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Storylines in Figured Worlds: Understanding Diverse College Students' Decision to Major in Computer Science

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Given the workforce demand for computer scientists, especially more racially, ethnically, and gender diverse computer scientists (U.S. Bureau of Labor Statistics, 2016), significant efforts have been made to recruit underrepresented groups to major in computer science (CS; National Science Foundation, 2018). However, there is very little research on how underrepresented students decide to major in computer science. The purpose of this qualitative study was to understand how racially, ethnically, linguistically, and gender diverse students in an introductory CS course, at a Hispanic-serving university on the U.S.-Mexico border, decided to major in CS. Findings demonstrate that participants drew on four principal storylines to decide to major in CS: social mobility and opportunity storylines, user storylines, interest storylines, and underrepresentation storylines. Students' storylines stemmed from multiple sources, including but not limited to the media and family. Findings also show that students' storylines did not align with official storylines found in the figured world of CS in higher education. Rather, results illustrated the nuanced ways in which the media, family, friends, and school personnel influenced students' storylines to shape their decision to major in CS. Implications for practice and policy are discussed.

Keywords: computer science education, qualitative, student diversity, figured worlds, choosing a major

According to the U.S. Bureau of Labor Statistics, in 2026, there will be roughly 1.3 million openings in computer science (CS) related jobs, and yet, the current number of students graduating from 4-year universities with a CS major is approximately 60,000 (U.S. Bureau of Labor Statistics, 2016). This is particularly significant among Latinx who constitute the fastest growing minoritized group in the United States, yet, represented only 10% of degrees awarded in CS in 2016 of which, an even more dismal 1.87% were awarded specifically to Latinas (National Science Foundation, 2019).

To meet the growing workforce demand for more computer scientists, especially more gender and racially diverse computer scientists, efforts to recruit and retain underrepresented groups to pursue a postsecondary degree in CS have gained significance and support (National Science Foundation, 2018). Salient examples of such efforts found in the literature emphasize different strategies and outcomes for recruiting and retaining Latinx students in CS education such as professional development for faculty on structural and psychological barriers that diverse students might face (Margolis et al., 2012) and opportunities for high school students to learn about CS (Peckham, Stephenson, & Harlow, 2007; Rusk, Resnick, Berg, & Pezalla-Granlund, 2008; Scott, Martin, McAlear, & Madkins, 2016). Missing from the literature, however, is research on how students, in particular, underrepresented students, actually decide to major in CS.

In this article, we explore how racially, ethnically, linguistically, and gender diverse students in an introductory CS course, at a Hispanic-serving university on the U.S.-Mexico border, decided to major in CS. The overarching research question guiding this study was: How do women and men students of color at a Hispanic-serving institution decide to major in computer science? In the following section, we provide a literature review to situate our study within the wider existing literature on how students choose a STEM-related major. In so doing, we also identify gaps in the literature to highlight the unique contribution of our study. Following, we introduce the theoretical framework, which we used to understand sociocultural factors that shaped students' decision to major in CS. We then describe the methodology, research context, and data analysis process of the study. Finally, we present the study's findings and discuss how students' decision to major in computer science reflected broader storylines, which the students created to author themselves into computer science. We conclude with implications for policy and practice.

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Literature Review

Decision to Major in STEM

To date, the educational literature suggests that students who take advanced mathematics and science courses in high school are more likely to choose a major in a science, technology, engineering, and mathematics (STEM) related field (Crisp, Nora, & Taggart, 2009; Engberg & Wolniak, 2013; Phelps, Camburn, & Min, 2018; Wang, 2013). Specifically, upper-level science courses in chemistry and physics, and advanced mathematics courses such as Algebra II, precalculus, and calculus (Allen & Eisenhart, 2017; Crisp et al., 2009; Trusty, 2002) and/or engineering and technology courses (Lee, 2017) are cited as strong predictors that a student will choose to major in a STEM-related field. Other high school related factors influencing students' decision to choose a STEM major include SAT math scores (Crisp et al., 2009), math self-efficacy beliefs (Wang, 2013), and summer programs (Rahm & Moore, 2016).

