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CAREER: Learning from Students' Identity Trajectories to Actualize Latent Diversity

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CAREER: Learning from Students' Identity Trajectories to Actualize Latent Diversity

This executive summary describes the progression of a research project focused on characterizing latent diversity (i.e., not readily visible attitudes, beliefs, and mindsets that are assets that students bring to engineering) through student narratives of their identity trajectories. Despite significant and large-scale initiatives, the field of engineering struggles with recruiting and retaining diverse talent, addressing diversity, equity, and inclusion, and promoting innovation in problem-solving approaches and engineering solutions. We hypothesize that engineering education's socialization process leads to the homogenization of students' ways of being, thinking, and knowing (i.e., a norming process to specific cultural norms). This process often alienates students who do not align with engineering's cultural norms and practices, which are shaped by Whiteness and masculinity. As a result, seemingly identical portrayals of what engineering is and who becomes an engineer have permeated engineering students' and professionals' stories for decades. This research provides a broader understanding of engineering inclusion by unpacking actionable ways to actualize latent diversity in engineering, leading to a demonstrable change in engineering climate and culture.

Introduction

A recent university-sponsored virtual fireside chat with Kimberlè Crenshaw, the attorney who coined the term intersectionality (a construct that has transcended disciplinary boundaries) made a profound statement recalling the Civil Rights movement. Unsurprisingly, her statement, "They made room for bodies, not ideas," mirrors what exists today in engineering education, where national prioritization is given to the recruitment of students minoritized (i.e., women, students of color, neurodiverse, LGBTQ+, and students with disabilities) in engineering [1]. Yet, engineering culture and practices privilege particular ways of being, thinking, and knowing that center Whiteness and masculinity [2]– [3]. Not only do these messages reinforce "what counts" and "who belongs" in engineering, but they create an education system that homogenizes approaches to problems, engineering mindsets, and rhetoric. The results of this system can stifle students' potential for innovation and continue cultures that were built to exclude [4]. We explore these complex dynamics between the process of engineering education and students' development in this project. This executive summary describes this NSF CAREER project's progression in first characterizing the breadth of incoming latent diversity in a national survey and the follow-on longitudinal narrative inquiry to understand the shifts in students' identities and innovation over time. This work provides insights into the institutional, classroom, and social supports that can reinforce students engineering identity development and inclusion in engineering education.

Project Overview

This project, *CAREER: Actualizing Latent Diversity*, employed a sequential explanatory mixed methods design to characterize the latent diversity of incoming first-year engineering students in a national sample. Latent diversity refers to the underlying attitudes, mindsets, and beliefs that can support innovation but are not readily visible in the classroom [5]. The quantitative portion of this study engaged 3,711 first-year engineering students in a national survey of 32 ABET accredited institutions. We found six different data progressions indicating differences in students' latent diversity. The qualitative portion involved engaging in narrative inquiry with 25 students from the six different data progressions.

In the follow-on qualitative portion of this study, we investigated students' longitudinal identity trajectories as they engaged in engineering culture over their undergraduate education. We had a particular interest in understanding if students normed to the dominant ways of being, thinking, and knowing in engineering, created unique ways to engage as engineers, or potentially left engineering. The results of this ongoing narrative inquiry provide insights into the multifaceted context of engineering students' development, including the identification and development of strategies and interventions to support these students inside and outside the classroom.

This study answers three research questions:

> 1) What kinds of diversity in attitudes, beliefs, and mindsets (i.e., latent diversity) are present in engineering students?
>
> 2) How do undergraduate students with latent diversity form engineering identities within an engineering community of practice over time?
>
> 3) What support, both inside and outside of the classroom, can be provided to promote inclusion of students with latent diversity in engineering?

The results of the prior work have been reported in detail, spanning discussions of survey development [6], topological data analysis [7]-[8], identity trajectory theory, and narrative construction [9]-[10].

To date, we have conducted five rounds of interviews with students since the Fall of 2018. Each interview used journey maps to elicit students' identity trajectories and probed further into their short and long-term goals and current educational environments, especially in response to the COVID-19 global pandemic and its impact on engineering education. In this research, we specifically use journey maps as a reflective tool for students to document their "high points" and "low points" within a particular semester (i.e., Summer 2019 to Fall 2019 or Winter 2019 to Spring 2020). We also used journey maps as an artifact to guide the interviews and operate as an element of procedural and communicative validation [11]. In alignment with the identity trajectory model,

these journey maps allow us to differentiate between the most minor and most salient experiences for students as they negotiate their identities as engineers.

In prior work [9], we discussed the nature of the interviews for rounds one and two. However, in subsequent interviews (i.e., third through fifth), we continued conducting narrative interviews designed to elicit responses about their identity trajectory. While all of the interviews involve the completion of a journey map and were tailored to capture students' dynamic narratives as they navigate through engineering, each interview protocol revisited students' survey responses to understand changes in constructs that may influence students' identity development. The third interview involved the researcher asking each student to verbally indicate their response to items measuring engineering identity, belonging in engineering, belonging in class, physics identity, mathematics identity, and controlled regulation. The fourth interview focused on students' short- and long-term career plans and asking them to reflect on their involvement in the CAREER project. Lastly, in response to the dynamic shift in engineering education, the fifth interview probed on students' school environment (e.g., traditional in-person, virtual, or hybrid modalities), co-curricular support (e.g., plans to participate and how their plans changed over time), and the impact of COVID-19 on their journey as an engineer, career plans, and belonging in engineering.

In addition to conducting narrative interviews each semester, we continued reviewing each interview transcript for accuracy, digitizing journey maps, developing "restoryed" case narratives, and compiling the conceptually clustered matrix [10]. The process of reviewing transcripts for accuracy entails at least one researcher listening to the audio file while simultaneously reviewing the transcript for errors and highlighting any personal identifiers for later redaction to protect the student's anonymity. An additional step to protect the anonymity of the student includes digitizing each handwritten journey map. This step ensures students will not be easily recognizable by their handwriting and potentially reducing the likelihood of being linked to this study.

Once the transcription accuracy process was complete, one researcher constructed restoryed case narratives with a first-person point of view, which entailed prioritizing the student's voice, including minimal narration from the researcher, and narrative smoothing [12]. Narrative smoothing involves organizing the interview into chronological order and adding in information and transitions to make the story read as a coherent narrative. We differentiate between the student and researchers' voice by using italics in areas where the extra text is necessary to enhance the narrative's clarity. See [10] to view additional details about the conceptually clustered matrix. The conceptually clustered matrix is an analytic tool that allows the researchers to identify comparisons and contrast among the participants' stories. In this summary we report the emerging themes through one restoryed narrative example.

