See Me as an Engineer: Understanding the Role of Language and Multiple Role Identities on Engineering Students' Identity Trajectory

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***Abstract*— This full research paper examines how first-year engineering students' recognition beliefs differ by household language (English versus non-English). An Exploratory Factor Analysis of 18 survey items identified two factors grouping students' recognition experiences into leadership-based and knowledge-based categories. An analysis of variance (ANOVA) showed that the First Language Not English (FLNE) students generally felt less recognized as an engineer than their peers. We present multiple excerpts from four "restoryed" case summaries of one student to provide insight into why differences in recognition may occur for FLNE students and how these students describe their identity development. The results of this study may indicate important ways to recognize students in the classroom and promote identity development and persistence.**

Keywords — Recognition, Engineering Identity, Language, Mixed Methods

I. INTRODUCTION

Engineering education is changing exponentially as the demand for engineers extends across disciplinary and geographical boundaries. Engineering educators need to consider the changing demography of students who populate today's engineering classroom, particularly as the number of First Language Not English (FLNE) students within the United States higher education system is growing [1]. The increased diversity among the FLNE population is a strength and benefit for the students' communities, the engineering workforce, and society at large [2]. Moreover, their diverse backgrounds are assets in the national demand for global engineers due to their awareness of and adaptability in multicultural settings. However, the increased diversity among cultural and social groups also presents challenges to all members of the education ecosystem (i.e., students, parents, educators, policymakers, researchers, etc.) [2].

Engineering students are socialized into a culture that often recognizes "narrow perception[s] of 'what counts' in engineering," which in turn influences whether they can see themselves as an engineer [3]. Students' ability to regard and be recognized as engineers by others is an integral piece of their identity development and persistence in STEM fields [4], [5], especially for first-year engineering students [6]. However, when students grow up in a household that uses a primary language other than English (thus cultivating different cultural assessments and diverse funds of knowledge), their perception of what it means to be an engineer may not align with traditional preconceptions about engineering. As a result, this may influence whether FLNE students are recognized by others and see themselves as engineers. Consequently, it is imperative to understand how norms in engineering culture perpetually exclude certain kinds of people. More importantly, the engineering education community needs to be responsive to the changing society by increasing efforts to make engineering more inclusive for everyone, including FLNE students, by recognizing their underlying differences as an asset in improving engineering.

This paper uses a sequential explanatory mixed methods research design to understand the recognition beliefs and identity development of early career FLNE engineering students. Throughout this paper, we use the established term First Language Not English (FLNE) to describe students whose first language is not English [7]. This language positions individuals not as "language learners" as many may be proficient in English or as "second language" students as many speak more than two languages. The first portion of the study uses data from a nationally representative U.S. survey. The second portion of the study uses one participant's, Amanda's, narrative to illustrate instances of recognition (or not) for identity development. Together, these data sources provide information on general trends and a deeper insight into how and why these trends may be occurring through an illustrative narrative. Our work highlights the value in using small numbers and narrative research methods to describe the insights gained from large-scale quantitative analysis and acknowledges the need to amplify FLNE students' voices and stories while broadening our understanding of how to support diverse students in engineering.

II. THEORETICAL FRAMEWORK

Recognition in STEM Education

Identity development is a critical component in understanding how students learn and see themselves as

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engineers [6]. Disciplinary role identity (e.g., in engineering) consists of three interrelated dimensions—students' performance/competence beliefs, their interest in engineering, and their recognition as engineers, which collectively inform how students make career choices [8], [9], persist, and establish a sense of belonging in STEM fields [10]. Although some studies suggest students' beliefs about their ability to perform research and learn STEM content have a lesser impact on their identity [11]—[13], many more quantitative and qualitative studies have shown how students' recognition beliefs are important to understanding how students develop STEM role identities [9], [12], [14]. Tonso's [15] ethnographic study of an engineering program highlighted how students' campus-related identities influenced how they were perceived or recognized by others as knowledgeable. For example, even students who engaged in activities that increased their knowledge about engineering and interacted with faculty were less likely to be recognized as engineers based on how their peers positioned them in the local campus community. These findings highlight why it is essential to understand how students develop STEM role identities within a particular context "beyond achievement and interest" to advance our understandings about how to attract and retain students in STEM fields [16].

A nationally representative survey conducted by Godwin and colleagues found similar results [9] when using structural equation modeling to understand how students' high school STEM role identities influence their decision to pursue engineering careers. Their work showed that performance/competence beliefs are not sufficient when understanding students' identity formation, especially for women; instead, recognition beliefs had a more substantial influence on students' identity development. Godwin and colleagues [9] suggested that high school and college faculty incorporate more opportunities to recognize students' participation in STEM by expanding notions of engineering and valuing students' lived experiences and background knowledge [9, p. 330].

In a third study of engineering students and identity development among women of color, Rodriguez and colleagues [17] used phenomenography to explore how seven Latinas developed their STEM identities concerning internal and external sources of recognition. These women recognized themselves as STEM people based on their interest in disciplinary content, ability to persist despite academic barriers, and alignment characteristically STEM ways of thinking and being. In addition to recognizing themselves as STEM people, external sources of recognition from peers, faculty, and family members also contributed to students' identity development. Students who reported more recognition from their peers also reported more motivation to persist in STEM. Our research expands this literature by understanding specific actions that contribute to students feeling recognized as an engineer, specifically highlighting how language and cultural diversity can be leveraged in engineering classrooms to broaden what it means to be an engineer.