Decision to Major in Engineering

A smaller body of literature examines college students' decisions to major in engineering specifically. These studies found that students' sense of self and whether it aligns with engineering identities weighs heavily on students' decision to become an engineer (Godwin & Potvin, 2017; Godwin, Potvin, Hazari, & Lock, 2016; Matusovich, Streveler, & Miller, 2010; Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008). There is also literature, which suggests that social support such as family and school personnel influence underrepresented students' decision to become an engineer (Charleston, 2012; Garibay & Vincent, 2018; Martin, Simmons, & Yu, 2013; Mein, Esquinca, Monarrez, & Saldaña, 2020).

Decision to Major in CS

Although CS is often part of engineering colleges, research related to choosing an engineering major has focused almost entirely on engineering fields such as electrical engineering, mechanical engineering, or industrial engineering. Thus, with a few exceptions (Beaubouef & Mason, 2005; Carter, 2006; Lent, Lopez, Sheu, & Lopez, 2011), the literature on students' decision to major in CS specifically remains understudied, especially as pertains to underrepresented students. Beaubouef and Mason (2005) suggest that students often enter CS degree programs with erroneous ideas about the major such as, "everything is about computers" and/or because they like playing video games but are often unaware of the mathematical and computer skills necessary to obtain a degree in CS. Similarly, Carter (2006) found that 80% of high school students who responded to a survey on experiences and perceptions of the CS field had "no idea what CS majors learn" (p. 29)—meaning that students may be choosing to major in CS with a limited view of what a degree in CS entails—whereas only 2% of the surveyed students had a good grasp of the field of CS.

Career Choice in STEM

In addition to the literature on how students decide to major in a STEM-related field is another related, and more robust literature on factors that influence students to choose a STEM-related career, in particular is a body of quantitative research that utilizes the Social Cognitive Career Choice Model (SCCCM)—social–cognitive career theory (Lent, Brown, & Hackett, 1994)—to examine factors that influenced minoritized students' career choice (Lent et al., 2005, 2008, 2011, 2015, 2013; Navarro, Flores, Lee, & Gonzalez, 2014). By using a statistical model based on the SCCCM (Fouad & Santana, 2017), researchers have found that social–cognitive variables are helpful in understanding students' decision to major in engineering (Flores et al., 2014; Lent et al., 2005, 2008, 2013, 2015) and more specifically in computing degrees (Lent et al., 2011). In addition, researchers found that high self-efficacy in high school STEM courses was a predictor for majoring in engineering for Black students (Lent et al., 2005, 2011) and Latinx students (Flores et al., 2014; Navarro et al., 2014). While the SSCT model shows that these factors equally predict career choices of women, Latinx, and Black students, more research needs to be done to understand each factor in depth and how they differentiate by population.

In addition, we argue that there is a need for qualitative research to explore the social and cultural processes of choosing a major because it is an activity that precedes choosing a career and cannot be understood solely in terms of psychological factors. Related to this, we also take the position that a reliance on sociological categories of race, gender, and ethnicity to examine factors that predict diverse students' educational experiences, like deciding to major in CS can lead to static, homogenous, and universal representations of diverse student experiences, rather than reflecting the complex ways in which diverse actors exercise their agency to author themselves into figured worlds, like CS. As such, our study aims to understand choosing to major in CS as a socially and culturally constructed process situated within wider relations of power and systems of domination. Specifically, we aim to address the literature gap on how racially, ethnically, and gender diverse undergraduate students choose to major in CS by examining the sociocultural storylines that students draw on to self-author themselves into the figured world of CS.

Theoretical Framework

By using sociocultural theories of identity (Holland, Lachicotte, Skinner, & Cain, 2003), we viewed students' decision to major in CS as socially situated and culturally constructed storylines. Within a sociocultural view of identity, storylines represent socially reproduced cultural resources in the form of narratives or plots that establish, evoke, and maintain recognizable identities that constitute a particular figured world. The concept of figured worlds derives from sociohistorical and anthropological theories of identity and involves four key features, which help us to understand how identities are formed through situated activities—participation—in particular cultural worlds. First, rather than objects to be apprehended, figured worlds represent "processes or traditions of apprehension," (p. 41) which shape our identities as we intersect with them. Second, figured worlds involve "social encounters in which position matters" (p. 41). This feature helps us to understand how power operates in figured worlds such that we may never enter a particular figured world because of our social position. Third, and relatedly, because figured worlds are socially organized and reproduced, "they divide and relate participants

(almost as roles) and they depend upon the interaction and intersubjectivity for perpetuation" (p. 41). Finally, figured worlds are cultural worlds that distribute social actors "by familiar social types and even identifiable persons, not simply differentiated by some abstract division of labor" (p. 41). In summary, a figured world is, "a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (Holland et al., 2003, p. 52).

