

Key Sociocultural Influences Shaping Latinx Students' Pathways to Engineering/CS: An Ethnographic Lens

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The underrepresentation of Latinas/as in engineering and computer science across the pipeline – from undergraduate studies into the profession – remains a persistent challenge. Based on 2017 NSF reports, only 10.3% of engineering and computer science degrees in the U.S. were awarded to Hispanics from 2004-2014 [1]. Similarly, a 2018 Pew report analyzing IPUMS data indicated that only 8% of the engineering workforce and 7% of the computing workforce, respectively, was comprised of Hispanics [2]. Studies from a range of disciplinary perspectives have shed light on some of the challenges faced by Hispanic students, hereby referred to using the gender-inclusive term “Latinx.” Some findings point to the role of decreased motivation and self-efficacy of Latinx students [3], [4], while others take a broader sociological perspective, highlighting the role that a “chilly climate” can play in the attrition of underrepresented minorities (URM) from engineering/CS [5].

The Academic Pathways Study (APS), sponsored by the Center for the Advancement of Engineering Education, builds on more than 100 papers to provide a comprehensive analysis of undergraduate engineering students' experiences throughout the pipeline, from recruitment to persistence to completion and entry into the profession or graduate studies [6]. One section of the APS report focuses on the experiences of women, Underrepresented Minorities (URM), and first-generation college students in engineering, but yields few findings for students who represent two or more of those categories, e.g. first-generation Latinas studying engineering. Our study utilizes an intersectional lens [7] to explore the professional identity formation and persistence of Latinx undergraduates in Mechanical Engineer/Computer Science (ME/CS), some of whom are women and first-generation college students, at a public, research-intensive university located on the US-Mexico border.

Drawing on one year of intensive ethnographic data collection, this paper looks at a sub-set of nine ME/CS program completers to examine the key influences shaping their decision to pursue engineering/CS. The paper adopts a sociocultural framework for understanding students' identities and pathways into engineering/CS education, contributing to a small but growing set of studies in this area [8], [9]. In particular, we draw on prior work in sociocultural identity studies in education to identify the identity resources [10] that enable or constrain students' decisions to pursue and persist in engineering. For the purposes of this paper, we focus on four of the most prominent sets of identity resources that emerged for this sub-set of students: affinity resources, aspirational resources, relational resources, and positional resources.

Theoretical Framework

In this study, identity is conceived of as multiple, dynamic, and situated in social contexts and social practices. Drawing from the disciplines of psychology, anthropology, and sociology, sociocultural views of identity highlight the ways in which individuals learn “to be” (and to perform) through participation in socially-situated activities and practices [11]. Identity is understood, in part, as a process of recognition, that is, as being recognized as a particular “kind of person” within a particular social space [12], e.g. being recognized as a “good student” within the norms and practices of K-12 schooling. For Gee, identity is produced in and through

Discourse, which refers to “saying(writing)-doing-being-valuing-believing combinations” that represent “ways of being in the world” [12, p. 6]. Drawing on activity theory, Holland [13] posit the concept of “figured worlds” to capture identities as formed through participation in “socially-produced, culturally-constructed activities” [13, pp. 40-41]. In our larger study, we focused on the ways in which Latinx students developed and negotiated their engineering identities within the “figured world” of undergraduate Mechanical Engineering and Computer Science. For the purposes of this paper, we focused on how nine participants discursively constructed their pathways to engineering and Computer Science, that is, how they made sense of the key people and experiences that influenced their decisions to pursue the major.

In order to understand the key influences that shaped these participants’ pathways to ME/CS, we drew on the notion of identity capital. Sociologists Cote and Levine [14] define identity capital as “the varied resources deployable on an individual basis that represent how people most effectively define themselves and have others define them, in various contexts” [14, p.142]. For these authors, identity capital are both material (tangible) and ideational/symbolic (intangible) resources that can be “cashed in” for a gain or outcome, e.g. membership in a particular group or being hired for a position [14, p. 143]. Educational researchers have taken up the notion of identity resources to analyze the connection between identity and learning, looking specifically at the material, relational, and ideational resources used by students in the development of their identities as track athletes [10]; and the orienting, technical, relational, and positional resources that supported math teachers’ engagement and learning in the profession [15]. In the present study of nine focal participants, the identity resources that emerged as most relevant in their decisions to pursue ME/CS were affinity resources, aspirational resources, positional resources, and relational resources.