Theoretical Framework

This work is guided by the framework of identity trajectory theory. Identity trajectory theory consists of three interconnected strands: intellectual, institutional, and networking, that can be used

to examine identity development over time. We adapted the framework to understand the identity development of undergraduate engineering students. The intellectual strand focuses on how students develop and draw on engineering knowledge when engaging in curricular (e.g., course projects and classroom discussions) and co-curricular (e.g., internships, co-ops, study abroad, professional associations and organization, etc.). The institutional strand consists of "institutional structures, resources, and responsibilities that influence students' identities within their academic institution and engineering as a career" [9, p. 2].The networking strand includes two elements of networks, interpersonal and intertextual to support their personal, academic, and professional development. Interpersonal networking consists of the present, past, and historical relationships built with faculty, peers, and professionals that contribute to students; identity development and success, while intertextual networking includes students' accessing books, articles, and educational technology to expand their knowledge and understanding of the field.

Results

Within the research project's lifespan, we have collected stories from 25 different students across the United States. These students have engaged in various personal, curricular, and co-curricular activities that inform their identity trajectories. While we retained participation from most participants, five students decided to discontinue their involvement in the project. As we stated in a previous executive summary, three students left engineering and have persisted in their new journey studying health data science (Hilda), business (Mark), and chemistry education (Jennifer). While each student gives an interesting glimpse into how engineering culture supports or undermines their identity trajectory, this paper explores the trajectory of one student studying engineering and mathematics as two distinct academic majors. Below, we describe Adriana's initial latent diversity profile and present her restoryed case narratives focused on her third year in engineering. Then, we describe how Adriana's narrative informs our understanding of latent diversity and highlight our future plans to continue data collection and dissemination to the engineering education community.

Restoryed Case Narrative for Adriana

Adriana is a mathematics and electrical and computer engineering student at a private Christian University in the Southwest. Prior to pursuing an engineering degree, Adriana lived abroad in several countries. Although Adriana repeated an academic year (i.e., was retained) in seventh grade, she attributed this year as the catalyst that sparked her interest in mathematics and science and the development of her worldview that embraces diversity and values the ability to connect with people from different backgrounds. Despite her brief setback in middle school, Adriana enrolled in multiple advanced placement (AP) courses (i.e., physics, chemistry, and calculus) in high school and expressed love for mathematics and physics in her initial interview. In addition to expressing interest in STEM subjects, Adriana also described how her peers and teachers recognized her as someone who could be an engineer. These sources of external recognition paired

with her interest and performance/competence beliefs contributed to her decision to pursue engineering. Adriana's incoming attitudes and beliefs aligned with individuals characterized as Group A in our prior quantitative work [7]. Individuals in Group A have a strong interest in mathematics, performance/competence beliefs in physics, and high intrinsic and extrinsic motivation beliefs. Before presenting Adriana's narratives, we provide an excerpt from her initial interview where she expressed her initial feelings about beginning her journey in engineering. This selection provides retrospective insight into how Adriana recognizes herself as an engineer and leverages an attitude that influences how she navigated engineering.

> When I first started engineering, it was very intimidating. A lot of students that I knew had had some engineering background already when they first started. They had been in a robotics club, or done something along those lines, or been in an engineering program in high school, and I had never, ever, had anything ... Like, I hadn't even had access to those sorts of things. And so, it was definitely very intimidating, and I felt a little bit like I needed to prove myself. I'm in a group with two guys and I will not be the girl that just sits there, and types notes on what we're doing. I actually want to be part of this. And so, even though I had absolutely no idea what I was doing, I decided that I was going to be in charge of all of the machines, and software, that we needed to use. I learned the 3D design and Fusion360 for MacBook's. I learned this other plastic, vacuum, suctioning, thing that we would have to use later on. All of these different things, and I was just like, "Okay, I'm gonna learn 'em because I do not wanna be that girl in engineering that just sits there and watches the guys do all the work."

In this paper, we highlight Adriana's narrative during her third year in her engineering program. Her journey map for the fall semester is shown in Figure 1, and her journey map for the spring semester is shown in Figure 2. We provide the restoryed narrative from her interview corresponding with the high and low points shown in each journey map. Then, we discuss how her narrative during the past year highlights aspects of her identity trajectory within engineering.

Fall 2019

> Sometimes over the summer, I'll go overseas to visit my father. *There are a* lack of college students and students just out of college. Tutoring pays very well so whenever I'm there, I think I was there for about a month, maybe a little over a month this summer. I would tutor I think mostly middle school and lower high school students in math *subjects* like algebra, Algebra 1, Algebra 2, some pre-algebra.
>
> It was really interesting because I took a class in *the* Spring semester of last year that was called advanced calculus or real analysis and it actually goes through and you prove all the things that you use in algebra and pre-algebra. It was really interesting tutoring these students *during the* summer because I got to use the things that I'd learned to actually help people, which is my goal in life. So yeah, that was nice.