In this article, we use figured worlds as our theoretical framework to argue that academic degree programs in CS at 4-year universities represent a particular figured world and that the Accreditation Board for Engineering and Technology (ABET)—a nongovernmental accrediting agency for programs in applied and natural science, computing, engineering, and engineering technology—plays a major role in constructing "the official" storyline that makes-up the figured world of academic degree programs in CS. Specifically, in stipulating the criteria for accreditation of CS degree programs based on specific student outcomes (what students should know by the time of graduation), curriculum (amount of coursework or equivalent), and faculty credentialing (some full-time faculty must hold a Ph.D. in computer science), ABET constructs the official storyline about what constitutes the figured world of academic degree programs in CS and in turn, who is recognized as a member of this cultural world (ABET, 2017).

Because of their status as "official" members of CS, faculty influence the maintenance and reproduction of the official storyline through their interpretation of what constitutes a recognizable—professional—identity in the figured world of CS (Ben-David Kolikant, 2011). To do this, faculty frequently draw on their own lived professional practices, research, and educational background as a representation of "legitimate" CS work and a CS identity that is recognizable in the figured world of CS. For instance, problem solving, using pseudo code, and computational thinking represent activities that faculty deem as centrally relevant to the figured world of CS and, thus, these activities are frequently invoked to differentiate between individuals who are recognizable—belong in CS—from those who do not.

In contrast, newcomers to a figured world, such as students who decide to major in CS, must engage in self-authoring themselves into that world by developing an identity that is viewed as reflective of the official storyline and in turn, recognized by official members. However, students who decide to major in CS—newcomers—frequently have a very limited notion of what a major in CS involves (Beaubouef & Mason, 2005; Carter, 2006). Consequentially, we argue and later show that students' decision to major in CS often involves a sociocultural process of self-authoring oneself into the figured world of CS through the multiple discursive resources and sources—storylines—that are "floating around" (Sfard & Prusak, 2005, p. 18) but that, differ from the official storyline in CS (Ben-David Kolikant, 2011).

For example, in this article, we draw from research on the cultural world of CS in higher education (Ben-David Kolikant, 2011) to highlight how "user storylines" shape students' decision to major in CS. User storylines help us to see that students often enter CS classrooms with a "user culture," which involves particular activities and identities, for example, playing video games or browsing the Internet. User culture can also be related to using technology and/or "fixing" devices, such as upgrading to a new operating system, cleaning viruses, or installing computer software, but does not involve knowing what a CS major entails (Carter, 2006).

Other newcomers who decide to major in CS but do not identify with a user culture, often draw on popular "opportunity storylines" that circulate widely in the media and which, provide a particular depiction of CS that does not fully align with the official storyline. A quick Internet search about "why major in CS," for example, offers the storyline that a degree in CS will lead to a plethora of limitless employment opportunities, excellent salaries, including nothing short of a six-figure salary after graduation, and the chance to significantly impact, if not change the world (Clark, 2017; Singal, 2013). In this article, we show how opportunity storylines can also be tied to what we refer to as a "social mobility storyline." In this context, a social mobility storyline draws from wider opportunity storylines that proffer the belief that a major in CS will automatically create an upward change in the socioeconomic status of an individual. In the context of our research study, wherein over 50% of undergraduate students are first-generation and low-income students, it is not uncommon to observe frequent and extensive references to social mobility storylines at the institutional as well as the individual level.

Related to but distinct from an economically driven opportunity storyline, is what we call the "underrepresentation storyline." Wider discourses about the underrepresentation of women in CS (Convertino, 2019) shape this storyline to suggest that because of the underrepresentation of women in CS, and the wider interest in broadening participation of women in the field, women will encounter limitless opportunities in CS, and, thus, should pursue a major in CS. In the following analysis, we use figured worlds to provide a more nuanced and differentiated portrayal of the storylines that our participants constructed to "figure" themselves into the cultural realm of the CS major. In this way, we problematize essentialized approaches to locate the specificities that differently shape diverse students' decision to major in CS, while simultaneously recognizing that these storylines are constrained by power relations, in particular the official storyline.