III. METHODS

This study is a part of an extensive longitudinal, mixed-methods study focused on understanding how latently diverse students experience the culture of engineering, and how those students form their identities within an engineering community overtime. Latent diversity is students' underlying attitudes, mindsets, and beliefs that are not readily visible in the classroom but have the potential to be instrumental in fostering inclusive environments, which in turn may produce more innovative engineers [18]. In previous work, we used nationally representative survey data and longitudinal narrative interviews to characterize latent diversity among early career engineering students. Below, we discuss how we drew from earlier results and both datasets to explore the recognition beliefs and identity development of early career FLNE engineering students via a sequential explanatory mixed methods research design. This research design enables a deeper understanding of how FLNE students experience and navigate the culture of engineering. Below, we describe the data collection and analysis process used to address the following research questions:

1) What are the quantitative differences in recognition beliefs between students whose primary household language is English, and students who grew up speaking another language before attending college in the U.S.?

2) Using their own words, how do students whose primary household language is non-English describe recognition experiences in engineering?

A. Survey Data Collection and Analysis

The data used in this study are from the CAREER survey administered to a stratified sample of 32 ABET-accredited institutions in the Fall of 2017 in the United States. The CAREER survey was designed to measure first-year engineering students' latent diversity across multiple constructs such as STEM role identities, motivation, epistemic beliefs, including recognition beliefs [19], [20]. We developed the survey based on existing literature and pilot interviews with 12 diverse first-year engineering students at a large Midwestern institution. The items measuring recognition beliefs consisted of 18 items. Using a 7-point anchored numeric scale from "0-Strongly Disagree" to "6-Strongly Agree," the items measured the extent to which they agreed with statements by completing the sentence, "I feel recognized as an engineer when..." See Table 1 below to view the complete list of items used in the analysis.

We used the responses from the nationally representative sample of students (n = 3,711) to understand the similarities and differences in first-year engineering students' (contrasting FLNE and native English speakers) engineering recognition experiencing. First, the data was digitized and cleaned by removing indiscriminate responses. A total of 2,417 students designated English as the primary spoken language in their household, and 475 students reported languages other than English as the primary spoken language in their household. We performed an exploratory factor analysis [EFA; 21] on the 18 items to evaluate the factors captured by the survey items. Finally, we conducted a one-way ANOVA [22] to examine the

differences between the two groups across the extracted factors before proceeding to the qualitative phase of the analysis.

TABLE I. RECOGNITION SURVEY ITEMS

I feel recognized as an engineer when:	
Q6a	My engineering instructors know my name.
Q6b	My non-engineering instructors know my name.
Q6c	I win an award for an engineering project.
Q6d	My family calls me an engineer.
Q6e	My friends call me an engineer.
Q6f	I receive acceptance into my desired engineering discipline (i.e., industrial engineering, mechanical engineering, etc.)
Q6g	I apply engineering skills to my assignments (i.e., homework, project, etc.)
Q6h	I receive compliments from an instructor for incorporating prior knowledge into my engineering design.
Q6i	My peers entrust me with the responsibilities of a leader.
Q6j	I volunteer for engineering activities that promote others' interest in STEM.
Q6k	My instructor says, "This class will make you more like an engineer."
Q6l	I apply my problem-solving skills in my everyday life.
Q6m	My team members recognized me for going above and beyond the requirements.
Q6n	My team members appreciate my contributions to the project.
Q6o	I participate in engineering clubs/societies in college.
Q6p	I participated in programs prior to college (i.e., Project Lead the Way, FIRST robotics, etc.)
Q6q	I participated in engineering classes.
Q6r	I feel that my engineering skills will contribute to society.

B. Narrative Research Methods

Most engineering education research prioritizes studies that can support generalizations about the student population. However, recent studies have shown the value in "small N" studies that enable researchers to highlight inequities through educational research methods that may not be possible with large samples [23]. More importantly, these studies enable researchers to leverage research methods (such as narrative) to understand the lived experiences of students that may have been ignored in studies that prioritize "representative" experiences [23, p. 137]. In this work, we draw on narrative research methods to serve as an explanatory tool through Amanda's story as a way to understand how she navigates the culture of engineering [24], [25].

a) Interviews

Data were conducted longitudinally during four consecutive semesters (Fall 2018 through Spring 2020) to capture how Amanda's identity developed over time. Although 25 students participated in the longitudinal narrative interviews, only one student indicated that they were an FLNE student. For this reason, as well as the need to richly represent her story, we focus on her narrative in this paper. The first interview focused on understanding stories about "how they came to be here" (where "here" referred to the time of our first interview) and their first-year engineering experiences. Subsequent interviews (Interview 2 through Interview 4) were designed to explore their experiences in the second and third years of their engineering programs, as a way to understand how students' identities are constructed over time.