Methodology

As mentioned previously, the findings presented in this paper are part of a larger ethnographic study examining Latinx students’ experiences persisting in and completing their undergraduate studies in ME/CS at a large, public research university on the US-Mexico border. At the time of this study, the university enrolled more than 25,000 students, 80.2% of whom were Hispanic/Latinx, with an additional 4.1% of whom were Mexican nationals [16]. In addition, 73% of the student body were Pell eligible, and 50.9% were first-generation college students [16].

With our focus on students’ identity development within the figured world of engineering/CS, ethnography [17] provided the methodological tools to explore the cultural contexts in which students operated, the interactional norms and positionings that occurred within those contexts, and the meanings that students attached to their experiences. The larger study focused on 27 students in senior capstone courses, with follow-up in-depth interviews one year beyond graduation into the workforce or graduate studies. The research team, which was comprised of two education researchers and two doctoral students in education (three out of four of whom identified as Mexican or Latinx), followed six teams of students enrolled in ME/CS senior capstone courses over one or two semesters, depending on the major (one semester for Mechanical Engineering and two semesters for Computer Science). Teams were selected by the

course instructor, with the primary criteria that the participants be predominantly Latinx and that there be at least one female team member, if possible.

For the purposes of this paper, we focused on two teams that met during the 2017-2018 academic year: one CS team comprised of five members, all of whom identified as male; and one ME team comprised of four members, two men and two women. All nine students were Latinx, defined in the broadest terms. More specifically, two of the nine students were raised entirely on the US side of the border; three were raised in both Mexico and the US; and four were transfronterizo/a (border-crossing) students who resided in Mexico and attended university on the US side of the border. This description of participants points to the nuance within terms like “Latinx” and “Hispanic.”

Table 1: Focal Participants

Name (Pseudonym)	Major	K-12 Schooling
David	Computer Science	Mexico
Herman	Computer Science	Mexico/US
Guillermo	Computer Science	Mexico/US
Javier	Computer Science	Mexico
Arturo	Computer Science	Mexico
Elisa	Mechanical Engineering	Mexico/US
Samantha	Mechanical Engineering	US
Alfonso	Mechanical Engineering	US
Francisco	Mechanical Engineering	Mexico

In this two-year study, we relied on five primary sources of data, outlined in Table 2.

Table 2. Ethnographic Data Sources

Participant Observation	More than 30 hours/semester of observation were conducted of focal students/teams engaged in classwork or out-of-class teamwork on projects.
In-depth Interviews	Three in-depth interviews were conducted with each participant. Interviews were structured using the Seidman method [18] of open-ended questions. The first interview also included a timeline component, where participants drew a timeline of key experiences and people that led them into engineering/CS. The interviews took place in the participant’s preferred language (all

	members of the research team were bilingual in Spanish and English) and were audio-recorded and transcribed.
Video-recording	More than 60 minutes of video-recording were collected across both focal groups as participants engaged in teamwork and project development.
Artifacts	Artifacts included participant timelines, course syllabi, and all documents associated with the capstone course.
Questionnaires	Demographic questionnaires were conducted in order to solicit information about participants' language and schooling backgrounds.

Data were analyzed through an iterative process that involved multiple stages. For the purposes of this paper, we focused on the interview data, which was cross-checked with the participant observation and artifact data. In an effort to understand the key influences that shaped these participants' pathway into ME/CS, we narrowed our focus to the first in-depth interview for all nine students. We relied on a process of "open coding" and "focused coding" [19] where we identified broad themes in the interview data in the first round of coding. Once the first set of codes were established, we returned to the theoretical literature on identity, where the concept of identity resources gained relevance in relation to what we found in the initial round of coding.

With "identity resources" as a frame, we initiated a second round of more focused coding. In that round, we identified at least seven sets of resources that emerged in participant interviews; for this paper, we will focus on four of the most relevant sets of resources: affinity resources, aspirational resources, positional resources, and relational resources. We also identified ways in which resources could act to constrain participants' pathways into and through engineering/CS; we called these "counter-resources." It should be noted that this analytical focus on identity resources is not intended to be predictive in orientation, but rather explanatory, as we sought to understand the key influence shaping students' pathways. All four sets of resources will be explicated in the next section.

Findings

Across the nine participants, four sets of identity resources were identified in how participants talked about their pathways to the ME/CS degree: activity, aspirational, positional, and relational resources. These resources most often served as enabling and facilitating elements in participants' pathways. For some students, however, the same *kinds* of resources operated to constrain their pathway into ME/CS; these counter-resources will also be explored in this section.