Methodology

This study is part of a larger ethnographic study on department-wide efforts and processes aimed at cultural and structural transformations to the CS department to broaden participation and increase retention among underrepresented groups at a Hispanic-serving university located on the U.S.-Mexico border. To understand the culture of computer science, we used an ethnographic approach to data collection and analysis (Hammersley & Atkinson, 2007). An ethnographic approach requires that the researcher immerse herself into the everyday interactions and experiences of participants to "grasp what they experience as meaningful and important" (Emerson, Fretz, & Shaw, 2011, p. 3). Specific to the present study, with its emphasis on understanding the sociocultural processes involved in deciding to major in CS, the framework of figured worlds takes up ethnography as a key methodological means for understanding how newcomers—students—draw from multiple discursive sources and resources to self-author themselves into the figured world of CS. Looking closely, from an ethnographic perspective, at newcomers' storylines helps shed light on the agentive ways in which diverse college students

attempt to self-author themselves into the figured world of computer science in higher education: thus, complicating monolithic representations that aim to attribute predictors to categories of ethnically, racially, linguistically, and gender diverse students.

Research Context

This study takes up an ethnographic approach to explore the storylines of students who are newcomers to the major of computer science at a large, open-access public university located on the U.S.-Mexico border. At the time of the study, the university's enrollment included more than 23,000 students, 86% at the undergraduate level, and 14% at the graduate level, the majority of whom came from the surrounding region and commuted to campus. The university context was unique in that more than 80% of the student population identified as Hispanic/Latino, with an additional 5% who were Mexican nationals crossing the border to study at the university. On average, more than 50% of students enrolled at the university were first-generation college students, and 37% of all students were eligible for Pell grant funding. The university was at the top of the list, nationally, among universities that promote social mobility of their students, based on analysis of income levels before and after graduation.

At the time of the study, there were over 700 undergraduate students enrolled in the CS department and over 100 graduate students. The majority of undergraduate students enrolled in the CS program were Latinx (80.70%) followed by White (7.64%), Mexican nationals (6.39%), Black (2.25%), Asian/Hawaiian (1.62%), two or more races (1.12%), and other international (.25%).[1] The vast majority of undergraduate students were men (81.83%) with women comprising only (18.83%) of the undergraduate students.

Data Collection

Data for this analysis was collected during Fall, 2016 and Spring, 2017 and included participant observations and ethnographic interviews with students.[2] Data were collected by the first author, who is an educational anthropologist with expertise in sociocultural approaches to learning, diversity, and equity as well as two doctoral students with a background in STEM education, one of whom is the second author. Participant observations consisted of 236 total hours of observations and field notes of two sections of an introductory CS course (CS1) during the fall, and two sections during the spring; sections were taught by different instructors. Observations focused primarily on course content, instructional practices, social interaction, and language use.

The four-credit CS1 course was intended for students to learn the basic principles of problem-solving with computers and involved three-credit hours of "lecture" with the course instructor and one-credit hour of lab with a graduate teaching assistant. According to the syllabus, students enrolled in this course were not required to have a background in CS or any programming skills. However, they were required to have a basic knowledge of running software applications, using a computer, and precalculus. As such, these prerequisites represented early indices of the official storyline, which newcomers are expected to know and understand before entry into the major. In fact, CS1 is a mandatory requirement for students who have chosen to major in CS; although students from other majors in engineering and science are eligible to enroll in this course.

In addition, we learned from our participant observations that CS1 exposed students to a brief history of CS, prominent figures in CS, as well as the latest innovations in CS. Another important feature of the course was the requirement of CS engagement points. At the time of this study, students were required to earn 10 points of their course grade by attending activities related to CS outside of the classroom. These activities, which were determined by the instructors, included attending talks given by researchers in CS, workshops (i.e., resume writing, interview preparation), company talks, hackathons, and reviews for the course. During these engagement activities, we observed that faculty frequently invoked the official storyline about the central role of problem solving, using pseudo code, and computational thinking to computer science—a phenomenon that we had also noted in the introductory course. However, in the course of several informal conversations with CS faculty as well as with newcomer students to CS, we also observed that there were some tensions between these official storylines and what newcomers deemed as important to computer science, in particular programming. As a consequence, during the second semester of observations, we decided to conduct ethnographic interviews with students in the introductory CS course to better understand students' preconceived notions about computer science and how those ideas might, or not, have influenced their decision to major in computer science.