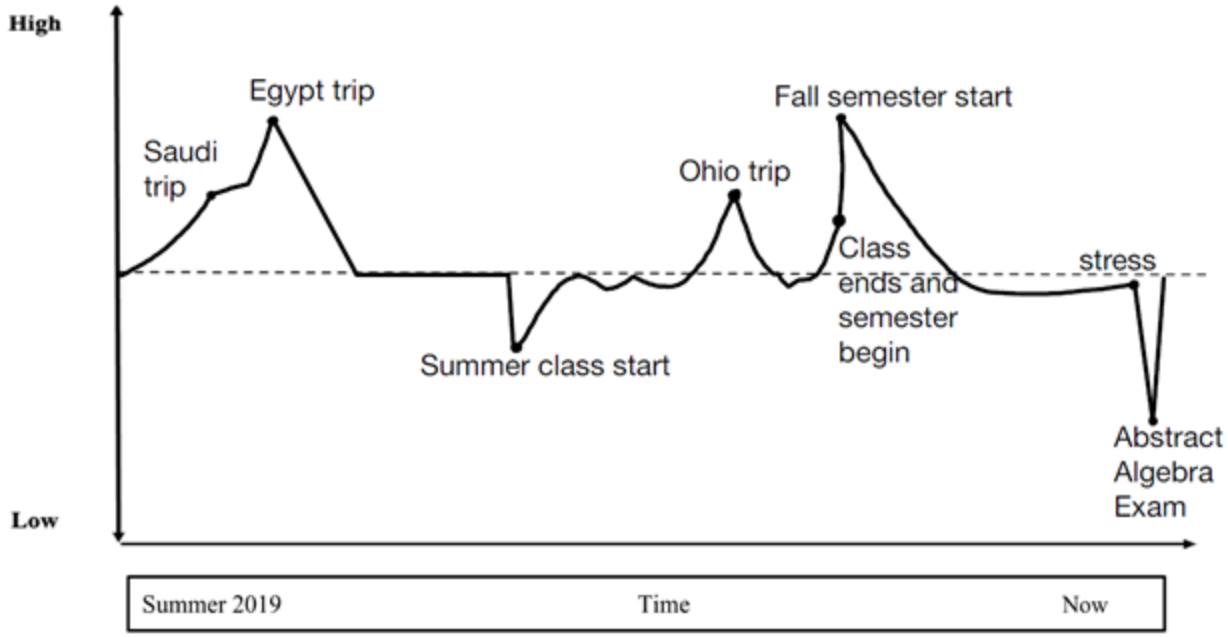

Figure 1. Prior to the interview, we ask each student to complete a journey map indicating their high and low points throughout the semester. The high and low points (as seen on the Y axis) represents their positive and negative experiences. Adriana's Journey Map for the first semester of Year 3 in Engineering.

> *When I returned from my visit abroad*, I took a class called "Minorities in America." *I learned* about the history of a bunch of different minorities. *This course influenced my experiences in* engineering *because* we're always working in teams. I think having a basic understanding of, well, minorities *and* what they go through slightly, is really good to have because you are going to be on a team with people who have been put down in the past because it's like who they are. I have a goal actually in my future engineering career *to make* sure everybody feels valued *on the team*. I went into the class kind of already with the knowledge of appreciating everybody for who they are. Again, just because of my background, but I think the class just took it up a little bit if that makes sense.
>
> I think *the class* just gave me a more in-depth knowledge of what minorities go through. Because again, I'm not really a minority and so I don't know *about their experiences*. Of course, I don't understand everything. I don't go through it, but *the course* helped me understand a little bit so that I can pretty much, I can better serve the people that I work with. As for being on a team and stuff like that, I actually, I did this, and I tried hard to do this in one of my projects *during* my freshman *and sophomore* year. I just kind of, I'm a natural born leader. And so, whenever I'm in a group, unless there's someone who knows more than me about what we're doing, I tend to fill the leadership position. And so,

whenever I am in that position, I try my best to ask everybody how or what they feel most comfortable in the project that we're doing and how they would feel most comfortable contributing to what we're doing. Because normally the things that you're better at, you're more comfortable with and therefore you're going to have more pride in it and you're going to do better in it if you're more comfortable with *the task*. And it worked really well for the two projects that I was on; we had a really good team that we came out with good products.

Thinking back to a project that we did last year, which *included Michael, and* another male engineering *student*. One of the best project teams I've ever been on *was for* Circuit Theory II. It was total teamwork and collaboration. We were all putting in ideas, and we delegated tasks based on what people again were best at and what could execute properly and successfully. And it was just great because a lot of times I throw things out there, and they'd be like, "Ah, yes, good idea. Let's do that." And it's like, "I'm part of the team."

Whereas in my class, Digital logic design, a lot of engineering men that I've met will mansplain things because they assume that the female doesn't understand it. Which is wrong. I understand things. But I actually had that in *the digital logic design* project. It was stressful of course. And I was doing a whole bunch of work on the board because even though it wasn't technically required for our project, I needed to do it so my brain could fully understand it and write the code better. And there was this, my friend, he was sitting behind me, and he's like, "You don't have to do that, right? Why are you doing that? Why are you doing that? You know, you don't have to do that." And I kept saying, "I need to do this so that my brain understands it, right? And so that I can get it and do the project." And he's like, "You don't have to do that. Why you doing that?" And then he would go and tell me where I was wrong on the thing. I'm like, "You're doing your thing. I'm doing my thing. We're not even working together in any sense." It was just, it was not fun. But it's okay. I did well on the project, *despite that experience*.

Now, I'm taking a few classes *such as* signals and systems, electronics, computer organization, oh and internship prep. But I don't really count that as a class. Signals and systems is actually taught by the chair of my *engineering* department and she's a woman. I love her. But I've had a good time in that class. I've really enjoyed the content because it's interesting, and it's really math based. And so also being a math major, I really enjoy that. And yeah, I'm nervous. It's been slightly difficult, but I have my first test tomorrow, so, yeah. We're going to see how that goes. I think it'll go well.

The course is difficult just because there's a lot of things that you have to take into consideration. We're actually *covering* one of the hardest topics in signals and systems. It's called convolution integrals. And it's just, it's weird and there's no one way to do it. You have to do differently every time. And so, it's just, it's more difficult to think about it

in that way. But I think because I've also taken math classes where you have proofs that you have to do differently every single time. I'm better equipped for it, but it's still hard.

I mostly understand what's going on in class because I take good notes, and I tend to be focused for the most part. For a while there I was getting 80s on my homework, and I didn't feel that *those grades* reflected the knowledge that I felt that I had. So, I started going to the professor's office hours and having her explain homework problems to me that I didn't understand. And, I think it really helped because some of her homework problems are a lot harder than the examples in class or on the exams. So, I was struggling because they're harder. So, I think going to her office hours really just cemented my understanding of certain things and also gave me confidence to be like, "You do know what you're doing." Because a lot of the times I had really small questions that I kind of already knew the answer to, but I just wanted to check. And so that's definitely been a resource that helps me *understand the material*.

I have the same teacher for Electronics. She runs her classroom the same way *for both courses*. We have a lab for *electronics,* and I am partners with a male, a junior electrical engineer, and he had been really great. We've worked through problems together, and it's been really helpful. But yeah, other than that I just had the same issues with the homework *assignments* in electronics because of the way she runs her classroom. *She designed the course where the homework problems are a lot harder than the examples in class or on the exams.* But again, I went to her office hours, and I had her help me, and I think I have really good understanding of it. I got a 97 on her first test, so I'm feeling good.