Before the interview, we also asked the student to complete a journey map to indicate experiences that occurred within a specific timeframe (i.e., Summer 2019 to Fall 2019). Amanda's journey map is not shown in this paper; however, the journey maps are instrumental in eliciting salient experiences. Follow-up questions were asked to probe deeper into the experiences on the journey map, including experiences that were not originally shown on the journey map. Each interview was approximately 30 to 60 minutes in duration and conducted by one researcher.

b) Narrative Analysis

Each student interview was transcribed and reviewed for accuracy. As narrative interviews rarely result in cohesive, straightforward storied events, the interview transcripts were constructed into two- to three-page "restoryed" case narratives. The process of restorying helps eliminate redundancy, highlight key elements of the story, clarify the chronological sequence of events, and preserve "place, plot, and scene" [26]. Similarly, a naturalist perspective alongside retaining first-person voicing assisted in preserving the quality and "richness" of each individual's story [27], [28]. While restorying participant narrative helps to provide understanding and richness, preserving clarity and context is also necessary. This process thus involved "narrative smoothing," wherein the researcher added extra text to preserve continuity [29]. Any text added in the researcher's voice is *italicized* to differentiate from a participant's voice and retain the authenticity of the participant's perspective. Similarly, when participants shared identifiable information such as institution or faculty name, identifiers were replaced with italicized, anonymized neutral language such as "*institution name*" or "*Dr. M.*"

IV. RESULTS

We used a sequential explanatory research design to understand the recognition beliefs and identity development of early career engineering students who use a primary language that is different from English in their household. The quantitative analysis identified how there are differences among the two groups, resulting in the FLNE students generally feeling less recognized as an engineer than their peers whereas the qualitative strand revealed how some students who are similar to Amanda might have lower recognition beliefs due to language differences and multiple role identities.

We organized this section into two parts to demonstrate 1) the quantitative analysis tools used to identify comparisons among the two groups, and 2) the narrative used to support the findings that emerged throughout Amanda's story. We note that while discussions of global engineering education focus on exposing engineering students to collaborative international projects [30], much attention needs to be given to support FLNE students who are paving pathways to and throughout engineering education.

A. Quantitative Results

Before identifying underlying differences between the students, we performed an EFA to identify the factors underlying the 18 survey items (Table II). This exploratory

factor analysis led to two factors emerging. The extracted factors categorize students' recognition experiences into those that 1) recognize them as leaders (6 items) and 2) recognition by their knowledge (4 items).

Recognition as a leader (6 items). This factor represents how students recognize themselves and are perceived by others (peers and team members) as leaders. These items focused on how the student was perceived as someone who exceeded course requirements and applied engineering knowledge and skills to real-world problems. The factor loadings for this factor ranged from 0.566 to 0.892.

Recognition as knowledgeable (4 items). This factor incorporates recognition experiences characterized by students' knowledge. These items focused on whether the student won awards for engineering projects, incorporated prior knowledge into engineering design, volunteered for engineering activities that promote others' interest in STEM, and participated in engineering clubs/societies. The factor loadings for this factor ranged from 0.502 to 0.806.

TABLE II. EXPLORATORY FACTOR ANALYSIS

Items	Factors	
	Leadership	***Knowledge***
Q6i	0.566	
Q6l	0.713	
Q6m	0.742	
Q6n	0.892	
Q6q	0.688	
Q6r	0.591	
Q6c		0.806
Q6h		0.726
Q6j		0.515
Q6o		0.502
Eigenvalues	3.20	1.85
% of Variance	26.6	15.4
Cronbach's α	0.87	0.80

Factor loadings of each item are all above 0.5, which indicates good construct validity. To evaluate the reliability of the outcomes, we used Cronbach's α, which for leadership factor is 0.87 and for knowledge factor is 0.80. The alpha levels for both factors were greater than 0.7, indicating there is internal consistency among the items for each factor [31].

To examine the group differences within the extracted factors, we used a one-way analysis of variance (ANOVA) where the null hypothesis was:

H_0: There is not a significant difference in engineering students' recognition experiences between students whose primary household language is English versus non-English.

The ANOVA yielded values for both factors that were statistically relevant ($p < 0.05$). The margin of error was calculated with 95% confidence. Responses on the leadership items ($F(2,630) = 23.29$, $p < 0.0001$) indicate that FLNE students scored lower than students who have English as their primary language. Similar results emerged in the knowledge factor ($F(2,643) = 21.00$, $p < 0.0001$), with FLNE students scoring lower than their peers. Therefore, for both factors, FLNE students reported lower feelings of recognition than their peers. Prior work has emphasized the importance of recognition from certain meaningful others [16], [17]. However, those studies do not address how students' identities are constructed over time.