We conducted ethnographic interviews with 18 participants (see Table 1): 10 identified as Latinx, two as Mexicans, three as White, one as Black, and two as biracial (one Asian and Mexican, and the other Latino and White). All of the participants had declared CS as their major at the time that data for this analysis was collected and had been advised by the CS department since declaring their major. Twelve of the interviewed participants self-identified as bilinguals (Spanish and English) and six as English monolinguals. Five of the 18 participants were first-generation college students. Twelve of the 18 participants were "transfer" students (i.e., they transferred to CS from another major, from another university or from a 2-year community college). When asked about their K–12 schooling, 14 reported doing all K–12 schooling in the United States, three reported doing a portion of their K–12 schooling in Mexico and the United States, and one student reported doing all of his K–12 schooling in Mexico. All participants names were changed to pseudonyms, and most participants chose their own pseudonym. Interview questions asked students to talk about their decision to major in CS, as well as their academic and social experiences in their first CS course. Interviews lasted approximately 30–60 min. Participants were given a choice to interview in English or Spanish. Four participants chose to conduct the interview in Spanish.

Data Analysis

In keeping with our ethnographic approach (Emerson et al., 2011; Saldaña, 2016), our analysis sought to make sense of diverse college students' decision to major in CS as a sociocultural process

[1] A nonbinary, gender-neutral term to refer to persons from Latin American origin or descent.

[2] The names of all students used in this article are pseudonyms.

Table 1
Interviewed Participants

Pseudonym	Race/ethnicity	Bilingual/monolingual	First generation	Transfer	Schooling place	Interview language
Juan	Latinx	Bilingual	No	No	United States	English
Michael	White	Monolingual	No	Another degree	United States	English
Minhee	Biracial	Bilingual	Yes	4-year university	United States	English
Romina	Latinx	Bilingual	No	Another degree	United States	Spanish
RR	Latinx	Bilingual	Yes	2-year college	United States	English
Sergio	Mexican	Bilingual	No	No	Mexico	Spanish
Arturo	Latinx	Bilingual	No	No	Both	Spanish
Elsa	Latinx	Bilingual	No	Pre-engineering	Both	English
Isaac	African American	Monolingual	Yes	Another degree	United States	English
James	White	Monolingual	No	2-year college	United States	English
Kenneth	White	Monolingual	No	Pre-engineering	United States	English
Pablo	Mexican	Bilingual	No	2-year college	Both	Spanish
Sam	Latinx	Bilingual	Yes	Another degree	United States	English
Daniela	Latinx	Bilingual	No	No	United States	English
David	Latinx	Bilingual	No	Pre-engineering	United States	English
Kassandra	Latinx	Monolingual	Yes	No	United States	English
Neo	Latinx	Bilingual	No	No	United States	English
Nofia	Biracial	Monolingual	No	Pre-engineering	United States	English

that occurs through and as a part of social interactions situated within multiple cultural contexts that may or may not overlap, that is, student's families, the media, and/or ABET. To do this, we conducted our analysis through a multistage process wherein we first coded field notes and student interviews for social and cultural representations and features of CS as a field of study and profession as well as representations of social practices recognized in the cultural realm of CS, like programming. During this initial stage, we also coded student interviews for instances where students talked about their decision to major in CS as well as instances where they spoke about their initial experiences of CS in the CS1 course. These initial rounds of coding helped us to identify what we perceived as possible disconnects between faculty representations of CS and students' initial experiences and views of CS.

During our initial stage of coding, we also developed several preliminary codes related to students' descriptions of their decision to major in CS, including: family, media, previous experience with CS, background knowledge, working with computers, fixing computers, and mentorship. Because we do not have a background in CS, it is our position that our initial etic (outsider) perspective of CS as a cultural world coupled with our developing emic (insider) ethnographic perspective of CS played an important role during this initial round of coding in that we were able to identify patterns in student and faculty representations of CS identities and practices as well as patterns in disconnects between those representations.