In addition to homework assignment in Electronics, we work with different groups of programs. One of them is Multisim where you're essentially simulating electrical circuits and different circuit components. And, the other one is we use the NI ELVIS Board and the NI ELVIS Instrument Launcher, which the two go together pretty much. The board has a bunch of functions built into it and you use the instrument launcher to, that's the software that goes with the functions. The functions that are on the physical board so that you can measure a whole bunch of stuff and make functions and all this stuff. It's amazing. I have never used a board like it, and I love it. I'm very picky with who I choose as my lab partner because I know how a lot of engineering males are wired. *Some men in engineering* will not listen to me as much as *they* listen to themselves *[male peers]*. It's just how it is. But I'm very picky in the people that I choose, so that when I have a lab partner, I'm not frustrated every time we do a lab. And so, his name *is Michael* and he's great. We work together on a whole bunch of things. And we've done I think six labs at this point, and it's been great. So, I'm really happy about that. He's, how many? Probably one of five or six. Well, no, let's go 10, well to round up, engineering men who I've met, who I know that I could be on a group with and be like, heard a lot of the time, if that makes sense.

This course is interesting because we're learning to code an assembly language, which is not a normal code that many people know. It's like normal code assembly language binary. *This language* has been difficult just because you essentially have to learn a new language. There's syntax and there's new words that you have to learn. They just have English syllables or English-like letters in them, but that's about all that it resembles to English. But it's been hard, but it's been really interesting because again, I love coding. I actually just finished the first project and I'm super happy about it. But it's really interesting to see how the computer views the code that we give it. And so, I'm having fun with that because we're also going into a little bit of computer architecture. And so, we're learning, why you're going *to* use certain registers and not use other ones and where the computer stores certain things and why it doesn't store it in other places. So, it's really interesting.

I love code because I have a very math-centered brain. Very much so. And so, code is actually, it's not mathematical in the sense of when you look at it, but how you problem solve through it is very similar to how you problem solve through math problems. And so that's why I really enjoy it because it works for my brain. Because I love problem solving and so I find a lot of the times with other engineering courses, it's more find the variables, plug them into the equation. It's effective, and it works. But I really like coding because it's all problem solving. You could do it million different ways, but one of them is going to be best, and it's just, I enjoy it. And you can always go back and change things and fix things and make it better and improve it, which is also interesting.

At this point, I'm definitely starting to feel more prepared. I still don't feel prepared to get a job. I don't think I ever will. But I am really hoping the job will help me once I get there, which I think it will. But as I gained more and more knowledge through my engineering courses, I'm definitely starting to identify more as an actual engineer and not as much an engineering student if that makes sense. Because an engineering student is an identity all of its own because it means working hard all the time and having a lot of things to do and taking hard classes. But then being an engineer is also, is kind of being able to take that knowledge and apply it to things. And my classes are finally at the point where I'm starting to realize, "Oh, that's how that thing works in the real world." For an example, this is really weird, but in my electronics class, we learned about rectifiers, which is something that's used in power grids a lot of the time. And so, it was interesting to learn that because I actually possibly might want to go into the power industry.

Early on, Adriana set a precedent that she was not interested being "the girl" who took notes during project meetings. Instead, she was adamant about making significant technical contributions to the project. This attitude has persisted throughout her third year in engineering where she has learned to be intentional about selecting team members like Michael. Michael and Adriana have worked on several labs together and she values how they are able to collaborate and maximize one another skillset because she's had adverse experiences with

other men. Her adverse experiences involve some men not listening to her perspective or "mansplaining" concepts in engineering assuming women would not understand. These experiences may influence her admiration for having a department chair who is a woman, and genuine interest in the courses taught by her department chair.

Spring 2020

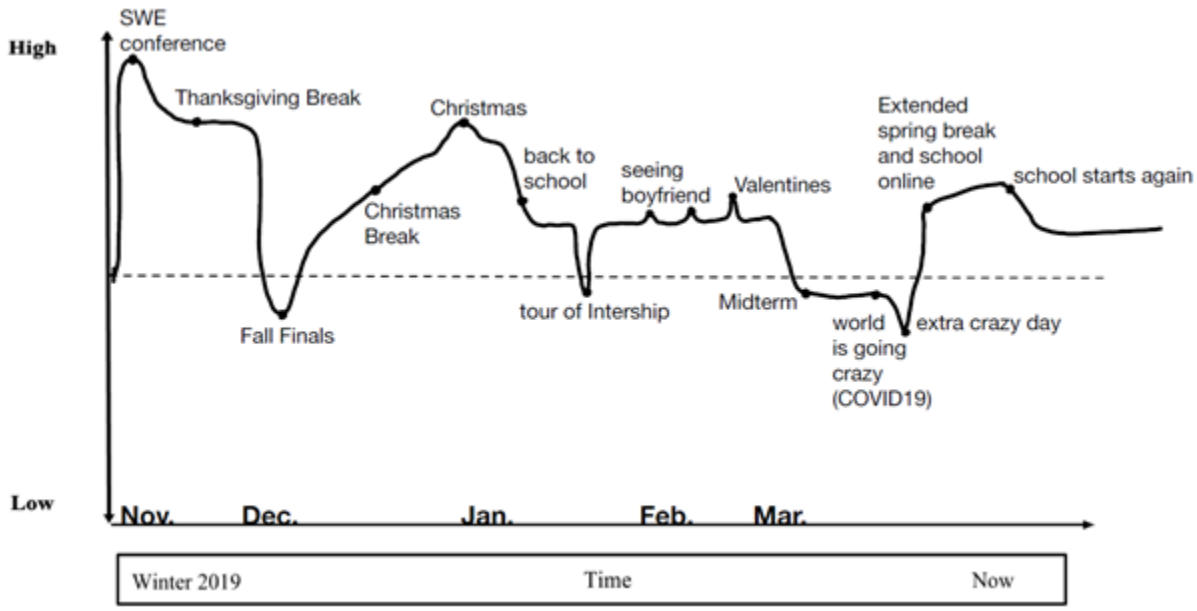

Figure 2. Prior to the interview, we ask each student to complete a journey map indicating their high and low points throughout the semester. The high and low points (as seen on the Y axis) represents their positive and negative experiences. Adriana's Journey Map for the second semester of Year 3 in engineering.

> In November *of 2019*, I went to a SWE conference and that was a huge high for me because I got multiple internship offers for this summer. *It was* unlike anything I had been to before; it was amazing. That conference is such an incredible opportunity because there 's hundreds of companies there and they're all there to hire women, which is not something that you get usually in engineering. There were some guys there and I actually asked some males looking for jobs and I actually asked one of them like, "Why are you here? They're looking to hire women, what is it going to look like if they come back from a SWE conference having hired a male like for these companies?"
>
> And he's like, "Well, some of these companies I would never get to talk to otherwise." And, I'm like, "All right, that makes sense." Because Boeing, Lockheed Martin, Tesla, and Apple *were at the conference. Including other companies and* it was incredible. I started out with the conference hoping to maybe get interviews with a couple of lower level

companies that I knew, not low but like not Apple. But some like mid-range companies I knew from Southern California and I had already had a little bit of contact with and maybe getting an interview with them, hopefully getting an internship.

