Engineering Identity Profiles of Low-SES, High-Achieving Incoming Engineering Students

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Abstract— **This work-in-progress research paper explores the way in which low-socioeconomic status (SES), first-year undergraduate engineering students develop their engineering identity. Identification with the field of engineering, or engineering identity development, is an ongoing process for students. While scholars have used retrospective studies to understand the developmental aspect of this process, a longitudinal study that follows students' engineering identity development could provide an advantageous viewpoint. In this study, we investigate the engineering identity profiles of incoming low-SES, high-achieving engineering students. We interviewed 13 students using a protocol focused on understanding the students' engineering identity profiles before entering engineering school. An integrated model of engineering identity development was used to frame the research and guide the analysis. Our preliminary results show existing pre-college identity-related patterns across students as well as initial ways of identifying with their major and engineering as a field. This work has contributions to research in the areas of engineering identity development as well as broadening understanding of engineering students who are both low-income and high-achieving. Our work has practical implications for academic and professional support programs for low-income engineering students and programs that aim to support engineering identity development.**

Keywords—engineering identity, low-income students

I. INTRODUCTION

This work is motivated by the need to address underrepresentation of low-socioeconomic status (SES) students in engineering. Professional fields, such as engineering, represent a potential for economic upward mobility for low-SES students. In fact, researchers [1] found that low-SES, high-achieving students may be attracted to the major not only for intellectual and scientific reasons, but also they are attracted by the potential of securing a job after completion of the degree. Financial aid and differential tuition are critical considerations for attending engineering school for low-SES engineering students [2]. While the low-SES student demographic has been historically studied from a deficit perspective, recent efforts [3], [4] have sought to show the assets that low-SES and first-generation students bring to engineering. Similarly, the work presented in this paper takes an asset-based approach to the research by focusing on the engineering identity traits that low-SES students possess.

Engineering identity is a developing construct in the engineering education community. Much of the current scholarly work has been derived from the Science Identity Model [5]. Research on engineering identity has emerged from various academic strands including psychology and sociology. Literature reviews summarizing the emergence of this construct within engineering education have been previously published [6], [7]. Some of the current research interests in this construct include understanding the impact that developing an engineering identity can have on students' outcomes in college and on institutional engineering culture.

Researchers [8], [9] have posited that identifying with engineering and developing an engineering identity can have an impact on a student's persistence and retention in the field. Researchers [10], [11] have also shown that there are various factors (e.g., years in college, type of institution, types of pre-college experiences) that impact the way students identify (or do not) as engineers. This study will focus on two gaps in the literature: longitudinal study of engineering identity and a focus on low-SES, high-achieving students. In this paper, we present a baseline understanding – engineering identity profiles – of identification with the field of engineering for pre-college, low-SES, high-achieving students. The engineering identity profiles presented in this paper offer a summary view of what constitutes identification with the field of engineering for these students during the pre-college stage of their engineering identity development. These profiles will serve as a baseline for the longitudinal study.

The categorization of low-SES students was determined by a student's FAFSA Expected Family Contribution. The categorization of high-achieving was determined by a combination of SAT/ACT scores and High School GPA wherein High School GPA was weighted higher than the SAT/ACT score. Further information on the categorization of

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low-SES and high-achieving students was published by the authors in [12].

II. Theoretical Framework

This work is guided by the theoretical framework presented in Figure 1. This framework is a combination of the Science Identity Model by [5], Model of Multiple Dimensions of Identity (MMDI) by [13], and the Community engineering identity dimensions by [14].

At the outset of the framework, following work by [5], we posit that recognition, competence, and performance are important pre-college tenets for engineering identity development. Similarly, we add community – being part of a community of engineers – as an important tenet for the same goal. According to [5], recognition is the most critical tenet of the Science Identity Model and it captures "recognizing oneself and getting recognized by others as a 'science person.'" Performance captures "social performances of relevant scientific practices." Competence captures "knowledges and understanding of science content" that "may be less publicly visible than performance." Community captures the group(s) of individuals that create an environment conducive to engineering identity development.