To help us make deeper meaning of emergent patterns, we then conducted several rounds of focused coding during which we wrote analytic memos to advance our understanding of how initial codes—family, media, previous experiences with CS, fixing computers, and so on—influenced students' description of their decision to major in CS. Concurrent with this stage of analysis, we returned to the research literature, finding very little to help us in our analytical efforts to explain these initial codes. We did, however, find research literature on the cultural world of CS in higher education (Ben-David Kolikant, 2011), which helped us to theorize the distinctions between faculty and student representations of practices and identities in CS as an important process through which recognizable or "official" identities in CS are constructed, maintained, and reproduced.

Because students' descriptions of how they decided to major in CS did not resemble official representations of CS found in ABET standards and or faculty representations, we then turned to literature on figured worlds (Holland et al., 2003) and identity-making (Sfard & Prusak, 2005) to further analyze students' narrations of their decision as an act of identity-making within the discursive space of the interview. The first author, an educational anthropologist, who uses these sociocultural and discursive lenses to analyze identity, power, and practice in diverse educational settings, recognized their analytical usefulness to advancing analysis of these data. This is because identity-making represents an analytical lens to theorize how newcomers to a cultural world, like CS, draw on available "narratives that are floating around" (Sfard & Prusak, 2005, p. 18) to "story" or self-author themselves into that world. Figured worlds, as we explained in the theoretical section, helps to further theorize self-authoring as a process that involves power and positioning on the part of established members of that world.

During this extended phase of analysis, in which we were writing analytic memos to theorize students' narrations of their decision to major in CS using identity-making and figured worlds, we also meet frequently to discuss the process of analysis. During these meetings, we discussed how different codes reflected the central theme in students' narrations about their decision to major in CS. Related to this, we also discussed and agreed that even though there were instances in the data where some students drew on multiple discursive resources and sources to construct their stories about their decision to major in CS, that is, stories from their families about the students ability to fix computers, one theme or what we later referred to as storyline always took precedence in the students' narration of their decision. Based on this, we individually and then collectively identified salient and patterned storylines found in our data. We then further theorized students storylines by researching and comparing them to wider narratives and discourses about choosing a major, social mobility, and underrepresentation in CS found in the media or through

online searches. Specifically, we did this to analyze students' identity-making processes by recreating some of the most salient and clearly identifiable ways in which they had drawn on available discursive resources to construct their decision to major in CS. Following, we developed thematic representations of storylines that were clearly influenced by wider discourses and narratives and that reflected individual students' narration of their decision to major in CS. Finally, we returned to figured worlds as an analytical lens to theorize the particular ways in which newcomers author or figure themselves into CS happens in a cultural world where power is unequal.

With regards to our multistage and iterative process of analysis, it is important to note that participant observations, while secondary to this analysis, served as an essential background to understand and contextualize the figured world of CS, in particular, the official storyline. It is also important to note that because underrepresented students comprise the majority of students at the university and in the CS department, and yet remain a minority in the wider world of CS (Margolis et al., 2012; A. A. Rodriguez & Anderson-Rowland, 2012), we purposefully chose to highlight the narratives of student participants from underrepresented groups; a move that reflects the researcher positionality of both authors who seek to rupture the dominance of reified representations of difference to understand the dynamic and contingents ways in which particular individuals engage in the difficult work of narrating selves into contested and exclusive cultural spaces, like the CS major. Moreover, because the goal of qualitative research is not to generalize, but rather to study a topic in depth by using a thick description of the context and the participants (Merriam & Tisdell, 2016), our findings provide a nuanced and situated portrayal of how ethnically, racially, linguistically, and gender diverse students decided to major in CS.

Findings

In this section, we present findings and discussion to show how students' storylines about their decision to major in CS intersected with broader storylines about CS found in the media, in particular, storylines that frame CS in terms of opportunity, social mobility, using computers and underrepresentation. Student's storylines were also socially constructed in the sense that family, friends, and school personnel were pivotal in students' creation of storylines that allowed them to author themselves in CS. Indications of the official storyline surfaced in instructors' frequent references to problem solving and pseudo code as activities that computer scientists engage in. Indications of the official storylines were also evident in the specific engagement activities, for example, interview preparation workshops where they highlighted the importance of working on CS related projects. Students' storylines, in contrast, helped to reveal the preconceived notions and perspectives that shape newcomers' ideas about the figured world of CS.