Affinity Resources

One category of resources that emerged in participants' accounts of their pathways to engineering/CS related to the affinity-based activities in which they engaged during childhood

and adolescence. In this way, we signal Gee's concept of "affinity spaces," understood as spaces of informal (but effective) learning through participation in a "common endeavor," with one example cited by Gee being found in online video games and their accompanying interactions among players [20].

Five of the nine students in our study highlighted participation in engineering-like activities outside of school as significant to their decision to choose engineering/CS. These activities can be visualized on a spectrum from weak to intense, in terms of level of participation, and loose to strong, in terms of their connection to the field. One example of weak participation in loosely-related affinity-based activities came from Samantha, a mechanical engineering major. In her interview, she indicated that she liked war movies as an adolescent, and she was drawn to weaponry; during her team capstone project in mechanical engineering, however, she positioned herself in one instance as an outsider in the machine shop, saying that she did not know how to use the equipment, a situation which adversely impacted her team's project development. On the other end of the affinity resource spectrum was David, the team leader in the CS capstone project, whose way to socialize with peers during high school years was through online video games. In his case, during high school, David and his friends used the school's wireless internet connection, which was banned, to play online games, which resulted in a battle against the school's internet security team to break down the system that was supposed to prevent them from playing. As a result of the emphasis on these activities, David reporting gaining specific skills in programming, hacking internet security systems, and establishing secure and private internet networks - all of which represented an intense level of participation in a CS-related activity that was strongly affiliated with the field.

Another mechanical engineering major, Elisa, described knowing that she wanted to be a mechanical engineer since middle school. One key influence was participating in building activities with her father: "We have to make a table...then I was the first one to go help my dad build it all. I always knew that I liked to build and that I liked mathematics. I was very curious about building and taking things apart." In this quote, Elisa - who was positioned as the leader of her capstone team - describes not only the activity of building with her father but also her affinity for the activity. Importantly, in the interview, her emphasis was on the activity itself; her relationship with her father, who was also an engineer, was more complicated because while he facilitated some engineering-like activities, he also excluded her from others explicitly because of her gender.

Aspirational Resources

A second category of resources that emerged in students' accounts of their pathways to engineering/CS was aspirational in orientation. In using the term "aspirational resources," we draw on Yosso's concept of "aspirational capital," which she defines as "the ability to maintain hopes and dreams for the future, even in the face of real and perceived barriers" [21, p.77].

Seven of our nine focal participants made reference to their aspirations in deciding to pursue ME/CS. These resources can be divided into three categories: economic, sociopolitical, and career-oriented. Six of the nine students mentioned the economic and social status benefits of pursuing engineering/CS. Four of the five CS students (Herman, Guillermo, David, and Javier)

and two of the four ME students (Samantha and Francisco) mentioned their aspirations of having well-paid jobs after finishing their degrees. David's desire for economic stability was closely tied to another, sociopolitical aspect of his aspirational resources: the hope for a green card to be able to work in the United States. Francisco, a border-crossing student who at age 32 was older than his peers, indicated having to choose between a career in professional baseball or engineering; with his father's prompting, he chose engineering: "And so my dad maybe didn't want to see me do that, to be working as a janitor. Which I am not saying anything, it's a job at the end of the day, but I had the opportunity to pursue a career so why would I not follow that path?" For Francisco, the decision to pursue engineering was a decision rooted in economic stability, which he referenced more than once in his interviews. The decision was also very strongly influenced by his father, who was also an engineer; this will be explored in more detail in a later section.

Two ME students, Elisa and Alfonso, also expressed career-oriented aspirations. In her account, Elisa emphasized her affinity for robotics and mechatronics, which was connected to her "curiosity" toward building and taking things apart (mentioned in the previous section). She described researching different sub-fields of engineering, and her decision to pursue ME was tied up in her decision to attend her current university (which only had ME) after graduating in the top 10% of her high school class and being offered a full scholarship. Alfonso, who grew up on the US side of the border to Mexican immigrant parents, described attending career day in second grade, when he heard a presentation on astronauts and realized that he wanted to pursue that line of work:

In the middle of the presentation they put on a show, and I think it was about an astronaut floating in space. And they explained, 'oh this is an astronaut and this is what they do. They live in space away from earth. And I was so shocked. How could a person live in space? I didn't understand, and then after that day they started asking us what we wanted to be when we were older and we would write what we wanted to be when we were older. And I said astronaut. Since that day since second grade, I can remember I always wanted to be an astronaut.