A lot of my friends were going for the big-name companies which were Boeing and Lockheed Martin and Northrop Grumman, what we ended up calling the Trifecta Aerospace. And I was really confused because I was like, "But they're such big companies. They want the best of the best; I could never do that." And then at one point I think, actually it was the very first day of the conference. I didn't have anything to do in the morning before the main fair opened up and so I decided to go to a *meet and greet with one of the companies. The meet and greet was* pretty much food and drink and a bunch of interviewers, that's all it was, or a bunch of reps looking for people.

I decided to go because I'm like, "I have nothing better to do at this point. You might as well get the jitters out and goes talk to some random people. I will not get anything from this *meet and greet* but we'll see." I spent I think at least an hour and a half there talking to six or seven people just working my way around and it was really interesting because I almost got two interviews out of that. I had a lady from Chicago wanting to interview me and when the guy from Southern California heard about that, he's like, "Nope, I'm going to steal you, you're going to interview with me." I'm like, "Okay." I probably looked like a lost excited puppy during the entire thing.

Originally, when I went *to the conference*, I was more just really nervous. The one interaction that I'd ever had with actual companies was the year before, trying and trying and trying to apply for internships and getting nothing from it. And so, I think I just had such a low, not really self-esteem but almost from that, that I went in thinking, "I am not good enough for these big companies." And then the first day when I went to the hospitality suite, it was only because a couple of my friends were going and I'm like, "There will be no better use of my time, I might as well go and see what this whole thing is about."

And when a couple of people there actually showed interest in me, I think that's when my shift *occurred* because I was like, "Oh, these people are actually interested in me, maybe I am actually at some value to them." And so, from there on out I started maybe talking to the bigger companies, I still didn't talk to many of them because again, I was nervous. Next year, I'm not going to make that mistake, but it was awesome. But my shift came when they actually started showing interest in me and wanting to interview and stuff like that, so that's great.

Another highlight of the conference was when one guy explained to me what he did every day. I giggled audibly in front of him. It was very awkward, but I was just so excited at the prospect of doing what he did working with aerospace. I was introduced to so many more

things that I didn't know that I could do which was an incredible opportunity, and I would tell every single women engineer that I know to go to the conference because it's amazing.

As a result of the conference, I received an internship offer with a global defense company. I got multiple internships offers and it was a really big high for me because I think it was the first time I realized that I'm like, "Wow, I am qualified to do things. People actually want me to work for them." Okay, what? So, it was really great because I got about five interviews while I was *at SWE* and two internship offers out of that. It was really great to actually feel like something was paying off out of all the hellish school that I've gone through.

Then, after *SWE, I went on* Thanksgiving break, *which is* always a good thing *to* hang out with family *and take* a break from school. Then right after Thanksgiving is finals and of course that's always a relatively stressful time for students. I ended up doing pretty good last semester. It was all right; it was just a stressful week or so.

Then Christmas break and Christmas, again, always a good thing. I visited my dad *abroad, and* my entire mom's side of the family got together for Christmas and we haven't done that in a few years, so it was really fun. Unfortunately, *I didn't tutor anyone while I was abroad* because I came into the country as soon as school had ended, so parents don't really have any need when there's no school happening. So, I didn't do any tutoring, but it was mostly just hanging out with my dad, hanging out with a few friends that were back. I think I was there for maybe a week and a half, maybe two weeks. And honestly, the only reason I was just to spend time with my dad because he's still has to work during that time, some of the time. But it was great, I just baked bread and did nothing.

Then, *after Christmas break,* I went back to school, which always makes things a little bit harder because it's school. In the middle of January, a few weeks after I had gone back to school, I did a tour of the place where I got my internship and it was a low point for me which is confusing because it sounds like it should be a high. But I got completely overwhelmed, I started thinking, "Wow, this is a natural, intense company. I can't do this, I am not qualified for this, I am going to fail." And so that was a low day for me, low week after that honestly because it was a lot to take in.

While I was on the tour, they *walked* me through some labs and I got to talk to the *person* who I believe to be the overarching manager on all of the ground systems, which was really cool because he's actually the one who hired me. But yeah, so it was completely overwhelming because I sat down with this manager and he laid out to me pretty much what his entire department does. There's two different main sections of the department that I could have intern for, and a lot of people throughout the day just kept asking me, "Oh, what do you think you'd be more interested in?" And I just kept answering, "I have no idea. I don't know what I'm doing." I didn't say that, but I just said, "I don't know." They

both sound interesting and I'm really not sure. But I think it was overwhelming because people kept asking me questions and I wasn't sure how to answer them. I'm like, "I'm just a little baby. I'm just here to learn, I don't know." But yeah, it was a lot. And then I did speak to some of the other interns turned hires, and it was just, again, they asked me a lot of questions that I didn't know how to answer. And I felt, I don't know, they were all very kind to me and gave me a lot of information, but it was also just, I don't belong here feeling probably because I was an intern and I was just touring. But it was very interesting and again, I've never been in an actual working environment before and so it was just weird and freaky. I'm going in, I'm trying to be all confident and then realized that I wasn't dressed right. I was dressed too professionals, which is good because that's better than less professional. But I was just, it really hit me that like, wow, I really have no idea what's going on. Because they showed me some of the projects that they were working on and I was just like, "Wow, that's a lot." I'm sure it's slightly less intimidating when you actually look at like the specifics of it because then you can break it down. But we're just looking at the overarching thing, I'm like, "Oh dang, I can't do that. I don't know how to do that." So I'm really hoping this summer goes well, I'm trying really hard not to dwell on it because I know they, no insurance, no nothing, but it's also a really big company. So, I'm like, "Well, maybe I am the best. I don't know. Who knows? We'll see." So yeah, it was a day, I got to Starbucks after that. I got a big fat Frappuccino! I'm like, I need comfort food.