Storylines Tied to Social Mobility

Participants' narrative accounts about their decision to major in CS revealed how storylines, which are socially constructed, often intersect with other competing storylines created by parents, friends, high school teachers, and the media. In this section, we present findings to show how participants in making the decision to major in CS drew on a wider storyline that links a degree in CS with social mobility. Specifically, these storylines elucidate some of the particular ways in which students and their families viewed the decision to major in CS as a practical decision to increase their socioeconomic status and gain financial security.

In an interview, Minhee, a self-identified Asian and Mexican bilingual and a first-generation college student narrated the following storyline about how her mom influenced her decision to major in CS, rather than linguistics:

> Originally my mom picked my major . . . 'cause my mom is like really big on, you have to get a good job when you graduate and stuff like that, cause it was the same with my other sisters, cause my sister chose chemistry, and I wanted to do linguistics, and my mom was like no, no, no. So, then I looked at her and just like, 'what do you want me to do?' She's like, do something you like, and then I was like, 'I live in the what was the 21st century, and that is progressing, and I like technology' so 'I thought why not computers', and then once I got into it I learned that it's not just about a computer, it's like how do you build it, what are the programs you're going to us so then, I thought it was interesting, so I choose that, and I just chose CS.

Minhee's decision to major in CS was tied to and constructed from different storylines. Even though not explicitly stated, Minhee's mom's storyline was about social mobility; she wanted her daughters to choose a major that would allow them to have a "good" job. Hence, Minhee's mom drew on a wider storyline that suggests a degree in the social sciences such as linguistics is impractical because there are fewer probabilities of finding a high salary job after graduation. In response to her mom's storyline, Minhee, in turn, drew on the popular storyline that technology is the future. Consequently, Minhee's storyline about her decision to major in CS, which intersected with storylines about social mobility and the ubiquity of technology to the 21st century, initially revealed little to no understanding of sanctioned storylines found in the figured world of CS in higher education, until she entered into her CS1 course.

In another example, David, a Latinx and bilingual student, also drew from the storyline of social mobility and economic advantage to narrate his decision to major in CS. At the time of the study, David was working full time at a grocery store. During his interview, David talked about the need to provide for his daughter, which involved finding a better job. About this, David stated:

> You start to realize that doing small jobs like that even if you make like close to 9 dollars an hour is not enough to get a house or payments. I need something that's gonna be able to manage me and my daughter, yes, small jobs aren't gonna cut it.

David revealed that upon initially thinking about going back to school, he wanted to attend a technical school. However, David's process of decision-making was also greatly influenced by family and friends who used storylines about a college degree as the pathway to social mobility to convince him to pursue an undergraduate degree from a 4-year university.

David also related that his decision to major in CS was tied to his desire to work at a "main" company such as Microsoft because he liked to play Xbox, which is a video gaming brand created and owned by Microsoft. In this instance, David connected his recreational use of Xbox with wider storylines about Microsoft found in the media, in particular, storylines that showcase job opportunities

with a leading company like Microsoft. He also suggested that he might be able to obtain a position at Dell since a father of a friend worked at a local branch and had indicated that maybe he could find him a job there. In total, David's storylines about his decision to major in CS are strongly influenced by his family's storylines about the role of a college degree to social mobility as well as storylines from friends, the media, and his own recreational use of Xbox. Findings such as these are not surprising when we consider the fact that institutions, which serve as channels for social mobility, include family, school, and occupational organizations (Sorokin, 2010). Nonetheless, findings also highlight the extent to which wider storylines about social mobility can influence students' decision to major in CS despite little to no knowledge or information about what a degree and a career in CS entails.

Opportunity Storylines

Opportunity storylines found in the data were similar to social mobility storylines in the sense that they equate a degree in CS with the opportunity to procure economic gain. However, they also differed in their focus on the idea that a degree in CS guarantees endless job opportunities. For instance, Romina, a self-identified Latina student, said that she changed her major from Biology to CS. Although she did not explicitly state her reason for changing majors, it appeared that she had drawn on an opportunity storyline to make her decision:

> *Hay muchas opciones, no de carrera sino de trabajo . . . puedo trabajar en una oficina o puedo trabajar de diferentes maneras o puedo trabajar desde mi casa*. There's many options, not of a career but about a job, I can work in an office or I can work in different ways, or I can work from home.