B. Narrative Research Results

Hence, in addition to Godwin and colleagues [9] three constructs for measuring engineering identity, we draw on an adapted model of McAlpine and Amundsen's [28] identity trajectory theory as a complementary methodological tool to conduct a longitudinal qualitative investigation of how Amanda developed her identity as an engineer [29], [32], [33]. This theory enables researchers to examine the past, present, and future experiences that influence a student's learning and development. This approach examines multiple roles simultaneously through narrative research methods to establish a comprehensive understanding of the student's identity trajectory, instead of relying on "snapshots" of the student's experiences. The following section focuses on Amanda's story about how she developed an interest in engineering, pushed through the adversity of learning English, and grappled with the tension of developing multiple role identities throughout her pathway as an early career engineering student.

a) Early Interest, Engagement, and Recognition from Meaningful Others as a Catalyst for Women in STEM

Amanda is a mechanical engineering student at a large Southeastern institution in the United States. However, she grew up in a European country where the education system was structured in a manner that tracked students into career pathways and preparation. A combination of her early interests, performance/competence beliefs in mathematics, and recognition from meaningful others (i.e., family and teachers) influenced her decision to pursue the engineering track in high school.

> I am from *a European country where* in high school, you can choose what track you want to do. *For example,* if you want to *pursue a career* towards engineering or economics and stuff. I chose to do engineering because I like math and physics the most. *I chose my track by looking at* what kind of courses every track offered, and that's why I chose to do the engineering *track*, because it's more like calculations and stuff, and that was the courses I liked in elementary school.
>
> *I also chose the engineering track because of* my whole family. They are kinda interested and good at more like the math part than like, drawing and stuff. Then, I think I was able to get a lot of help from home, and therefore, I kinda got good at math and I think you start to like stuff that you're good at. That's why I kinda started to like *math* because I was good at it and I think that's mostly because I got help from home, and because of the professors. So then, I picked engineering because I was good at math. Of course, I

could pick something easier when I got here *[United States]*. It doesn't matter what I picked in high school, but I felt like I just wanted to keep going because I felt like I kinda knew what I was doing.

b) Pushed Through Adversity While Learning English

Later, Amanda also decided that she was interested in attending college in the United States, so she could play soccer at the collegiate level and receive an engineering education.

> *In high school, I also decided that* I wanted to come to the U.S. to start playing soccer. *However,* it's a lot of paperwork to do just to get here *[United States]*, and it started maybe my last year of high school. I have lots of friends who play soccer and learn English. I talked with a company at home who had different connections with different schools here *[United States]*. I just told them that I want to play soccer, *and* um, get an education. Then, I recorded a video *when* I was playing soccer and then sent it out to the coaches in hopes that I wanted to do something with engineering. So, that company found the different schools that wanted me to come play soccer and I could just pick what school I wanted to go to. But then they call me to do lots of tests, like an English test, *and* the SAT. That process and everything takes one year. I need to pass the test to be able to come here *[United States]*. I passed a lot of them but the English, like my English wasn't as good as it had to be. So, when I got here *[United States]*, I needed to take some extra English classes, so therefore I am behind with my studies right now. So I need to take extra courses when I got here because I was slow with *learning* English.
>
> My first semester I take three different English classes. One was English reading, one was English grammar, *and* one was English writing. Then, I also took one class, kinda bonus class, you just have to take it. I was enrolled in one math class *because* it was a new rule that said you need to be enrolled in a certain amount of credits, just to be able to play *soccer*. The plan was I was only gonna take English class my first semester but since this changed rule, I need to take the *bonus* class and math class. Therefore, *I'm* not as behind now *as I initially projected*.
>
> First, I was kinda struggling. I remember struggling with some tests like I didn't understand the question, and it's not because I didn't know what to do, like I knew the calculations. I just didn't know the words. Like if it said "counter-clockwise," I didn't know what it meant so I didn't know what it was asking for. I usually went to my professor after the test and was like "I'm sorry, but I don't really understand," and they treated me really well and explained *the material. For example, the professor* helped me to reduce some parts of it because they knew that I could do it. It was just the English that I was struggling with. But then, after the first semester I was here, I don't think the language has been a problem anymore.

Even though she passed the exam designed to assess the language proficiency of students who want to attend post-secondary education in the United States, she shared how she faced difficulties with learning STEM concepts, due to the context of particular terms like "counter-clockwise." Despite her initial hardships during her first semester at her institution, Amanda pushed through her adversity by relying on her faculty as a resource to improve her understandings of the engineering problems and content.

c) Identity Building Experiences in Engineering

After Amanda's first semester, she was integrated with "normal students" since she progressed through the initial requirements for FLNE students. During this time, she also described how she reached a sufficient level of English skills to understand engineering in class better. Throughout these accounts, Amanda described her experiences working with her peers on engineering projects, acquiring a leadership role on her teams, and leveraging her prior knowledge to complete a project. Unlike her other interviews, Amanda discussed comparisons about the education system between her home country and the United States throughout the initial interview.