Aside from the tour, right now, I'm taking microcontrollers, Electronics II, linear algebra, engineering junior design, control systems. Oh, and leadership cohort. *Microcontrollers is* like the only class I have issues with. I am being taught by an older gentleman who has very interesting opinions on a lot of things that differ from my opinions. And so, it's been a frustrating course because he's a very scatterbrained man but a lot of times, being a professor, that comes off as him not being prepared. And so, it's very frustrating as students *considering* we are constantly expected to be prepared all the *time, so when* a professor isn't *prepared,* it's very frustrating. *Not to mention, our class* going online has not made it any better. I was really hoping, the university extended our spring break by a week to give the professors an opportunity to learn how to do all the online software which is great for them because I know that's a hard transition.

When my professor in microcontrollers says he's going to post things and they have a due date, he *actually* posts them four days later with the same due date and I'm like, "That's not okay, you can't do that." But I've just had a lot of frustration this semester with him not listening to students' concerns or ignoring them completely or occasionally being slightly sexist, which is not okay with me and it's been a lot. My grade is still good in that class luckily, but it's been a frustrating ride, and I'm very happy to be done with this course in a few weeks.

I have a binder of notes *for my microcontrollers course*. I actually have a, or I had, because right now we don't have class, or we do but it's online. I had a bunch of sticky notes in the back so that when I got frustrated with the professors, I could not glare at him but instead doodle on a sticky note and I actually have like five or six little doodles in the back of my binder now. But to me in class, the content is relatively easy and so it was just kind of sit, highlight things on your notes, that was about it.

But, sometimes those frustrating situations would come up where a student would point out maybe something that was confusing in the lecture or didn't seem quite right and he would constantly tell the students that they're wrong, even when multiple students in the class were agreeing with the other student. He wouldn't even acknowledge the fact that he might be wrong, which was frustrating. I've actually asked him multiple questions that he never addresses, *which* happens quite often. Like he says he'll get back to me or get back to another student in the class and then it never happens. It's actually come to the point where somebody will ask a question in class and later on, a student in my class will email all of us the answer because they looked it up and they figured it out, which is kind of depressing but great because I have that peer group who does that. But a lot of times in class he will move us on to the next portion of the lecture because he has to get through stuff that kind of makes sense, but it's never really addressed after that.

There was one point in lecture where he referenced something on the board and he'd be like, "I don't really know what that means so, viola," and then just get going, we're all like, "Okay. That's great, all right." Maybe it's important, who knows? It was a great moment.

The people that I'm close to in my classes could always see when I was frustrated and what I always like need little smile or a little pat-pat because I wear all my emotions on my sleeves, so it's obvious.

I'm honestly not sure how much relevant information I'm going to gain from this class so it will be interesting to see if I ever use it again and if this frustration was worth it.

I question whether this information is relevant because it's very specific. It's a microcontroller class so we're focusing on one type of microcontroller. And I understand how maybe some of the general overarching concepts might be useful if we ever worked with microcontrollers in our career but there's no guarantee that we're going to work with this very specific microcontroller. And the course is actually, it's a pre-made curriculum by Texas Instruments and I love them, they're great. But my professor is trying to adapt it in ways that don't always work, but the course is centered around a little robot that can move around and race and do other things.

So, all of the lectures are tailored to that purpose, and so it seems like when we don't have a robot that's moving around, are we going to use all this information? I don't know. I feel

like if there was maybe a little bit more, what's the word? Like differentiation in the examples, it might become a little bit more useful because you can see another context. I might get to the end of this course and be like, "Oh my gosh, I use this stuff all the time and I just don't know yet."

Engineering junior design is actually a really interesting course because I think the specific name of it is engineering documentation and design. *Throughout the* semester, we think of a project and then we go through the documentation of that project. So unfortunately, especially with COVID-*19 pandemic*, all the school being online now, we don't actually get to build our project. We were going to make an autonomously flying drone which would have been super cool, but we no longer get to make project.

We had all the parts, *including* the sensors. The drone was put together, but we can't make it, it's very sad. But that course was really interesting because it really is giving us an eye into how much work goes into a more professional project rather than what my professor calls a garage project where you don't have to document anything, you just make it.

In the junior design course, I have a great group. I'm working with two or four other guys; I'm the only girl and they've been really great. We have two kind of sort of designated leaders. There's one guy named *Chase* where he actually worked on a project very similar to this in an internship *that* he had last summer. And so, he kind of has an idea how the project would flow and what things we need in order to build it, but it was interesting seeing everybody else's take on it. And then also, I've kind of become the administrative leader just trying to designate tasks and keep everybody going and made sure everything's tipped up, so we all get A's. *Overall, the project has* been really interesting.

I've really liked working with my group because they're all very respectful and nice, which is cool. We had a $500 budget for this course that was paid for by the university and so all the materials that we bought, we had to order through our professor and through the head of our department. So again, it was very much what I assumed to be like industry because I had no idea what industry is actually like, but it seemed like it, so that was really cool.

We realized how repetitive the documentation is because we really wanted to just go ahead and do the thing because we know what we needed to do. But a lot of the steps along the way, we were actually premature and so we were having a hard time going back and trying to kind of document things, trying to document the thought process of things that we'd already done, which was really interesting. And I understand the importance of it especially when you're working at a break project, you need to make sure that everything's actually going to fit together before you do something, it's just something that a lot of us haven't experienced before.

Although the course actually does not require us to build it, we wanted to build it because we wanted to build it. But, the course itself is focused on documentation and so us not being able to actually get together in a group fortunately hasn't affected pretty much anything. We still have the same amount of assignments so what we do now is we go on Discord for about two to three hours a week, three to four, three to four hours a week. And we'll work on the documentation portions of our project which we do through Google Drive. We did that previously as well. So, for that course specifically, *transitioned to remote learning* hasn't really changed much except how we meet, which is now no longer in person but online.

Although the junior design course didn't change a lot, a lot of my labs have changed though because we don't have access to lab equipment and the school isn't going to require us to buy like a $3,000 box. So, a few of my labs or one of my labs had been canceled and a lot of others have gone online to MATLAB simulations, MATLAB or Simulink or Multisim.

Three *of my* courses have labs, which is the microcontrollers, electronics II, and control systems. Now, the control systems lab has altogether been canceled, well, sort of. There's one more lab that is an online simulation as well, they're still formatting that, we haven't got it yet. But, the rest of the labs have been canceled because a lot of those labs have to do with a very specific software and very specific set of tools that you have to use, and they're all based on that.

So obviously if we don't have those tools at home which we don't, we can't do it and so then microcontrollers is again the frustrating class. The professor claims we're going to do two or three more labs in the rest of the semester, but he told us he would send it to us on Monday and we still don't have it. So again, with that one, I really can't say if we're going to continue. Unfortunately, there was a whole bunch of stuff that went on that I honestly probably should added another low now that I think about it but almost all of my belongings are still at university because I came back.

