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WIP Exploring the Interplay Between Social Identities and Engineering Identity Formation

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Work In Progress: Exploring the Interplay Between Social Identities and Engineering Identity Formation

Introduction

While the study of engineering identity has grown significantly in the last ten years, little research has been conducted about groups in engineering education that are not only high-achieving, but also from low-socioeconomic (low-SES) and first-generation college students (FGCS). The purpose of this work-in-progress study is to investigate the interplay between these social identities and engineering/computing identity. The U.S. Department of Education defines FGCS as individuals whose parents or guardians have not earned a four-year college degree. While definitions of FGCS may vary, this study adopts the Department's classification, recognizing FGCS as students from parents or guardians without a completed four-year degree.

The study was conducted at a university located in a major U.S. Midwestern city. This institution is recognized as a Minority Serving Institution. The institution is research-intensive (R1), with an undergraduate student body that is diverse, primarily commuters, and serves a large population of first-generation college students. Furthermore, the participants in this study are engineering and computer science students who are also part of the Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program. The S-STEM program is a federal effort funded by the National Science Foundation to support low-SES, high-achieving students in their pursuits of STEM degrees. S-STEM program provides comprehensive support through mentorship, financial assistance, academic guidance, and structured activities. In addition to scholarships that alleviate financial burdens, the program offers mentorship from faculty and industry professionals, academic guidance tailored to individual needs, and structured activities designed to foster a sense of belonging, community, and professional identity.

To address these objectives, we aim to answer this research question: How do first-year students reflect on their engineering/computing identity in light of other social identities?

Literature Review

In the last 10 years, engineering identity has become a vastly researched construct in the engineering education community, with much of its foundation rooted in the science identity model [1]. Research on this topic has drawn from various disciplines, including psychology and sociology. Reviews of literature on engineering identity have examined engineering identity as a unilateral framework, with relatively few studies examining its intersections with other dimensions of identity [2]. This growing understanding of engineering identity provides a framework for examining the experience of marginalized identities, including low-SES and FGCS: identities that often intersect with dimensions such as race, ethnicity, and gender. Moreover, Fletcher's and Shryock's systematic review [3], calls for further research on the experiences and identity formation of underrepresented populations.

Historically, people identifying as low-SES and FGCS have been viewed through a deficit lens. Recent scholarship [4], [5], [6], however, has shifted the focus to emphasize these students'

unique strengths and valuable contributions to engineering. Researchers are beginning to unravel the complex factors that shape STEM identity for marginalized students, considering and including the intersection of multiple identities such as race, ethnicity, and gender [1].

Marcos-Bujosa et al. [6] explore the experiences of FGCS in STEM at a predominantly white institution, revealing how social, academic, and professional structures can perpetuate feelings of exclusion and inadequacy. These challenges often lead FGCS to question their ability to succeed. The authors highlight the need for support for FGCS such as creation of first-generation learning communities, summer bridge programs, and peer or faculty mentoring. Similarly, Smith and Lucena [4] examines the funds of knowledge that low-income, first-generation engineering students bring to the field. The authors argue that for these students to feel a sense of belonging, it is crucial for them to integrate their funds of knowledge into the field of engineering. By recognizing and building on the strengths of low-SES and FGCS students, institutions can help bridge the gap between their backgrounds and the demands of engineering education.

Theoretical Framework

In this project, we view engineering identity from both a personal and a social identity perspective [7]. To do so, the framework used in this project incorporates Carlone & Johnson's science identity model [1], specifically their science identity dimensions of performance, recognition, and competence. In addition to these dimensions, we also incorporate a dimension of community to the model. Nestled in the dimensions of identity, we add in aspects of the Model of Multiple Dimensions of Identity (MMDI) [8] to underscore engineering identity as one of many ways of identifying for students as the MMDI includes other ways of identifying such as race, gender, and ethnicity, that are in interaction to each other. Through the addition of MMDI, we can view identity as dynamic and fluid, related to one's core based on the contextual influences and background surrounding the person.