In this quote, Alfonso's career-oriented aspirational resources come to light as something that held meaning for him as he described his decision to pursue ME. It's important to note that these aspirational resources were developed, in this case, within a particular context and set of relations: his discovery of wanting to be an astronaut stemmed from a career presentation at school, and was extended by school-based activities that encouraged students to think about what they wanted to do when they grew up. In this way, this aspirational resource occurred as part of a larger constellation of people and activities that sparked his interest in being an astronaut.

One exception in the group of nine participants was Arturo, a CS major. In his interviews and observations, he did not show an evident aspiration towards economic, sociopolitical, or career-oriented factors. During our interviews and informal talks with him, he did not declare having any specific goal or aspiration after finishing his studies. This absence of reported aspirations could be connected, in part, to a dilemma he experienced early in his undergraduate studies, where he was torn between Electrical Engineering and CS and eventually chose CS.

Positional Resources

Another identity resource utilized by the participants was positional resources, which can be described as the ways in which actors are recognized by others within a particular context. How one is positioned is wrapped up in relations of power: on an individual level, being positioned in a work setting by an authority as “competent,” for instance, can lead to differential opportunities and outcomes than being positioned as “incompetent” or “underperforming.” On an institutional scale, students’ being positioned as “at-risk” or academically “deficient” can shape not only how students view themselves but also their access to particular kinds of resources, such as teacher recommendations or internships.

These are just two simplistic examples of how positioning operates at multiple scales. For five of the nine focal students in this study, positional resources emerged as relevant to their pathways toward ME/CS. All five students - Herman, Javier, Elisa, Samantha, and Alfonso - made reference to being “good at math” during their K-12 schooling. This was not something that they experienced only “in their heads,” but rather through their experiences and interactions with teachers and other authority figures. These positionings often had a material impact on their pathways and decision to pursue engineering/CS. Elisa, for instance, described moving from Mexico to the US in fifth grade and finding math to be easy “because it was the only language that I didn’t struggle in.” Four years later, when she started high school, she was placed in Advanced Placement Calculus without her initial knowledge or consent: “I didn’t even choose it. They put me in, but for me it was better.” Being placed in AP Calculus paved the way for her to start in Calculus II as a freshman. Elisa’s being positioned by school personnel as competent at mathematics ultimately shaped her pathway by opening up the opportunity for her to take an AP course that she might not have known about or chosen on her own. In this way, the positional resource of being recognized as “good at math” had a concrete impact on her academic trajectory into engineering.

Relational Resources

In addition to and in conjunction with affinity, aspirational, and positional identity resources, students also made extensive and varied references to key people and relationships that influenced their decisions to pursue ME/CS. In the Nasir and Cook study on track athletes, relational resources was defined as “the positive relationships with others in the context that can increase connection to the practice” [10, p. 47]. In our study, relationships played both an enabling and constraining role in participants’ decisions to pursue ME/CS: students’ accounts made references to the positive impacts of some kinds of relationships, and the obstacles imposed by others. We will explore both in this section.

All nine participants made reference to positive relationships and networks that they had built across various settings (e.g. school, social life, household) with different actors (e.g. teachers, mentors, parents, friends). In most cases, students had not one, but rather several, key relationships that shaped their decisions to pursue ME/CS. In our analysis, we sub-divided students’ references to relational resources into three categories: family, teachers/mentors, and peers. The first two categories - family and teachers/mentors - were represented as exerting the strongest influence on participants’ decisions to pursue ME/CS, and will be explored here.

Four of the nine participants - Francisco, Elisa, Arturo, and David - cited family as having a key influence in their decisions, but in different ways. For three of the four students (Francisco, Arturo, and David), the influence of family was represented in strong terms of wanting to be like a parent, or of being told to study engineering by a parent. In the case of Francisco, an older student who worked as a technician at a maquila in Ciudad Juarez while studying at the university, he reported choosing engineering because his father was an engineer. His decision to pursue the field of Mechanical Engineering, specifically, came directly from his father:

And well I just knew that I wanted to study engineering because my dad was an engineer. I knew I wanted to study engineering but I never investigated what branch I wanted to study. I didn't know which but in speaking to my parents my dad told me to go with Mechanical Engineering. He said there is a high demand and that there are few engineers.