Currently, I'm *not on campus.* I *left* for spring break just to hang out with my aunt and uncle. *However, while I was away for spring break,* the university informed us that we had to move off campus. But my aunt and uncle's job has told them that if anyone in their household goes 50 miles or more outside of *the city limits,* they cannot come into work for two weeks because they might be infected. And so, my school's 150 miles away, so since I'm planning on living with them which I am now, I can't go get my stuff.

Unfortunately, that also means that for the microcontrollers, the control board that we had in the processor unit is at school and so I don't have it. So, I don't know how he's planning on doing the labs for that. And then Electronics II, all of those have gone online to simulations through Multisim.

We learned a new IDE for this specific TI controller but [...] I don't know. *The lab* was mostly pre-made code that we would go in and either expand, edit, or change. Well, edit and change is like the same thing, but you know what I mean. And so, most of those labs were observation of some sets of code and then expansion of another code. So that we could observe what we need to do and then actually do it. Sometimes it was confusing to see how they match, but most of the time it was quite closely linked to the actual lectures because again, it is a pre-made curriculum, so everything fits together kind of well, pretty well.

Yes, I love this professor *for Electronics II.* She is the only woman in the electrical and computer engineering department, and she's awesome; she's the head of our department. So, I really liked that course, *but* it's not a course that a lot of people like. *A lot of people don't like* electronics I and II because it is quite difficult and while you are dealing with physical objects it's hard to visualize them because they're so small, like the length of it will be nanometers small. And so, for me, I really like it because it's like almost completely mathematical, like even the theory that you're doing is theory with math. And so, me being also a math major, I really enjoy that because I like math. But yeah, I've really enjoyed that course, it's been hard sometimes but I actually just took a test earlier today in that class and I think it'd be pretty well so it's getting kind of cool.

I love that she's a woman. Like it's just how it is, we bond together, we stick together. I also really liked the course though, again, because it makes sense to me, which is strange because for a lot of people this is one of the hardest courses of junior year, but it just makes sense for me and that happened a lot. The hardest courses somehow just do that, sometimes, some of my math courses not so much, but that happens a lot of time with engineering. But then the easier classes I have a hard time with, it's very strange.

But I really liked the course because she's been teaching it for so long that it's very organized. It's already put together in a way that very nice and it's easier for her to deliver. And I also just think she's an absolutely fantastic professor. She's really interested in what she's talking about, which is always good because when people are passionate that tend to explain things better. But I think her teaching style also just fits really well with my learning style, so she'll present like the equations and stuff like that and then go through examples, which is how I learn more, so I enjoyed that. There's been a few times where I'll go to her office hours and be like, "I have no idea how to do any single question on this homework." And she will sit there with me for hours and helping me through each one and she's just very sweet in doing it.

So, *the lab for Electronics II* is one of the most difficult labs. Electronics I *was difficult* as well because there's always so many little things that can go wrong with like transistor chips. My lab partner and I last semester were using one transistor chip all semester, and

every single lab we had hours upon hours of issues that we set it up right, everything was like programmed correctly. But when we actually ran it, it wasn't working, and we had no idea why, but we had a different lab professor then. This semester, our very first lab, we realized that our chip was bad, and it wasn't working, and it was the same chip that we had used all of last semester. So, *when we realized that it was a bad chip,* we're like, "Well that makes sense." The lab is mostly difficult because all the circuits are very intricate, and you can put one thing in a slightly wrong place and your whole circuits messed up and it's very hard to find where you've gone wrong. So, it was very interesting to see the simulation results, or the not simulation, the actual experiment results. Because a lot of times they are very closely correlated to what we're doing in class and so they actually prove what we're doing, or sometimes they show that the theoretical and the actual are so completely different that why do we calculate the theoretical, we had a lab like that, where our theoretical was like a value of 70 and then our actual was value of 40 and we're like, "*Professor,* we must have done something wrong." *However,* she was like, "No, that's still right." I'm like, "What?" But yeah, I like it.

My other course, leadership cohort, is essentially a book club. We read a chapter or two of a book about leadership or about something else. Right now, we're reading about the consequences of innovation. *I have* no idea how that has to do with leadership. I'd BS my way through it, it's fine. But it's essentially a book club where there's only seven people in my course. So there's eight, including the professor and we read these chapters. *Then,* we write what's called a format which is essentially a summary and then reflection on the reading. Then we take one hour a week and we have a discussion about it. It's really interesting because at least once every two weeks, at least my professor in that course will point out that I'm the only girl in there because it's section by major. And so, I'm with all the ECs and of course EC is mainly male. And they actually tried to section by gender. So, there is an all-girls section of this, which I think is ridiculous. But, unfortunately, I could not attend to that meeting time and so they had to put me on one of the guys sections, but I really don't understand why they do it by gender. I think maybe so people feel more comfortable, but that's also slightly ridiculous because you always have to deal with the other gender when you're actually in a working environment. We just sit around and talk for an hour about whatever the reading was.

My linear algebra course is my only course of this semester, that's not engineering. So, it's *with* the math department and it's with a professor that again, I really love him, he's fantastic. I've taken only one other course with him, but I've also heard so many things from so many students where they absolutely adore him, he's a younger professor so I feel like he relates to the students a little bit more. But he's also just very good. Again, I think he's done this for a while and so he's just very good at explaining what he's talking about. And he's also one of those who's just very compassionate, and if I'm not understanding something, I can go to his office hours and he will fully explain it to me. And no matter

how many times it takes, because last semester I had him for one of my pure math courses for Abstract Algebra II, which again, you can sit there for hours and not understand something because it's just so weird and abstract. But yeah, I'm enjoying that course, also because it's pretty easy, it's my easiest course this semester I would say but yeah, it's going good.

I can't say *I navigated the semester* 100% gracefully for sure. I've actually started talking to a life coach throughout this semester to help me deal with some of the stress that I feel when I get into those positions. But mostly just trying to take it one step at a time, I tried to identify the things that are stressing me out and then I try to work through them so that, because most of the time it's academic just because that's what my life is right now. And so if a test is stressing me out, I will study for it, and then that tends to release some of my stress because I feel more prepared. With the internship, with the tour, it was more just reminding myself that they don't expect me to know much and I will sit in here more when I actually work here. And it's just trying to take it one step at a time and to remind myself that I'm going to be okay. And then midterms of course it's just, again, it's academic, so just trying to take it one test at a time, trying to get through the week, that sort of thing.