The framework was used throughout the project starting with the conceptualization of the research agenda. Because this framework was previously used in a similar project [5], the authors were able to leverage it to create the interview protocol, inform the purposeful sample for this paper, and guide the data analysis.

Methods

This qualitative study draws primarily from interview data to understand students' lived experiences in relation to the following research question: How do first-year students reflect on their engineering/computing identity in light of other social identities?

Data Collection

Although there are 18 students who consented to this Institutional Review Board approved study, interview data was collected from 17 of them. Students were invited to one semi-structured interview and one online survey. Our analysis focused on the baseline, preliminary results from the semi-structured interviews. The interview was conducted by the second author of this paper. The interview was held on a college campus. The interview questions dealt with students'

perceptions of the engineering field, their engineering journeys, and the four key elements of the framework: recognition, competence, performance, and community. The online survey had a similar focus; however, only the demographic survey data was used for this paper. These data included: parents' highest level of education, pre-college engineering attributes, race, gender, and ethnicity.

Participants

The students invited to participate in this study were also part of the S-STEM program. At the time of the interview, the students had just started college – the interview took place in the first or second week of the Fall 2024 semester. To answer the research question, we used a purposeful sample of participants. The purposeful sample included students who were FGCS, and either a racial/ethnic or gender minoritized group in engineering. Out of 17 students, this yielded a sample of 10 students, all of whom are pursuing a degree in a College of Engineering, which includes computer science degrees. From these 10 students, 5 were chosen for this work-in-progress paper. Out of 5 students, 3 identified as women and 2 as men. Three identified as Latinx/a/o or Hispanic and 2 identified as African American or Black. Pseudonyms were chosen by authors. Additional details about the Summer Bridge Program (SBP) can are shared in a prior dissemination of related work [9].

Data Analysis

The audio-recorded interviews for the five participants included in this study lasted 29 minutes 16 seconds on average. The interview data was transcribed verbatim using the Sonic AI software, and was reviewed by the interviewer to ensure accuracy. Using MAXQDA, the interview data was then individually coded by two of the authors. Inductive coding was done using a robust codebook. This codebook was developed based on the engineering identity development framework guiding the larger project. The two authors then convened to engage in group coding, seeking to resolve any disagreements in their initial coding through discussion. Where there were disagreements, the authors discussed the data block and the respective codes and either applied the code after discussion, or did not apply any codes. After group coding was completed, the two authors completed project summaries for the most prevalent codes in the data. The project summaries were then used to discuss the preliminary findings across all participants, iterating between summaries, raw data connected to the codes, and the research question.

Preliminary Results

There are two prevalent themes that answer the research question: namely, the importance of family/community and access to resources/support. To underscore the connection to engineering identity dimensions, we underline the dimensions in connection to each finding below.

Family and community propel students' engineering journey and identity

Family and community (beyond family) are at the center of students' engineering/computing identity in rooted and positive ways and are often the reason for the pursuit of engineering degrees. As discussed by the students in the study, family is defined primarily as immediate

family, but in some cases also included extended family such as cousins and grandparents. Although community is mentioned and asked about broadly in the interview, students generally defined community to include friends and teachers – all in relation to engineering.

a. There is recognition from family, often alongside performance

Performance is a dimension of engineering identity, defined as the ability to perform related skills. We found that three out of five students felt recognized as engineers by their family members because of their performance of engineering skills. Sometimes students performed engineering skills in the home in front of their family members, and sometimes they did so through structured programs. Abina, a computer engineering major, discusses how her family calls her a tech person, but she sees this as an engineering recognition.

> Abina: Well, my family members. They call me the tech person. They didn't say engineer. They always said I was a tech person. So any, you know, problem they had with their phones, laptops, they'd be like, "give it to [Abina]. She got it, she fixed it." I was like, okay, um, but it was just this, um, you know, when I started college and I was like, okay, I'm actually an engineer, you know?