> *During* my second semester, I go into the school with normal students. Then, I took another math class and I started to do my physics class, *and* some engineering programming. The programming class, I'd never done programming before. Another class I was working with MATLAB, so that one's like totally new for me. I didn't know anything, *so* I was not interested *in the topic* going into the class. *Also,* it was a lot of work required in that class. I think it's fun when you get it, but it took a lot of effort. I guess, like understanding what you're supposed to do. And then for graphical communication *class*, so we did a computer. In high school, at home, we had *a similar* program but it was really helpful to have done those before.
>
> One class that all engineers *take* is *an Intro engineering course* that *requires* a few projects throughout the semester. One *project* was you were supposed to design an airplane or you were supposed to do the calculations. You were not really supposed to design it*, instead we were required to calculate* like how much air and drag it had. And it would give you some practice, like it would need to be able to fly from here *[United States]* to Europe and then you need to do some assumptions and calculations, so that was more like a math project.
>
> *Then,* we had a second project *where* you were supposed to do a ball launcher for a dog which the dog can use without the owner being home. That was a lot of math calculations, maybe like what angle you wanted the ball to be thrown in and stuff, but that one we were actually supposed to build. We didn't design it on the computer because we hadn't learned how to do that so we just had to sketch *the design* on the paper

and a few classes you can be in *the* workshop and working on it.

I'm just the kind of person that wants stuff to be done as quick as possible and not to do it the night before, so I think I usually take the role where I'm like trying to make a group of the students pass the ball and like making sure we get started. But then, I think we stayed equal amongst all of us. Some people come with some ideas *about* what kind of ball launch we could do and all of us came up with like two different ideas that was like what we decided to do. Then, one day we met up and just discussed which one we liked the most. There was a combination of two of them and then we started to build and there was one guy in our group that had been a worker once, so he kinda knew the most and he kinda told us what to do and how to build it.

I have sorta done *workshop* before in *high* school. I don't know if you guys also have it, but we have this class called workshop, so *taking* that for like four years, we worked on how to handle stuff in the workshop. It can always get more complicated and I used some stuff I hadn't used before, but it was not the biggest problem. It was not that complicated, just some pieces of wood and just stick it together.

That's the big difference to home. At home in high school, you barely have homework and then at the university you never have homework, you have maybe like two weeks during the whole year and that's it. From going from our high school where you have learned that you need to be self-independent and professors don't give you homework. Then you come here *[United States]* and it feels like you're in elementary school again, because they're giving you homework for everything in class. Even just a big difference which I didn't really like in the beginning because it felt like just let me start it the way I want to start it and when I want to do it and I will do well on the exam. But then, *I realized that* I need to do this, like all the homework.

Overall, the process of transitioning to a school in the United States makes *me* more self-independent. Of course, I have developed my English skills enough, but it's like a deeper personal experience and development than if I had just stayed home and studied. You feel like you're moving away from all the safety you had, like you don't know anyone and figure out everything myself. From living at home and having your parents there to support you to not having them. It has developed me a lot as a person. I think it's worth it. I want to try new things. I think it just makes me grow.

Amanda described how she primarily focused on applying for internships while taking engineering courses in vibrations, heat transfer, machine design, and materials. Amanda shared how she scored well on her exams in vibrations and materials. Also, she described strategies some of her professors use during lectures to ensure students are comprehending the material such as:

The professor uses PowerPoint presentations, and *sometimes* he *may* start to show a YouTube clip with a bridge that's vibrating. And then, he's breaking down this bridge *into* simpler components, use like a square or something like that. And then, he says this has a mass, and you have a spring component that is this value, and then you can get these vibrations, looking at these equations. *We also completed about* seven quizzes throughout the semester *and a small project about water towers*.

Toward the middle of the semester, Amanda shared how she received several offers from companies and decided to accept two internships abroad in her home country. She also began making more connections with professors, which resulted in increased exposure to engineering concepts and applications.

This semester I've started to have more *of a* connection with *my professors*. It started with me have to ask one of my professors for internship assignments, so I got a really good consult with him. And then, he introduced me to another professor that is in charge of a lot of different research projects at school. So then, I started to talk with him, so now I'm involved in some of his research projects. Right now, I don't contribute anything. I'm just there to learn.

In Amanda's third interview, she described her role during her internship focused on data acquisition to understand athletes' movements using force plates. She discussed how she leveraged her knowledge from her internship in her biomechanics course.

Actually, I didn't think we were going to *use anything I learned from my internship*, but *now* we have *a* project in Biomechanics *where* we *are* using force plates for collecting data. And that was a bit helpful, *since* I had used force plates during my internship. I don't really know what we're going to do with the data. Hopefully find out *at some point.* We used the school's lab, which have force plates and a lot of markers that you put on yourself *surrounded by* a lot of cameras. The cameras will see all the markers. We can determine the movements and the forces, which is calculating the forces.

In addition to biomechanics, she also described a yearlong group project where they are focused on designing an ankle brace that prevents ankle sprains in soccer. Amanda and her peers also attended a biomedical engineering conference, so they could gain more knowledge for the design project. Similar to her second interview, Amanda highlighted how the faculty members were very helpful, even when they were not currently taking their course. More specifically, she described how her materials engineering professor helped her group identify an appropriate material for the ankle brace.

We are using a flexible plastic called CPAs. That is supposed to allow natural range of motion and also provide forces *at* a higher velocity. We are 3-D printing the brace to be able to do thin, because current braces on the market are very bulky. And we have now downloaded prototype, and obviously it's going

> to have to be redone because it was used the outer shell of it. So, there's no support yet or anything.