Nestled inside the identity tenets (i.e., recognition, performance, competence, and community), we place the MMDI and posit that engineering identity is one of many ways of identifying and play a role in the development of an engineering identity. The MMDI offers an understanding of college student identity development that is contextual and fluid. In particular, at the center of MMDI is the core of "self" that remains unchanged regardless of the context (e.g., sociocultural conditions, current experiences). Ways of identifying (e.g., race, sex, religion) surround the core, cannot be understood in isolation, and their salience can change based on the context. Previous research [15] has used the MMDI to understand engineering identity development alongside other ways of identifying (e.g., race, ethnicity, gender).

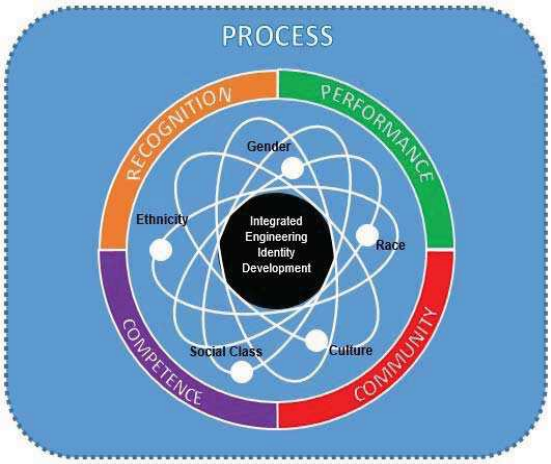

Fig. 1. Integrated Engineering Identity Development Framework

III. Methods

This research study aims to address the larger research question: How do low-SES, high-achieving engineering students develop their engineering identity over time? In this paper, we focus on the baseline, preliminary results from semi-structured interviews conducted with 13 incoming, undergraduate engineering students. The interviews were used to provide an understanding of students' identification with the field of engineering before they entered their engineering programs. The data gathered via the interviews served to develop the engineering identity profiles for these students. These profiles are presented in the Preliminary Results section.

At the time of the interviews, the student participants were part of a summer bridge program to transition into the university. Further information about the summer bridge program can be found in [16]. The university is a Minority Serving Institution, both a Hispanic Serving Institution and an Asian American and Native American Pacific Islander Serving Institution, located in an urban setting. The majority of College of Engineering students at the institution are non-residential.

The audio-recorded interviews were conducted in the summer of 2018 and on average lasted ~28 minutes. Questions for the interview protocol were developed using the theoretical framework that drives the larger project. Questions centered around students' views of the field of engineering, pre-college experiences aligned with engineering, and four main tenets of the framework: recognition, competence, performance, and community.

Interview data were transcribed verbatim and the MAXQDA Software was used for individual and team-based data analysis. Three of the authors analyzed all of the transcriptions individually using inductive coding guided by the integrated engineering identity development framework that drives the larger project. The same authors met as a team to discuss agreements and disagreements in initial, individual coding and to develop a robust coding book. So far in this work-in-progress, the team has completed two rounds of team-based analysis and has developed a codebook that is saturated

enough to show preliminary results. A sample codebook is shown in Table I.

TABLE I. SAMPLE CODEBOOK

Code	Description	Engineering Identity Profile
Capability as self-improvement	Students express feeling a sense of competence or capability because they feel they can improve upon their engineering skills	Competence as Self-Improvement
"Building stuff"	In-vivo code — Students discuss activities where they built something (e.g., robots, Lego sets, towers made from household materials) as examples of their engineering skills	Extracurriculars and "Building or Fixing Stuff"
Community in high school	Students discuss their high school groups (e.g., study groups, student clubs) that made up their community of engineers	Supportive Communities Without Engineers
Recognizing self in others	Students discuss recognizing themselves as engineers in others who are engineers (e.g., mentors, teachers, family members)	Self-Recognition, Teachers, and Family

IV. LIMITATIONS

While this study is still preliminary and a work-in-progress, there are limitations that constrain the transferability of the results presented. This study was conducted at only one institution and the results are only abstracted from one-time interviews. In the future, we plan to provide results from the larger, longitudinal study. We are collecting data annually and plan to present those results at a later date. Yet, we argue that the baseline results provide an important insight into profiles of engineering identity for students who are incoming, low-SES, high-achieving students. Additionally, we acknowledge that focusing on low-SES, high-achieving students provides only a partial understanding of low-SES students. Undoubtedly, many more students, beyond those studied here and beyond those that fit within the "high-achieving" categorization, are in fact high-achieving, but may not be classified as such because of educational structural barriers.