For Nayeli, she mentions how her cousin changed her social media name to refer to her as engineer after having attended a Zoom presentation where Nayeli presented a game she programmed through a structured program. As these representative quotes encapsulate, students' performance of engineering skills was tied with recognition from family as engineers.

b. Family is part of a student's community in engineering

A person's community in engineering often defines how successful they will be in their career, or how many challenges they will be able to easily overcome. When we asked students about their community in engineering, four out of five mentioned that their family is part of their community. Family members were "motivational" or supportive by providing words of affirmation especially when students were facing challenges. For example, Rogelio, discusses how his mom is motivational, and also how his school counselor was pivotal in helping him to overcome challenges.

> Rogelio: Yeah, I would say, other than my school counselor, I would say no, but my mom is motivational. Right. I guess she motivates me a little bit. Yeah, but other than my school counselor from high school. And I guess the little sprinkles of motivation that my mom gives me from time to time, I would say.

Other students mention family as part of their engineering community in that they can rely on them for support and affirmation. For example, Abina mentions how her cousin "pushes" her anytime she mentions that engineering is "hard," and her mom affirms to her that "you got this." Similarly, Rogelio noted a few instances when his mom encouraged him with "échale ganas," even though she did not understand his engineering coursework. Nayeli mentions that her sister

shares challenges she faces as a graduate student in engineering and Nayeli views those vicariously, framing them as motivational for her given her sister's persistence in engineering.

c. S-STEM community is part of their engineering journey

A students' community in engineering not only includes family members, but also the S-STEM community. At the time of the interview the students had only known each other and other S-STEM members (e.g., staff, faculty) for about 3-4 weeks. All five students included in this study mentioned S-STEM as part of their engineering community. They recalled how they all "come from similar backgrounds," how they are all "so smart," and are there to support each other. Abina and others shared how almost immediately, students set up a group chat to share resources and connect. Sammy mentioned that they "all just clicked," and the environment shared during the Summer Bridge Program was a conducive environment to allow for building of community.

> Sammy: I think that everybody there sort of related to each other…. We were all open. We all came from similar backgrounds, you know, we all have gaps in our knowledge. In some areas…Um, and so when I had conversations with people in the bridge program and like, my roommates talking to them. Um, we all we all just clicked. It was, you know, it was a nice, relaxing environment.

d. There is recognition from S-STEM community, all through SBP

While the environment of the SBP was purposefully created to be one that is supportive, all students noted being recognized as engineers from the S-STEM program. In particular, most students mentioned that the Principal Investigator of the program, who was present during SBP almost daily, gave students "validation" and a sense of accomplishment. Other scholars like Rosalina mention that they were not treated "like kids," instead they were engaged with engineering challenges that they had to solve as a team.

> Rosalina: I would say mainly my [S-STEM] professors. Yeah. I mean, they didn't treat us like kids. They kind of just, like, gave us the stuff and knew that we were doing…They gave us a challenge, like a real-world challenge.

Access (or lack thereof) to resources and support informs the way students identify as engineers

The discussion of resources and support is abundant across all students, and especially in how it informs the way that students identify as engineers. Though the data presented in this section are from different sections of the interview, the majority stem from the question and conversation thereafter about socioeconomic status and how it impacted the student's engineering journey.

a. Performance through structured programs, including free programs

Three out of five students discussed performance through structured programs, one of which included the Summer Bridge Program, others included free programs that were sought out by

family members. Sammy, who was a homeschooled student, discussed how his mom sought out free programs for him to work on his engineering interests, noting that paid programs were not always an option for him and had to make sacrifices (including health) to homeschool him.

> Sammy: I think, I mean, okay, so my parents, because they decided to homeschool me. My mom made the decision to not have a job, and my dad worked extremely hard during my childhood to take care of everybody. Um, so at times it was difficult. And my parents did a very good job of hiding the financial difficulty from me.

