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Low-Income, High-Achieving Students and Their Engineering Identity Development After One Year of Engineering School

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Low-income, High-Achieving Students and their Engineering Identity Development After One Year of Engineering School

Abstract

This complete research paper is a part of longitudinal study that investigates how low-income, high-achieving engineering students develop their engineering identity over the period of their first year of undergraduate education. This longitudinal study that follows students' engineering identity development provides a valuable and a perspective alternate to retrospective studies of engineering identity. This study uses semi-structured interviews to examine how students self-identify and are identified as engineers. An integrated model of engineering identity development was used to frame the research and guide the analysis. The results show that all model dimensions of engineering identity (i.e., community, recognition, performance, and competence) played a role in the students' engineering identity development. 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

Context

The motivation for this study is informed by the need to address the well-documented underrepresentation of low-socioeconomic status (SES) and minoritized students in engineering and other related careers [1]–[3]. Researchers advanced that, in addition to intellectual and scientific reasons, low-income students are attracted to the major by the potential prospect of employment after completing a degree [1], [4]. Financial considerations are critical for low-SES engineering students; this includes considerations of financial aid and differential tuition [5]. Programs such as the National Science Foundation Scholarships in STEM (S-STEM) have been implemented to address financial assistance of low-SES students. This study is part of a longitudinal five-year S-STEM project investigating low-income, high-achieving students' engineering identity development.

All the participants in this study are part of a program that provides financial, academic, professional, and social support. The students accepted into the program and invited to participate in this study are considered low-income and high-achieving. Low-income status was determined by a combination of Pell-grant eligibility, Estimated Family Contribution calculated from by FAFSA, and percentage of financial unmet needs at the institution of matriculation. The high achievement was determined using a combination of students' high school GPA and SAT/ACT scores, where the student's high school GPA was weighed higher.

Historically, researchers have used a deficit lens to study students from a low-SES demographic. For instance, cultural capital and social capital researchers attribute school success and failure to children's cultural and social resources [6]–[8]. Lamont and Lareau [9, p. 156] describe cultural capital as "institutionalized, i.e., widely shared, high status cultural signals, (attitudes preferences, formal knowledge, behaviors, goods, and credentials) used for social and cultural exclusion, the formal [social exclusion] referring to exclusion from jobs and resources, and the latter [cultural exclusion], to exclusion from high status groups." Researchers using cultural capital theory to study students from a low-income demographic often focus on how the lack of social and cultural resources correlates to their academic failure and lack of resilience. Similar to the cultural capital theorists, the stereotype researchers [10]–[12] study the minoritized group through the deficit lens by studying the negative effect of racist stereotypes on the group. In contrast to these views, this study employed an asset-based approach [13], [14] to analyze the students' engineering identity development. In this value-added approach, [15, p. 69] argues for an anti-deficit inquiry in studying how low-income high achieving students "cultivate meaningful and value-added relationships with STEM faculty and well-connected others in their fields." The conceptual framework used in this study is driven by this approach and is discussed in the next section [4].

Literature Review

Research on engineering identity emerged from various academic strands, including psychology and sociology. Identity in this study is defined as "being recognized as a certain 'kind of person' in a given context" [16, p.99]. The given context focuses on individual social performances rather than their uniqueness as a person. In addition to being recognized by others, self-recognition is also included within our definition of identity. Reviews of literature that summarize this construct's emergence within engineering education have been previously published [17], [18]. Identity as a construct has been used to study engineering students in different ways:

i. students' diversity in engineering [19], [20]. Godwin [19] explored latent diversity approach as a complementary focus for diversity research that focuses on the students' nonvisible identities (experiences, attitudes, mindsets, and innovation) to address the lack of diverse ways of thinking necessary to solve multifarious problems currently missing in engineering. Foor, Walden, and Trytten [20] studied how an individual diversity—the breadth of experience of a single individual with multiple observable identities can be used in research to disrupt the transmitters of dominant culture of engineering existing in higher institutions,
ii. engineering students' identity development and its influence on their learning [3], [21]–[23]. Some of the current research interests include understanding the impact of developing an engineering identity on students' outcomes in high school leading to college and on institutional engineering culture [24], [25]. Researchers have posited that identifying with engineering and developing an engineering identity can impact students' persistence and retention in the field [17], [26], [22]. The authors [17, 21, 22] list interest in and positive attitude to STEM fields, sense of belonging, and preparedness as factors that could influence students' persistence and retention. Overall, belongingness mediates between students' identity and persistence.