Amanda also expressed how being a student athlete required time management because she did not have as much leisure time as her peers. However, she believed that managing soccer and engineering motivated her to be more focused and productive during the time she allocated for homework. While Amanda described her classroom experiences in her fourth interview, she primarily continued discussing the current status of the design project because they were expected to validate their prototype using multiple tests such as tensile and fatigue. However, their project was impacted by the COVID-19 global pandemic, which resulted in a limited timeframe for testing. As a result, they were only able to rely on the tensile test to validate their product. In addition to limitations mentioned, when we asked Amanda about her interactions with professionals in her field, she described how she and her peers experienced difficulties with the company contracted to make some parts of their ankle brace. She suspected the company reacted in this manner because they were students.

d) Experiencing Tension Between Multiple Role Identities

Despite the difficulties experienced during this semester, Amanda described how she and her peers started a company related to their design project. However, she also expressed how she did not have intentions of pursuing engineering as a career after graduation. Instead, when we asked about her short-term and long-term career plans, she stated how she was interested in focusing on her professional soccer career.

> I'm not sure. I'm currently on the women's soccer team here at the university so I do a lot of soccer and I wish to continue to play afterwards. That's my current goal to find a professional soccer team where I can go and play. Eventually, I will do my masters and do a job as well. Either a master's in mechanical engineering since I'm doing my bachelor's in it. Or I was thinking about sports engineering but the industry for that is much smaller and maybe not be a good idea to do a master's in it if it's difficult to get jobs.

> Before I got here *[United States]*, I applied for different programs back home in my home country and then I applied for industrial engineering and management just because it's always something I've been interested in like in engineering economics. Then, I got here *[United States]* and after like a couple of semesters I realized sports engineering was a thing and that is something I'm even more interested in because I love sports. I do enjoy using my brains to solve problems. To put those two together would be something I would enjoy doing.

Lastly, Amanda reflected on her initial intentions for attending school in the United States, which resulted in her suppressing her engineering identity.

> *Originally,* I came here for my soccer experience and then the engineering has just become a lot bigger than I expected. I spend much more time on it than I expected. I have liked it.

> In my first semester, it just started off with a ton of homeworks and assignments and test. It was a big, big workload so I was kind of forced into it. With my personality, I'm always trying to do my best even though it would be enough to just get a passing grade on an assignment. I would not complete an assignment with something I didn't think I was going to get 100% on. That's how it started off. That was very annoying. I didn't like it at all because I came here for soccer and the engineering took over when I didn't want it to. My last year, my senior year, has been more focused on engineering but that's because I wanted it.

This narrative provides valuable insights into the experiences of FNLE for multiple reasons. First, Amanda's journey to a career in engineering began at an early age, due to reinforcement from her teachers and family members, which is a crucial aspect of increasing the likelihood of girls choosing and persisting in a STEM career. Even though it appeared as a catalyst for Amanda's pursuit of a career in engineering, Amanda later shared how she felt forced to prioritize engineering instead of her identity as a soccer player. While Amanda's narrative materialized as a story about a student who persisted in STEM (despite adversity) and was confident in her ability to learn and be an engineer, she also grappled with conflict between multiple role identities. These findings highlight how deeper considerations in understanding what contributes to a student developing an engineering identity and underlying richness provided by longitudinal narratives when examining students' identities overtime.

V. Discussion

The purpose of this paper was to examine the recognition beliefs and identity development of early-career engineering students who use a primary language other than English in their household. While the recognition beliefs of early career FLNE engineering students were lower than their peers, Amanda's story highlighted three considerations for engineering educators—1) Early interest and engagement in STEM are important for women choosing and persisting in a STEM academic major and creating alternative paths of success; 2) Women in engineering make negotiations with their identity as an engineer concerning other aspects of themselves (i.e., race, class, and gender), including others professional role identities; 3) Adversity presents an opportunity to increase the accessibility of engineering content and identifying ways to support students' transitions into engineering education.

Despite Amanda establishing an early interest in STEM, actively engaging in curricular and co-curricular activities, and incorporating her soccer interests in her projects, Amanda experienced tension between her competing interest in engineering and sports. Prior literature has discussed the importance of connecting engineering content with student interest and how competing interests relate to students making negotiations about their decision to pursue or leave engineering [34], [35]. However, Amanda's tension between soccer and engineering did not affect her degree attainment. Instead, the taxing nature of engineering "forced" her to foster a stronger engineering identity by obtaining multiple internships and

starting a company with her peers to build on their senior design project overtime. However, this finding also highlights how women not only negotiate their identity concerning their gender [36] in engineering. Instead, these findings highlight how some students intend to leverage engineering to support their long-term success by engaging in entrepreneurship and maximizing their future careers.

Unlike prior work [3] where early career students describe engineering as an obstacle that must be conquered, Amanda often referred to her experiences in engineering as positive and consistently relied on faculty as a resource to overcome her difficulties while learning English, completing engineering projects, and networking with faculty. However, despite her ability to navigate adversities with foundational language courses and discussing her difficulties with faculty during her first year at her institution, these findings present opportunities to advance the accessibility of engineering content and support students' transitions into engineering education. For example, when Amanda described difficulty with understanding terms such as counter-clockwise, this situation presented an opportunity for the professor to integrate illustrations in their presentations to mitigate confusion.