Another student discussed being part of a coding program for girls because of her sister, who was also involved in the program and helped the student join. Although structured programs such as the coding program for girls Nayeli participated in are free, they may not be known to all students and in the case of Nayeli only known as a result of the sister. On the other hand, high school curriculum could also serve as a resource for a person's journey into engineering. In the case of the interviewed students; however, only one student discussed access to a computer programming class before college. Performance of engineering skills through these programs and class helped some of these students cement their interest in engineering before college.

b. Support and resources or lack thereof to do engineering are connected to competence

Another way in which resources was discussed among students was in relation to their competence. Three out of five students reported feeling competent because they had access to resources and support through the S-STEM program. For example, Rosalina mentions that the S-STEM program reinforced the support that is provided to students, which made her feel like if she struggles, she can just reach out to someone who will be able to help them.

> Rosalina: feel like I'm capable of it. Um, you know, it's just a long journey, and I know that the professors, um, from S-STEM program to, you know, they have my back. So I think I have a lot of, like, um, support. I do. I do feel like I have a lot of support. So if I do struggle, I'll, like, reach out to them.

Through the S-STEM program, students felt like they had a wealth of resources that they could easily access, and in addition they could share resources among themselves as they began to create their own network of support. This was in contrast to the resources some students were lacking in their academic journey up until college. For example, Nayeli discussed that her high school had less "opportunities" in math and science than other students in the coding program for girls that she attended over the summer.

> Nayeli: And so like when I joined, like those programs, I was like, I was kind of I wasn't as confident because, like, the people around me were from people who actually lived or went to high school, like around here that had more opportunities. And so I felt like they knew more like I felt like they were better.

Moreover, students were keenly aware of the types of financial resources and considerations that may have impacted their engineering journey and specifically their competence, such as their neighborhood, being in "debt" especially due to college costs, and (lack of) access to curricular and extracurricular programs/activities to engage with engineering. Rogelio reflected on his childhood neighborhood and home life, explaining how his desire for his mom to have a "better" life drives his ambition to be "the best."

c. Support entities such as family and S-STEM add to students' confidence to become engineers even when they report a lack of self-identification as engineers

Interestingly, four out of five students when asked if they identify as an engineer, they hesitated and characterized themselves instead as a "striving" engineer or engineering student. However, although they may not yet identify as engineers, their confidence in their abilities to become engineers in the future was undeniable and shows their competence. Such confidence was fueled by supportive entities like their families and the S-STEM program. For example, Nayeli mentions that getting into the S-STEM program makes her feel "more comfort in knowing that [she] will receive that [engineering] title in the future." Similarly, Rogelio echoes that sentiment and adds that through S-STEM he have access to "18 people" that could help them complete their engineering degree—referring to the 18 students in the S-STEM program.

> Nayeli: And it's really, like, nice to know that with getting into, like, the S-STEM program, like it does give you more comfort in knowing that you will receive that [engineering] title in the future, you know, becoming an engineer.

Conclusion

In this work in progress paper, we investigated the engineering journeys of first-year, low-SES, high-achieving undergraduate students in relation to their engineering/computing identity. Our preliminary findings underscore the importance of family/community and of access to resources/support in the way that students identify and are identified as engineers. Family plays a motivational role in pushing students to pursue and persist in engineering, they also play a role in shaping students' engineering journeys either directly (through matriculation in engineering-related free programs) or indirectly (serving as inspiration through community). Like family, the S-STEM program, although very briefly, leaves an impactful mark on students' engineering identity cementing confidence in achieving their engineering degree through performance and recognition. In this paper, we are looking for feedback from the community on connecting these data beyond this sample of students to the rest of our sample (all low-income students) and receiving feedback on the connection between engineering journeys/experiences and identity dimensions. We hope that our preliminary results will be useful to engineering educators in planning or implementing similar programs that target students from low-SES backgrounds.

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