Similarly, other studies showed 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 [4], [26]. These studies [4], [26] indicate that the number of years in school, high school experiences, and early exposure to science and engineering factor in students' identity as engineers. The way students identify as engineers has also been linked to culture via Community Cultural Wealth [28]. According to [29], community cultural wealth includes familial, cultural, linguistic, aspirational capital, and role modeling. The model of community cultural wealth provides dimensions of understanding engineering identity previously absent in the engineering education scholarship [28], [29].

The literature gaps that this study seeks to address include a longitudinal, asset-based study of engineering identity of low income, high-achieving students [30]. Low-income and high achieving students have been studied extensively often from a deficit lens. However, there has been less focus on low-income, high achieving students in engineering literature. There is a need for more studies on academically successful low-income students from an asset-based lens to understand the factors that contribute to their success and how they develop their engineering identity. This research seeks to address this gap with the contributions that this longitudinal, asset-based study on low-income, high achieving students will add into the field of engineering

Conceptual Framework

This study was guided by an integrated engineering identity conceptual framework including the science identity model [31], the model of multiple dimensions of identity, the model of multiple dimensions of identity [32], and aspects of community-based dimensions of engineering identity [4]. The science identity model posits that recognition, competence, and performance are important principles for engineering identity development. There are four interrelated dimensions of science identity in this integrated model (see figure 1), combined with other identities (e.g., gender, religion, ethnicity) that students develop in a fluid and dynamic way that shapes their engineering identity [32]. Carlone and Johnson's science identity model [31] has been used as the basis to develop a construct for engineering identity development within the engineering education community. The science identity model advances that science identity develops intersectional and over time. Research on engineering identity emerged from various academic strands, including psychology and sociology. The definition of identity in this study is viewed through the social lens. Identity is defined as "being recognized as a certain 'kind of person' in a given context" [16, p.99]. The given context focuses on individual social performances rather than their uniqueness as a person. Our context is this study is specific to engineering and how students self-described and are seen within the context of engineering.

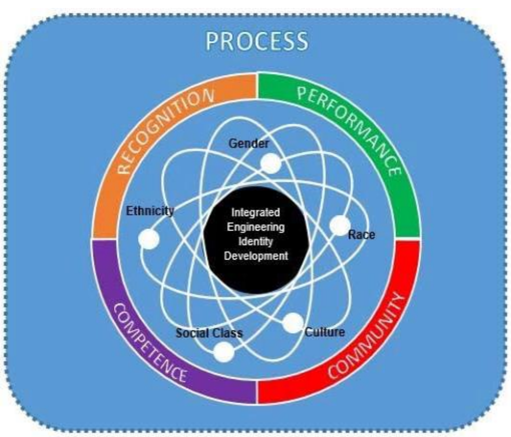

Fig. 1. Integrated Engineering Identity Development Framework

At the outset of the framework, following the work by [31], we posit that recognition, competence, and performance are essential pre-college tenets for engineering identity development [24], [33] Similarly, we add community—being part of a community of engineers – as an important tenet for the same goal. According to Carlone and Johnson [31], 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" [p.1191]. Performance captures "social performances of relevant scientific practices" [1191]. Competence captures "knowledges and understanding of science content" that "may be less publicly visible than performance" [1191]. Community captures the group(s) of individuals that create an environment conducive to engineering identity development [29]

Nestled inside the identity tenets (i.e., recognition, performance, competence, and community), we place the Model of Multiple Dimensions of Identity (MMDI) and posit that engineering dimensions are interconnected with other forms of identifying (e.g., race, gender, ethnicity) in the development of 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., socio-cultural 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 [32], [34] has used the MMDI to understand engineering identity development alongside other ways of identifying (e.g., race, ethnicity, gender).

Methods

In this paper, we built on the baseline understanding of engineering identity profiles and identification with the field developed from the analysis of the pre-college interviews of cohort One during year 0 with the interview analysis at the end of year one. The results presented in this paper will provide a preliminary analysis of how engineering identity changes after being exposed to a full year of university.

Data

This study implements one-on-one semi-structured interviews of undergraduate students as the analysis items, focusing on the interviews conducted before (year 0) and after the cohort's first year in college (year 1). The flexibility of semi-structured interviews help generate relevant follow-up questions during the interviews and finetune the following protocol interview for a richer data collection [35].