In this quote, Francisco highlights the key influence of his father in his pathway to engineering: on the one hand, he makes reference to the ideational influence of his father ("because my dad was an engineer"); on the other hand, he makes reference to the very concrete influence of his father in his "choice" to study ME specifically: his father "told" him to study that particular field.

The "choice" to study engineering as being heavily influenced by parents was also visible in two other cases, Arturo and David, both CS students. For Arturo, the decision to pursue CS was based on wanting to be like his father, who was a civil engineer; he stated not choosing Civil Engineering because of the "lack of development," in Mexico, where he lived, and presumed lack of job opportunities for Civil Engineers. He was initially torn between pursuing Electrical Engineering and CS but eventually chose the latter. For David, the decision to pursue CS was more complicated. In middle school and high school in Ciudad Juarez, David wanted to pursue postsecondary studies in history or psychology. His decision to ultimately study CS came in part from his uncle, who stimulated his interest in computers, and his older sister, who was studying engineering at the same US university that he was to attend. In his account, David represents his mother as having the greatest influence on his decision to pursue CS:

So, from her [his mother's] side, it is always there, the constant pressure that 'and so are you only going to study to be a historian, just with a bachelor's,' so no I did not, the pressure of 'you will end up poor and starving' has always been present.

In this quote, David represents his decision to pursue CS as being shaped by his mother's insistence that studying a liberal arts field will lead to economic hardship. In this way, his "choice" to pursue CS is not so much one of personal autonomy, but one shaped in part by compliance with his mother's wishes.

In addition to family serving as an important, if sometimes constraining, identity resource, three students - Herman, Elisa, and Alfonso - also emphasized teachers and mentors as critical resources in shaping their decisions to pursue ME/CS. CS major Herman, for example, was strongly encouraged by his mother to become a doctor, and he intended to follow that pathway; in part because of the positive influence of teachers and mentors in both high school and college,

however, he switched to CS, to which he felt greater affinity. Elisa and Alfonso, both ME majors, both identified key teachers and mentors in high school who provided information and guidance that fundamentally shaped their decision to pursue ME. For Elisa, the influence was indirect: she named an architecture teacher in high school who influenced her not to study architecture, and a swim coach who played a key role in her decision to attend her current university over others in the state. Alfonso, who grew up in an economically marginalized area of the city (US) and who was a first-generation college student, also highlighted the direct support of key teachers and mentors; in middle school, he was inspired by Coach B, and named the support of the TRIO program, while in high school he was positively influenced by his AP Calculus teacher, Mr. W. In Alfonso's case, his school-based teachers and mentors played a stronger role in influencing his pathway to engineering than his family.

Discussion and Conclusions

In this paper we analyzed ethnographic data sources, focusing on in-depth open-ended interviews, with nine Latinx ME/CS majors at a university on the US-Mexico border to understand the key influences shaping their pathway into Mechanical Engineering or computer science. The findings presented here support and extend earlier findings on the complex influence of family on Mexican-origin engineering students' decision to pursue engineering in college [22]. In that study, Mexican-origin students who had parents as engineers were heavily recruited by their families to study engineering; students who were first-generation college students or whose families did not include engineers reported much stronger influence from school-based teachers and mentors. In the present study, we use an identity resource lens to analyze the key assets identified by ME/CS students that shaped their pathways. These resources were both material, as in the concrete support provided by parents or engineering-like activities in which students engaged, for example, and ideational, as in the economic, sociopolitical, and career-oriented aspirations expressed by students. Some resources, such as positional resources, were both material and ideational in nature: how students were positioned by authority figures (e.g. as "good at math") helped structure the kinds of opportunities available to them (e.g. placement in AP Calculus in high school).

The focus on identity resources provides an analytical lens for identifying and understanding elements of engineering/CS students' academic and professional trajectories that enable or constrain their success in the major and their persistence into (and success in) the profession. Identifying resources that positively influence students' - in this case nine Latinx students' - entry into engineering/CS can help shed light on the constellation of interlocking factors and experiences that shape students' decisions prior to, during, and following their undergraduate studies. Additional research and analysis are also needed to identify resource patterns among different sub-groups of students, for example first-generation students. Such analyses can help contribute to the strategic identification and implementation of support mechanisms designed to facilitate the persistence of underrepresented students, in this case Latinx students, through the degree and into the profession.

Acknowledgements

This work was supported by the National Science Foundation through grant #1734967. The findings and analysis presented represent those of the authors and not of the NSF. The authors would like to thank the additional members of their NSF project team.

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