In addition to incorporating multiple modalities of learning (i.e., words, models, or videos), additional considerations for supporting students transitions into engineering education include integrating support structures for FLNE students such as summer bridge programs. For decades, support structures have existed to bridge the gap for students who are traditionally minoritized in STEM to increase interest, sense of belonging, networking, and enhance student knowledge in STEM content [37]. While these efforts are necessary for increasing representation in STEM, additional sources of support for language should be integrated to support students in their transition as an undergraduate engineering student in the United States. Respectively, the engineering education community needs to identify and enact ways to support these students throughout their STEM journey.

VI. Conclusions

This mixed methods research study begins to reveal the impact of language and multiple role identities on engineering students' identity trajectory starting with recognition. First, our work delves into how FLNE students feel generally less recognized as engineers than their peers. Then, our work highlights how some students may have lower recognition beliefs early on because they are experiencing adversity, in addition to the obstacles associated with studying engineering. More importantly, this work allowed us to make sense of students who may be similar to Amanda concerning negotiating between multiple roles and social identities, which in turn may contribute to their decision to pursue an alternative career. Our future work includes using stories of latently diverse students to promote an inclusive culture in engineering through pedagogical interventions that support student identity development over time.

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References

[1] P. G. Altbach, L. Reisberg, and L. Rumbley, Trends in global higher education: tracking an academic revolution. 2009 UNESCO World Conference on Higher Education, 2010.

[2] National Academies of Sciences, Engineering and Medicine, English Learners in STEM Subjects. Washington, D.C.: National Academies Press, 2018.

[3] B. Benedict, D. Verdin, R. Baker, A. Godwin, and A. Thielmeyer, "I Don't FIT the Stereotype, but I see Myself as an Engineer: First-Year Engineering Students' Attitudes and Beliefs about their Engineering Identities," in Proceedings - Frontiers in Education Conference, FIE, 2018, vol. 2018-Oct, doi: 10.1109/FIE.2018.8659229.

[4] B. M. Capobianco, "Undergraduate women engineering their professional identities," Journal of Women and Minorities in Science and Engineering, vol. 12, no. 2–3, pp. 95–117, 2006, doi: 10.1615/JWomenMinorScienEng.v12.i2-3.10.

[5] M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra, and R. A. Layton, "Persistence, Engagement, and Migration in Engineering Programs," Journal of Engineering Education, vol. 97, no. 3, pp. 259–278, 2008, doi: 10.1002/j.2168-9830.2008.tb00978.x.

[6] A. Godwin, "The Development of a Measure of Engineering Identity," in 2016 ASEE Annual Conference & Exposition Proceedings, Jun. 2016, vol. 2016-June, doi: 10.18260/p.26122.

[7] E. Harder and S. Varga, "ESL, ELL, or FLNE? How to Describe Students Whose First Language Isn't English.," AMERICA'S PROMISE ALLIANCE, Sep. 27, 2017. https://www.americaspromise.org/opinion/esl-ell-or-flne-how-describe-students-whose-first-language-isnt-english (accessed May 22, 2020)

[8] Z. Hazari, G. Sonnert, P. M. Sadler, and M. Shanahan, "Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study," Journal of Research in Science Teaching, vol. 47, no. 8, pp. 978–1003, 2010, doi: 10.1002/tea.20363.

[9] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, Critical Agency, and Engineering: An Affective Model for Predicting Engineering as a Career Choice," Journal of Engineering Education, vol. 105, no. 2, pp. 312–340, Apr. 2016, doi: 10.1002/jee.20118.

[10] D. R. Johnson, "Campus Racial Climate Perceptions and Overall Sense of Belonging among Racially Diverse Women in STEM Majors," Journal of College Student Development, vol. 53, no. 2, p. 336, 2012, doi: 10.1353/csd.2012.0028.

[11] Z. Hazari and C. Cass, "Towards Meaningful Physics Recognition: What does this recognition actually look like?," The Physics Teacher, vol. 56, no. 7, pp. 442–446, Oct. 2018, doi: 10.1119/1.5055325.

[12] D. Verdín, A. Godwin, and M. Ross, "STEM Roles: How Students' Ontological Perspectives Facilitate STEM Identities," Journal of Pre-College Engineering Education Research (J-PEER), vol. 8, no. 2, pp. 31–48, 2018, doi: 10.7771/2157-9288.1167.

[13] J. Wang and Z. Hazari, "Promoting high school students' physics identity through explicit and implicit recognition," Physical Review Physics Education Research, vol. 14, no. 2, Sep. 2018, doi: 10.1103/PhysRevPhysEducRes.14.020111.

[14] D. H. Jensen and J. Jetten. "Exploring interpersonal recognition as a facilitator of students' academic and professional identity formation in higher education," European Journal of Higher Education, vol. 8, no. 2, pp. 168–184, Apr. 2018, doi: 10.1080/21568235.2017.1374195.

[15] K. L. Tonso, "Teams that Work: Campus Culture, Engineer Identity, and Social Interactions," Journal of Engineering Education, vol. 95, no. 1, pp. 25–37, 2006, doi: 10.1002/j.2168-9830.2006.tb00875.x.