Both interview protocols were developed using the Integrated Engineering Identity Development Framework [fig. 1]. There were eight driving questions in the first protocol with five sub-questions. The eight driving questions addressed the four engineering identity dimensions (i.e., recognition, competence, performance, community). In the second interview, the driving questions remained, but more questions were raised because of the findings from the first data analysis and 15 sub-questions were added to the protocol. Most of the questions in the second protocol overlapped with the first.

The protocols were tested by an undergraduate student representative of the study sample participants. The interviewers raised other follow-up questions based on the responses of the interviewees asking for clarifications and details sometimes made possible by the nature of semi-structure interview [36].

The study participants participated in two interviews, in summer 2018 and summer 2019. The baseline round of interviews (summer 2018) included 13 students. The interview was conducted after the participants completed a Summer Bridge Program, an interdisciplinary support program aimed to prepare incoming scholars through evidence-based activities for a smooth transition to college in the fall [34],[37]. All of the participants were interviewed again in summer 2019; however, only 11 students were available to participate, and 1 interview was lost due to audio difficulties. In total, 10 of the 13 original participants interviews were recorded and utilized for the second interview (summer 2019). The average length for both interviews was 35 minutes.

This study is situated in a university—a Minority Serving Institution, 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.

Analysis

The engineering identity profiles for the students after year 1 were analyzed through the integrated framework's lens presented in Fig. 1. The interviews were transcribed verbatim and imported to MAXQDA software for analysis. Four of the authors analyzed the interviews individually using deductive coding analysis guided by the framework and a codebook from the baseline interviews with the same cohort of students, as reported in [4]. The same authors performed two cycles of group coding to achieve consensus on instances and the meaning of codes. In the second cycle of coding, we began discussing patterns in the data, developing categories, and discussing nuances in the categories created. Consequently, we developed themes around these categories and connected them to past literature that resulted in the findings discussed in this paper. Examples of some of the codes are illustrated in Table 1 below.

TABLE 1 Sample Codebook for Year 1 Interviews

Code	Description
Support from others	The students' sense of self-competence here dependent on external expectations
Engineering mindset	Students discuss applying their engineering skills both in conventional and unconventional contexts
Community of friends	The community as described by the students is academic, peers taking the same courses in the same academic level.

Lack of self-recognition	Students list some reasons for lack of self-recognition – being beginning engineers with lack of engineering course work, projects, and experience

Results

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 current understandings of engineering identity development. All the dimensions of engineering identity (i.e., community, recognition, performance, and competence) played a role in the student's engineering identity development [31]. During year 0 all students self-recognized as engineers or aspiring engineers, but after year 1, only half of the students interviewed recognized themselves as engineers, having been exposed to some basic and core engineering classes. Nevertheless, some considered themselves as engineering students/engineers-in-training. But all students except one felt competent in their pursuit of an engineering degree. Family and peers served as the primary sources of recognition for these students. Notably, people who are deemed experts in the field (e.g., engineering faculty) are missing sources of recognition in the students' engineering trajectories. For students who identified as women, they mention clear intersections of gender identity and engineering identity. Also, two major influences for students' engineering identity development were their socioeconomic status and their family.

After one year of undergraduate school, students continue to identify with engineering as they feel competent in the field via performance in courses and are recognized as engineers by others.

A. *Competence as Acquirable*

The traditional conceptualization of competence as a dimension of engineering identity depends on tangible identity markers such as receiving an engineering diploma or engineering licensure. Nevertheless, we found that students continue to view competence as acquirable and accessed via resources.

While students felt competent in their abilities to pursue an engineering degree, they described competence as individual knowledge and understanding of engineering and access to resources. These resources were described as people (e.g., advisors, tutors), and as non-human resources (e.g., libraries, relevant laboratories, tutorials). Having access to resources made them feel competent and confident in themselves in the present and in their future. Often students conflated competence with confidence, which we plan to discuss in a separate study, but in general, students felt like competent learners. Therefore, they felt confident they can become engineers in the long run. Access to resources made sense as contributing factors to students' competence—they impact the students' confidence in their ability to succeed as engineers, as seen below.

