in their epistemic commitments.

Absence of support in navigating career possibilities.

Irene was a third-year student in Human Factors Engineering having a challenging time crafting her future career trajectory.

> "Human Factors is so broad that it's like, I don't think it's possible to even cover all of that in a class, honestly. Because there's like, I could just go be a Mechanical Engineer with a Human Factors perspective. Like there's anything, almost anything I can do, anything that there's a user involved, yeah I could make a case for. And so, that's really hard."

To Irene, Human Factors Engineering is such a broad field that any work with a user involved can be a potential work that she can make a case for. The curricula are designed so "you know a little bit of everything but you don't know as much as a lot of other people." Therefore, it is challenging for a student in Human Factors Engineering to choose a career. Through taking courses in Mechanical Engineering, Irene found her passion in robotics but was not sure how she could craft her career trajectory in the field with her Human Factors Engineering background. She wanted guidance and support from the professors and the department but was disappointed by what she had been receiving.

> "Professor [name], amazing, really nice guy, has just too much on his plate and he's my major advisor. (...) he's always open to meetings, but he doesn't remember things about you. (...) And he has face blindness and so that's so allowed, but I… I wish that he recognized my name on an E-mail."

Irene expected to consult her major advisor for career advice but was disappointed that her advisor did not remember information about her, not even her name. She did not feel a rapport between her and her advisor for her to discuss her career, which is a sensitive and personal topic.

Discussion and conclusion

In this study, I presented the tensions that 6 engineering students narrated as they were figuring out their career trajectories. These tensions emerged as the students interpreted the values reflected by the engineering industry, and saw a misalignment between those values and their identities. Some students talked about their missions to make a positive impact on their communities and society through their work in engineering. However, a lot of the options for careers they see are either in a defense sector that creates weapons or in companies that do not adequately consider the impact on the communities where their work happens. Other students like Sarah and Andrew talked about their aspirations to work in roles that can make them feel like they are making an impact. In contrast, online media projects the work one takes on in a high-profile large company to be trivial and replaceable. Rebecca adopts the epistemological identity of a sense-maker [45] where she spends time figuring out how things work as she engages in design projects. However, her internship experience let her see that the industry prioritizes epistemic commitments to financial goals over sense-making.

Students carry their identities upon arrival [17], and continue developing these identities in engineering school. The values students interpret in engineering school impact how they develop their identities in engineering. Gonsalves and colleagues [46] documented in their study that engineering students' interpretation of the culture in engineering workplace plays an important part in their identity work in engineering. As engineering education is shifting towards reframing engineering as a sociotechnical field, this study demonstrates that the students develop their

identities along with this reframing to see the values of engineering in contributing to a more just world.

Students interpret the values in the engineering workforce and figuring out how their identities are in position with these values. The students I talked to attempted to interpret the values through information on online media, stories from their peers, and their internship experiences. They found various misalignments between the interpreted values of industry and their values and identities, and these misalignments caused them to feel tension when choosing their future careers. I do not have data on what these students would do with this tension and what they finally decided to do after graduation. However, I imagine that the tensions will prompt the students to do more identity work in figuring out how to position themselves in the values of the industry. They may eventually find jobs whose values align with their identities, or they may take on jobs whose values do not fully align with their identities and "cut off" some of their identities, just as traditionally students of minoritized groups had to sacrifice their cultural identities to "belong" in engineering school [25].

Although the students are doing a lot of challenging identity work regarding their career trajectories, students like Irene do not feel like they are well-supported by their department or engineering school in this work. Through my conversations with students and faculty, I learned that there is a variance in how students are supported in considering their future careers. Some departments have more resources than others. While academic mentorship is a resource all departments provide, different professors treat their roles as academic advisors differently. Some professors make a substantial effort to empathize with the students and provide guidance, while some see mentorship as routine and a chore. This affects students' trust in their advisors and whether they feel safe seeking their advisors' help regarding their career plans.

Implications

From the research standpoint, this study is by no means a comprehensive work on this topic. The students I interviewed share similar characteristics in many aspects. They were all recruited from the pool of research assistants and teaching assistants affiliated with engineering education research at the university, so they may be more aware of the social justice issues in engineering. Most of the students major in Mechanical Engineering and may share targeted views of engineering that are different from students of other engineering majors. All of them identify as White and may not represent students of other racial identities. However, I see the value in reporting the emergent trend to start a conversation in the engineering education field about students' concerns regarding their future career trajectories. This study provides initial findings to suggest that future research on engineering students' career considerations can investigate further into students' identity work negotiating the tensions between their identities and the workforce's projected narratives. As a future study, it will be important to study students of different characteristics to develop a more holistic view of their identity work regarding future careers.

From the perspective of engineering schools designing learning experiences for students, lacking support from engineering schools means that the students have to carry the heavy weight of identity work regarding their career trajectories on their own. They have to seek out resources on their own and rely on the information they encounter to figure out what the engineering industry

values. It may raise equity issues as some students may have access to less cultural capital regarding engineering careers than others because of the communities they engage in. Therefore, I call for the engineering education field to further the study of the nature of engineering students' identity work regarding career trajectories to better support them.

When designing venues to support engineering students' career paths, engineering schools can pay closer attention to the gap students experience between their view of engineering as a sociotechnical field and their image of engineering companies disregarding the sociotechnical aspect of engineering. Engineering companies that work with communities may still be a minority but they do exist, and engineering schools can support the students to learn about these companies and see if their values align.

At the same time, I call for the industry to listen to the voices and aspirations of engineering students who are the to-be-engineers to work towards a more just future. In this study, I saw many engineering students felt pushed away from the traditional engineering industry because they felt their identities did not align with the values of the industry. The students I talked to were especially empathic and thoughtful towards social justice issues. If these students decide to leave, it will leave only those who are already suited to the epistemic and ideological commitments in the engineering industry, hence reinforcing the status quo. Therefore, the engineering industry should take the students' concerns as input if the industry wants to work towards the reframing of engineering as sociotechnical, and the commitment to social justice.

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