V. PRELIMINARY RESULTS

The ways in which the students conceptualized their engineering identity provides an insight into the understanding of their pre-college engineering identity. The engineering identity profiles for these students were analyzed through the lens of the integrated framework presented in Fig. 1. As such, we found that the engineering identity tenets of competence, recognition, performance, and community are evident in these pre-college students though in re-conceptualized ways that enhance upon the Science Identity Model from [5].

A. Competence as Potential and Improvement

While all of the students who were interviewed were categorized as "high-achieving," a representative sample discussed their competence in engineering as potential for the field or as the capability for improvement. Further, the students equated their potential and capability for improvement to engineer's characteristic and one that they already possessed. As a representative example, the student quoted below discusses competence as a process of learning by "trial and error."

> *Even if I don't even know how to fix it I like to learn on my own and I feel like that's what engineers do…Even if they don't know how to fix or don't know how to work on something they will learn along the way through trial error and failure. –Student, June 18, 1*

At the time of the interview, the students had not taken any courses at the engineering school they would attend and as such there was no GPA to be used for the analysis of competence, as was done in [1].

B. Self-Recognition, Teachers, and Family

All except for one student recognized themselves as an engineer at the time of the interview. The student who did not recognize himself as an engineer shared that he realized that many of his engineering peers in the summer bridge program had academic and other pre-college opportunities that he did not have. To note is that the pre-college academic profile (GPA and ACT/SAT score) of this student was not different from his peers.

In addition to recognizing themselves as engineers, all of the students had at least one teacher or family member, including parents, siblings, aunts/uncles, grandparents, who recognized them as engineers. Others recognized these students' perceived potential to succeed in engineering because of the skills that they exhibited in school (pre-college) and at home. As an example, the student quoted below discusses how their parents seek their help for "fix[ing] problems" around the house.

> *They [parents], they've always looked at me like an engineer 'cause I've always helped them fix problems and I've always been there for them…in like if they've ever had a problem they can count on me to, to fix. –Student, June 16, 2*

For these high-achieving, pre-college students, teachers may be one of the first points of recognition in their educational journeys outside of their family. Students shared being told words of recognition by teachers in science and mathematics classes such as "I think that engineering is right for you."

C. Extracurriculars and "Building or Fixing Stuff"

Students performed their engineering identity primarily through extracurriculars or work, however, these activities were not always directly related to engineering (e.g., music club, volunteering at museums) and sometimes through classes. While we did not examine the types of resources available at high schools these students attended, the vast majority did not mention having access to engineering classes in their high schools.

Another way in which these students performed their engineering identity was through building or fixing stuff. As a representative quote, the student quoted discusses performing their perceived engineering skills at work in a supermarket.

> *So sometime equipment did break down and I had to. Uh, I was one of the youngest people working at the supermarket so many of the older people there didn't understand um how things worked because they'd always been, always working in supermarkets all their life. If anything broke, if they couldn't figure it out themselves they'd usually get me. – Student, June 18, 1*

D. Supportive Communities Without Engineers

All students expressed having communities around them that supported their pursuit of engineering. However, only one student had a community that included engineers before college. For almost all of the students, the summer bridge program that they were a part of during the time of the interview was the first time that their community – group of people supporting and following a similar goal – was primarily composed of engineers and/or engineering students. While some of them had met engineers before college, only one had engineers who were part of their community. In this student's case, his parents were engineers. For the rest of the students interviewed, their supportive engineering communities consisted of math and science classmates and family members.

VI. Discussion

The intersection of low-SES and high-achieving characteristics that, in some ways, define these students may be evident in the ways they exhibit their engineering identity. In particular, students re-defining competence as something that they already possess and as a process of improvement rather than as a terminal (e.g., having an engineering diploma) or tangible marker [17]. Also, all of these students recognized themselves as engineers or aspiring engineers and demonstrated many ways in which they performed skills that they deemed to be engineering skills. All the while, they identified communities, albeit the majority did not have engineers as part of those communities, that were supportive in their educational journeys and pursuit of an engineering degree.

VII. Future Work

Moving forward with this work-in-progress, we are working on another round of team-based data analysis to develop a robust coding book that provides a more nuanced understanding of the results. Part of this nuanced understanding will be achieved by incorporating the second part of the Integrated Engineering Identity Development Framework – namely, other ways of identifying (e.g., gender, race, social class) as they relate to engineering identity.

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