> *And the fact that with my group [SBP Summer Bridge Group], that there's always someone to fall back on. And that there's always people who actually do care or look out for you. I know there are some people in SBP who are not doing well--yeah I don't want to get into that. But they--we look out for them because we all came in together, we want all of us to finish together. Like that.* Dominic, Civil Engineering, Year 1

At the end of the first year of exposure to engineering or general courses, there is a shift in the students' narratives of their identity to what we described as dependent perceptions of self-competence: how students compare their competence to their peers. Most of the students shifted from capacity for improvement to confidence in coursework. This students' perception of competence was centered on external expectations based on academic success in coursework and peers' performance—

> *At this point I would say I feel very competent being an engineer even though I don't have much of the knowledge that a lot of engineers in the world do have. I feel like I'm on the right track to be a competent engineer. So, at my level, I feel as though I am a competent engineer. People that are around me, there are people around me that are taking the same classes, I feel like I'm at the same level as them to be-- or at the same level as competent as them as being an engineer.* Diego, Mechanical Engineering Student, Year 1

> *Feeling competent in something is knowing...the material enough that you don't need help from an instructor. Like you know, like if you're given a problem, with your notes you're able to solve it. If they ask you a different question that they don't have in lecture, like you're able to figure it out as you go through it. Like you understand the material well enough where you don't need someone to help you. And like for the rest of the classes, I can do that.* Emily, Civil Engineering Students, Year 1

B. Decline in Self-Recognition

In their year 0 interviews, all students had self-recognized as engineers. However, by the end of their freshman year, most students no longer self-recognized as engineers. As seen in the quote below, after one year of engineering school, the students qualify themselves as engineering students, but not as engineers. In the first year of college, students gained a perception that they lacked the qualifications to identify as engineers. These qualifications to self-identify depended on having "engineered something." The students' descriptions of an engineer include "someone who creates, engineers, solve problems," among others. To the students, "engineered something" is synonymous to inventing or creating something.

> *I would say...as an engineering student...no. I'm not a qualified engineer. I'm not sure anyone can be an engineer if they haven't engineered something. If they didn't build something or design something. Just a--maybe not an official one. Paulina Mechanical Engineering,* Year 1

Further, we found differences in change of self-recognition between men and women. Students who identified as women had no longer self-recognized as engineers, and only half of the students who identified as men self-recognized as engineers. The quotation below is from a student who self-recognized as an engineer before college, and after one year in college, no longer self-recognize as an engineer.

> *I'm definitely getting there (laughs). But I think I still need to accumulate some more of my own technical skills and develop more of my analytical thinking and problem solving to really be able to put forth my best solutions and opinions.* Kate, Computer Science, Year 1

Recognition from others (family, academic space, and peers) continues to exist, but this does not include faculty or non-peer engineers. Though satisfactory to the students, some of this recognition, they expressed that it did not carry much weight because of the person doing the recognizing. As expressed by the student quoted below, the little brother recognizes the student as an engineer.

> *Probably my little brother. Because he doesn't. He's always like, "oh, you're an engineer." But I don't think he knows what that means. But he's just really excited. He's like, "oh, you're an engineer." Because we don't have engineers in my family. We're the first generation. So we don't...we have my sister who's a finance major. She's graduating this semester. So we have that. So that's very exciting. But like an engineer. I feel like this society values it more. So he's like "oh, like you're an engineer." But he doesn't really know. So I'd consider my little brother, to some level.* Computer Science, Year 1

C. *Performance via Use of Inter- and Intra-personal Engineering Skills*

Some students took general education courses that were not related to their core courses. Nevertheless, they all took a general engineering course that gave them an overview of the program and introduced them to engineers from various fields as guest speakers. Such students who took general education courses are less exposed to engineering concepts in terms of quantity and rigor of course work at this point. As a result, most of them gave non-conventional examples of engineering performance such as volunteering work or baby-sitting. Their description of engineering performance was close to their definitions of engineers as "problem solvers" or people who come up with solutions by "thinking outside the box." We asked the students for examples of when they have used their engineering skills to gauge performance. Below are examples of non-conventional ways in which students conceptualize engineering performance as using skills such as optimization,

> *Probably when babysitting, which is probably not a very conventional answer, but when you're working with small children, umm, unexpected things can happen, and you have to learn kind of how to think on the spot the best way to solve the problem. Umm. The best way to occupy the time -- a good game for them to play or something like that. Best way to convince them to eat their vegetables (chuckles). So. Umm. Thinking outside the box and coming up with solutions that other people might not. Kind of helps with that.* Kate, Computer Science Student, Year 1

The perspective of engineering as a profession gained from ENG 100 (an introduction to engineering class), by the following students, even though the first is yet to take any of his core courses toward a degree in civil engineering, he understands that both inter- and intra-personal skills are vital engineering skills-