[16] H. B. Carlone and A. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens,"

Journal of Research in Science Teaching, vol. 44, no. 8, pp. 1187–1218, Oct. 2007, doi: 10.1002/tea.20237.

[17] S. Rodriguez, K. Cunningham, and A. Jordan, "STEM Identity Development for Latinas: The Role of Self- and Outside Recognition," Journal of Hispanic Higher Education, vol. 18, no. 3, pp. 254–272, Jul. 2019, doi: 10.1177/1538192717739958.

[18] A. Godwin, "Unpacking latent diversity," in *2017 ASEE Annual Conference & Exposition*, Columbus, Ohio, 2017, [Online]. Available: https://peer.asee.org/29062.

[19] A. Godwin, D. Verdín, B. S. Benedict, R. A. Baker, T. J. Milton, and J. T. Yeggy, "Board 51: CAREER: Actualizing Latent Diversity: Building Innovation through Engineering Students' Identity Development," 2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah, Jun. 2018, [Online]. Available: https://peer.asee.org/30050.

[20] A. Godwin, B. S. Benedict, D. Verdín, A. R. H. Thielmeyer, R. A. Baker, and J. A. Rohde, "Board 12: CAREER: Characterizing Latent Diversity Among a National Sample of First-year Engineering Students," 2019 ASEE Annual Conference & Exposition, Tampa, Florida, Jun. 2019, [Online]. Available: https://peer.asee.org/32207.

[21] A. P. Field, Discovering statistics using R. London ; Thousand Oaks, Calif.: Sage, 2012.

[22] M. H. Kutner, C. J. Nachtsheim, J. Neter, and W. Li, Applied linear statistical models, vol. 5. McGraw-Hill Irwin New York, 2005.

[23] A. E. Slaton and A. L. Pawley, "The Power and Politics of Engineering Education Research Design: Saving the 'Small N,'" Engineering Studies, vol. 10, no. 2–3, pp. 133–157, 2018, doi: 10.1080/19378629.2018.1550785.

[24] J. Case and G. Light, "Emerging Methodologies in Engineering Education Research," Journal of Engineering Education, vol. 100, no. 1, pp. 186–210, 2011, doi: 10.1002/j.2168-9830.2011.tb00008.x.

[25] A. L. Pawley, "Learning from small numbers: Studying ruling relations that gender and race the structure of U.S. engineering education," Journal of Engineering Education, vol. 108, no. 1, pp. 13–31, 2019, doi: 10.1002/jee.20247.

[26] J. W. Creswell, Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research, Enhanced Pearson eText with Loose-Leaf Version--Access Card Package. Fifth Edition. Pearson Education, Inc, 2015.

[27] N. N. Kellam, K. S. Gerow, and J. Walther, "Narrative analysis in engineering education research: Exploring ways of constructing narratives to have resonance with the reader and critical research implications," 2015 ASEE Annual Conference and Exposition, Conference Proceedings, 2015, doi: 10.18260/p.24521.

[28] L. McAlpine and C. Amundsen, Identity-Trajectories of Early Career Researchers. Macmillan Publishers Ltd., 2018.

[29] J.-H. Kim, Understanding Narrative Inquiry: The Crafting and Analysis of Stories as Research. SAGE Publications, Inc, 2015.

[30] B. Jesiek, M. Borrego, and K. Beddoes, "Engineering Education Research: Global Trends and Collaborative Opportunities," 2008

[31] R. M. Thorndike and E. Hagen, Measurement and evaluation in psychology and education. New York: Merrill, 1997.

[32] B. Benedict et al., "An Early Adaptation of Identity Trajectory to Understand the Identities of Undergraduate Engineering Students," in 2019 IEEE Frontiers in Education Conference (FIE), Oct. 2019, pp. 1–5, doi: 10.1109/FIE43999.2019.9028365.

[33] A. Godwin et al., "CAREER: Actualizing Latent Diversity in Undergraduate Engineering Education," 2020 ASEE Virtual Annual Conference, Jun. 2020.

[34] J. Cruz and N. Kellam, "Beginning an Engineer's Journey: A Narrative Examination of How, When, and Why Students Choose the Engineering Major," Journal of Engineering Education, vol. 107, no. 4, pp. 556–582, 2018, doi: 10.1002/jee.20234.

[35] A. Godwin and G. Potvin, "Pushing and pulling Sara: A case study of the contrasting influences of high school and university experiences on engineering agency, identity, and participation," Journal of Research in Science Teaching, vol. 54, no. 4, pp. 439–462, 2017, doi: 10.1002/tea.21372.

[36] J. Jorgenson, "Engineering Selves: Negotiating Gender and Identity in Technical Work," Management Communication Quarterly, vol. 15, no. 3, pp. 350–380, 2002, doi: 10.1177/0893318902153002.

[37] M. Ashley, K. Cooper, J. Cala, and S. Brownell, "Building Better Bridges into STEM: A Synthesis of 25 Years of Literature on STEM Summer Bridge Programs," Cbe-Life Sciences Education, vol. 16, no. 4, 2017, doi: 10.1187/cbe.17-05-0085.