Then, *the* COVID-*19 pandemic* happened and that was just insane, it's really interesting because my parents are kind of stuck around the world. Luckily *my mom is* able to come home, she's actually coming home on Sunday, so I'm super excited. I might actually get to spend time with her this summer, which is cool. But yeah, that one's a little bit more difficult. But my roommate actually had some very strangely simple but effective advice because I'm a planner, very much a type a person. If I don't have a plan then I don't know what's going on, when things are changing, I panic, which of course is not good in this situation because things are changing like every two hours. My roommate said, "Just have a plan to not have a plan." And I'm like, "Huh, that kind of works. Okay, I'm going to do that." So pretty much from then on, I've just been taking it one day at a time and not really worrying about it too much, hopefully, I'm trying, I'm trying really hard. I don't know if it's 100% working, but yeah.

Overall, I think I've definitely had more progress *over the past few months* because I finally, do have an internship and have really communicated with people in the industry where I hadn't really before. And especially also with the project that I'm doing in the project course I'm going through; I'm getting what seems to be an experience with what I might actually be working with or what it's kind of like to work. And especially with my classes becoming more higher level, I think I'm sort of on the way, like I've taken a few steps forward, but I'm definitely not an engineer yet for sure, I'm still a pre-engineer and I know that. I don't think I'll feel like I'm a full-fledged engineer until like a couple of years after I've graduated. But yeah, I think I've definitely taken some really important first steps into feeling like I do belong in engineering. Not really that I belong, I know I belong here

> because I'm good at it, but more comfy in it, if that makes sense, that's a really weird way to say it but that's the only thing I can think of.

Throughout Adriana's narrative, she emphasized how gender played a role in her experiences as an engineering student. She continued to describe her adverse experiences in engineering with her peers and professors, who were men. Despite these experiences, she found solace in attending a national conference tailored for women in engineering and taking courses with her department head. Since gender is a common construct described throughout Adriana's narrative, below, we discuss her gendered experiences and how these experiences influence her identity trajectory.

Discussion

The purpose of this executive summary is to describe the progression of this research project, which focuses on characterizing latent diversity and understanding how engineering culture contributes to latently diverse students' identity development and innovation. Several insights can be drawn from this single narrative within the larger study. We also note that there are numerous other narratives to draw insights about students' engagement in the culture of engineering to examine in this work. For brevity, we present Adriana's story and focus on one common thread woven throughout Adriana's narrative, which involves her gendered experiences intertwined with her identity as a latently diverse student.

Throughout her story, Adriana recalled multiple accounts where she distinctly described her teaming experiences with men. While she recognized some of the men in her courses as excellent collaborators, she also described how the other men failed to listen, recognize her contributions to the team, or expected her to take on gendered roles (i.e., administrative tasks). In addition to failing to recognize her contributions to the team, Adriana described a scenario where her peer undermined her learning and problem-solving process in Digital Logic Design. Her peers did not see value in her process of understanding and writing code because this particular process did not "count" towards their grade. However, Adriana did not conform to their perception of thinking, being, and knowing valued in engineering. Instead, she continued using her learning mechanism to ensure she is prepared to apply her engineering knowledge to a real-world context in the future. Additionally, Adriana discussed the empowering experience of attending the SWE conference in seeing and networking with other women in engineering. These instances in her narrative illustrate the importance of networking on her identity development and how various interactions can both constrain and enable her engagement with engineering and perceptions that her ways of being, thinking, and knowing are valued.

These examples highlight how students like Adriana may face a disconnect from their peers' motivation beliefs and the curricular expectations of what is required to learn and apply the material. These findings support prior literature that suggests gender is "deeply embedded in institutional structures as a means to preserve male privilege" [13, p. 385]. Like many engineering

departments, Adriana's program is not unaware of these concerns and tried to create a structural solution by creating gender-segregated classes in leadership and innovation. However, this institutional approach did not support Adriana within her education and instead created an environment where she was the "only one" (because of class scheduling). Adriana also focused on the reality that this structural solution "was ridiculous" and did not reflect "when you are actually in a working environment." This illustration emphasizes how institutional strands (policies, procedures, etc.) can impact students' educational experiences and should be considered alongside networking and intellectual strands. Attempting to address these issues requires attention to students' needs and listening to their voices, as overcorrecting with non-student-centric solutions can produce additional feelings of alienation.

In addition to gendered constructions embedded in engineering culture, these narratives highlight particular ways of thinking, being, and knowing that pervade engineering culture, which could result in some students' decision to leave engineering. For example, Adriana discussed her experience of writing code in her digital logic course. Her peer believed that the best approach was to sit down and begin to code within the terminal. However, Adriana wanted to engage in planning using the whiteboard before attempting to code. This approach is consistent with best practices in development but was dismissed in this interaction as not the "right" way of solving this engineering problem. This instance engages both a gendered and stereotypical expectation of what it means to be a successful engineer. Hence, it is essential to understand how students are minoritized both from a social and epistemic perspective due to the complex forces that may result in dissatisfaction or misalignment with an engineering identity.

Future Work

As we progress into the grant's final year, we are continuing our data collection efforts and have begun to develop ways to translate our findings to inclusive classroom practices. As it relates to data collection, we plan to amend the sixth interview protocol to revisit the survey items measuring identity, motivation, and belonging. This data will aid our understanding of whether students' identification in the data progressions identified in the original topological data analysis remained constant or shifted. In addition to traditional dissemination efforts (i.e., conference papers and journal articles), we plan to facilitate a professional development workshop focused on equipping educators with tools to promote inclusion for latently diverse students for the ASEE Commission on Diversity, Equity, and Inclusion in Summer 2021. In this workshop, we also plan to highlight how our work on latent diversity and person-centered analyses can amplify and center the voices of those traditionally minoritized in engineering and provide advances in engineering education research's methodological approaches and positioning.

An additional dissemination effort includes developing a platform to host and share our data and findings from this research project and collect further insight into students' experiences that span this research study. This platform will serve as a resource to faculty and practitioners to engage

with the STORIES (STories of Resilience and Inclusion of Engineering Students) website to learn how to support latently diverse students in engineering and promote inclusion in their classrooms. Also, this STORIES website will serve as a resource for students to learn about how students across the nation navigate engineering culture or leave engineering due to a misalignment between their identity and engineering culture. Overall, this research aims to understand how students construct their identities overtime to promote inclusive classrooms and leverages the dynamic nature of mixed methods research to challenge the ways inclusion is defined and explored in engineering education.

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