> *Like, you work alongside teams. Like, that's the whole point. You have to work with others. And I work well with other people. So I'm like, "okay, this shouldn't be that hard." But like, umm. At least in my major--civil--I want to go into environmental engineering and I hope in the future I am able to like, not only to communicate with peers in this country, but like, global. So we can find a problem. Because climate change is going to affect everyone. And it's affecting--I'm from El Salvador, and that a third world country. Like, I feel like third countries, they're going to be hit the hardest. So we have to talk to the engineers over there. We have to work alongside everyone.* Emily, Civil Engineering student, Year 1

> *Engineers have to be collaborative. Because in my --I'm a civil engineer and I was an ME course, and those skills were very --seemed very relevant. And I talked with my mentor about that. But umm. I enjoyed the interdisciplinary aspect of it. Because I know it's something that happens a lot in the real world. You go to your job and you'll be working with a lot of different kinds of engineers. Especially if I did pursue research and researching with all kinds of engineers on different projects that are happening. There's a lot of collaboration. I would also say...building to be fluid and... adapt to change...because sometimes your environment throws things at you that you --if you don't change, you're going to fail or you're going to fall behind. So, you need to be adaptable to the world around you. The environment. The people you need.* Harper, Mechanical Engineering student, Year 1

Some students on the other hand, were immersed in core engineering courses in the first year with full exposure in class projects, lab work, interactions with professors, graduate students and internship. This exposure provided such students platform to perform some engineering related work which help to describe engineering performance with suitable examples. These students had opportunities to engage in relevant scientific activities with others as their engineering is socially constructed, as clearly indicated by the following quote.

> *I joined the Biomedical Engineering Society, and I was able to use Inventor and like SolidWorks to work on a prosthetics hand. I worked on the thumb part of the hand which needed a revolver. So, we came up --me and the main person working on it, Christian--worked on the thumb because that was the most difficult part.* Ahmed, Bio Engineering, Year 1

D. Engineering as Community of Peers

Community continued to be vital for the students in their engineering identity. After the first year of undergraduate work, all the students interviewed identified as being a part of an engineering community. At a closer look at what constitutes community for the students, we saw a horizontal community made up of fellow engineering students. These communities have academic components such as working together on collaborative coursework or studying together. For most students, these communities were also described as friend relationships that were more personal than purely academic or professional in nature, creating an overlap between social and academic groups. Considering that these student communities were heavily academic in orientation, it was notable that faculty, staff, and graduate students were missing from nearly every student's engineering communities. Notably missing in nearly all student interviews (except one) was participating in an on-campus student engineering society/organization. This is probably because most of the participants are commuters. They are yet to create an engineering community outside of their horizon or self-integrate into existing engineering societies. Nevertheless, their current community was vital as they motivate and encourage one another as shown below.

> *Because we [*the student*s] all do the same thing. We have similar goals, so we motivate each other to do homework. Sometimes we can help each other if we're in the same courses. This is a perfect community that...doesn't drive me away from my work. Which, I probably wouldn't pick a community that takes me away. Paulina, Mechanical Engineering, Year 1*

The academic environment is new and unfamiliar to the students. Students adapt to their new environment by developing plans that will help them thrive. According to [Tate], students affiliate and identify with on-campus groups that help them make sense of the larger setting. Sometimes, these groups are given or already exist as social and academic groups to "provide academic, emotional and cultural support" [p. 484] to the students as being part of the same cohort within the S-STEM program. The shift in community from year 0 to year 1 was from having a prescribed engineering community to gaining community in engineering with engineering people (other engineering students). The students see the community where the members have shared experiences and goals. This sounds comforting as seen below.

> *It's supposed to be hard. That we're supposed to struggle. So, I get comfort in that. We're* [students] *all facing the same kind of issues and we're all kind of going through it together. And like, when we talk about it, we'll like to understand each other and what we're going through. So that's the talking about and understanding that we all are going through this together is kind of the most helpful part because if you didn't have that I feel like. Myself. Because I have anxiety, I'd just have greater anxiety about it because I can't -- I feel like I'm the only one in the world doing it. But now since I have this group, the anxiety lessens. Diana, Industrial Engineering student,* Year 1

Discussion

Our goal was to investigate how low-income, high-achieving engineering students develop their engineering identities throughout their undergraduate education. In this paper, we analyzed data collected from the first cohort in an S-STEM program to examine their engineering identity development from year 0 to year 1. The most significant trend we noticed is the lack of self-recognition as engineers. Also, the first-year exposure to engineering courses led to changes in students' definitions of engineers and the way they view their competence, as we explained below.

The steep decline in self-recognition as engineers from pre-college to the first year of engineering school was notable. We hypothesize that the significant changes in the environment and academic position (end of their high school career vs. the first year of their college career) may have played a role in this abrupt change. In their first year of engineering school, students absorb messages and experiences that help them better understand a prescribed engineering path for success (e.g., rigid engineering curricula, expectation of extra-curricular activities). This finding supports a previous study [22] that suggests that educational progression levels how students self-identify as engineering students. The danger in a prescribed path is that this translates into a dip in students' self-recognition. In other words, after one year of engineering school, they realize how much more they have to achieve (e.g., coursework, internships, practicum, project experience) before they can "become engineers." Instead, we would advocate for messaging that meets students where they are and acknowledges their current skills set and knowledge. If this decline proves to be a consistent phenomenon throughout engineering school, intervening to reduce or prevent a decline in self-recognition may help better facilitate engineering identity development.

Engineering organizations were missing from these interviewees' engineering communities despite close proximity. This is not surprising at this stage and level of students' education. Future research may want to explore the reason the students did not identify with engineering organizations should it continue. The academic environment is new and unfamiliar to the students. Students adapt to their new environment by developing plans that will help them thrive. According to [38, p. 484], students affiliate and identify with on-campus groups that help them make sense of the larger university setting. Sometimes, these groups are given or already exist as social and academic groups to "provide academic, emotional and cultural support" to the students. In year 0, students identified belonging to communities that support their engineering education, however, the majority did not include engineers in those communities. In year 1, students' engineering communities were made up mostly of peers in engineering, including prescribed communities/groups such as their S-STEM cohort.

These findings suggest that a more concerted effort to facilitate the engineering community between undergraduate students and faculty in addition to graduate students may help to expand the engineering community of undergraduate students. Faculty and graduate students were also missing as recognition sources for students—recognition being the essential belief of the science identity model [39]. Study showed that faculty integration was vital to students' engineering identity. Vogt [39] suggested that academic integration had a positive effect on self-efficacy which in turn had a strong positive effect on students' effort and critical thinking. More efforts should focus on expanding first year students' community to include both faculty and graduate students beyond students' classes to include mentoring and advising to enhance their development [40]. Also Newman [14] findings suggested that faculty referral to other opportunities, students' involvement in faculty research laboratories, and career related internship encourage students from under represented group to persist in their respective majors. Another area for community growth includes engineers from industry or non-academic spheres. For example, [41] showed that communities of practice play a key role in career and identity development.

Coursework is a significant source of learning and exposure to engineering skills and concepts for many first-year undergraduate students. We found that the interviewees often identify course-related work as examples of them performing engineering. As previously mentioned, many of these students no longer self-identified as engineers, and many students cited needing more engineering experience to self-identify as an engineer. Therefore, it may be salient to align engineering course content with how students identify engineers: content that more closely aligns with improving the world, helping individuals, and solving problems. It should also be noted that few of the students had the opportunity for a summer internship on campus and with a few industries. However, there is a need to create more such opportunities for students.

The intersection of low-income and high-achieving characteristics that, in some ways, define these students may be evident in the ways they exhibit their engineering identity. In the first year, students redefined competence as a process of improvement rather than as a terminal (e.g., having an engineering diploma) or tangible marker [22]. Nevertheless, we see them defining competence in terms of potential and possibility, given the history of academic achievement that they already possess.

The change in the students' narratives as engineers at the end of their first year in college indicates the learning and growth that have taken place. The preliminary results show that these students have development in their engineering identity with regards to competence, performance of engineering skills, intersections of identity development for women, with regards to gender and engineering, seem to be critical and at this stage students embrace and rationalize this intersection from an asset-based perspective. This study has implications for engineering educators and administrators to structure support programs in a way that aid students' engineering identity development.

Limitation and Implications for Future Research

This complete research paper is a part of a longitudinal study investigating how low-income, high-achieving engineering students develop their engineering identity throughout their undergraduate education at a large university. Because the study focuses on a particular group of students in a specific context, the questions and participants' responses are geared directly to how they develop their engineering identity within the first year in their program.

Conclusions

This study on low-income, high-achieving students and their engineering identity development shows the changes in engineering identity development over a year in engineering school. Upon admission into their program, students self-identified as engineers, but at the end of year 1, most students no longer see themselves as engineers. Recognition is central to the students' engineering identity. Therefore, it is important to foster messages that meet students at their level and acknowledge their current skills set and knowledge as those of engineers. Various factors contributed to the changes in the engineering students' identity, the Integrated Engineering Identity Development Framework helped us to understand them.

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