At a closer look, Romina's storyline about her decision to change her major to CS also reveals a subtle but significant differentiation between a career in CS and work conditions in CS. Tech companies, that is, Google and Facebook, widely advertise flexible work conditions to attract future workers. Some companies advertise that they allow their employees to work remotely (Moore, 2018), while other companies, that is, Google are often rated highly for employee satisfaction because of several "perks," such as trips, free food, or opportunities to work on other projects (Hartmans, 2017). Storylines about the range and flexibility associated with work conditions in CS, however, are different from storylines that reflect the diverse career options in CS, for example, software development, artificial intelligence, or cyber security. Knowledge of the latter requires a more in-depth and informed understanding of what is involved in a career in CS to self-author oneself into the figured world of CS.

Thus, Romina's storyline about how she decided to change her major to CS suggested that she entered the figured world of CS with very limited knowledge about what a career in CS entails. In addition, her description of her initial experiences in CS1 revealed a storyline filled with uncertainty about what is involved in a CS major. Specifically, she stated that the labs in the CS1 course were her first experience with CS, and as a consequence, she often felt lost:

> *Bueno, en primer lugar, porque cuando yo entre el primer semestre de CS, yo no sabía absolutamente nada, nada, nada y lo que me, no me molestó, pero como que me incomodo fue que, tenías que aprender ciertas cosas ya, y pues mucha gente ya, osea ya sabía que era esto y aquello y pues osea yo estaba completamente perdida y eso es como que, pues me sentí un poco mal porque yo estaba perdida y pues se me hacía que yo era la única que no entendía nada*. Well, first of all, because when I started the first semester of CS, I knew absolutely nothing, nothing, nothing, and what made me, not angry but uncomfortable was that you had to learn certain things, and there are many people that already knew this and that, and I mean, I was completely lost and so I felt a little bad because I was lost and I felt like I was the only one that didn't understand anything.

Even though the syllabus of the course stressed that students were not required to have prior knowledge of programming, Romina shared that she struggled with the vocabulary related to programming used in CS1. For example, when the professor covered "strings," she had to ask a male classmate sitting next to her about the meaning of that word and other words. She also revealed that when she asked him how he knew so much about CS, his answer was "*ay pues es algo que tú ya tenías que saber desde que tú ya entraste aquí!* Well, that's something that you should already know before you got here!" In total, Romina's narrative revealed the contrast between the storyline with which she wanted to self-author herself into the figured world of CS—flexible work conditions—and sanctioned storylines about what is involved in earning a degree in CS. Romina's experiences in the CS1 course also parallel the storylines of other women students in CS, who are positioned by men students in CS as "unrecognizable" in the figured world of CS in higher education (Convertino, 2019).

Juan, a self-identified Latinx bilingual student, said he wanted to major in something related to CS because of the many employment opportunities offered by this type of degree. In narrating his decision to major in CS, Juan mentioned a homework assignment, which he had completed for a high school course, and which required him to research future job opportunities. Although Juan does not explain the keywords or process, which he used to conduct his research, it seems likely that he searched jobs that earn six-salary figures, which took him to information on software development as "one of the top ten jobs right now, [and] growing." It is not uncommon to find information that identifies three CS related jobs: software developer manager, software engineering manager, and software architect in the top 10 list of employment opportunities with six-figure salaries (Talajkowski, 2018). However, what is notable about the influence of the job search on Juan's decision to major in CS was the fact that he was unable to articulate any basic knowledge about what is involved in studying and working in software development, "I just knew I wanted to like work with computers, that's all I knew, it could be maintaining them or like just programming, but I just knew I wanted to work with computers."

Juan also talked extensively about other hobbies and interests that he had, such as making videos, playing musical instruments, his love of fashion, and his desire to join the military. He shared that he had applied to West Point but was not accepted. Later in the interview, when prompted about what he wanted to do as a software developer, Juan's efforts to self-author himself into the figured world of CS through his storyline of becoming a software developer were notably haphazard since he had no "official" knowledge or informed understanding about what a software developer actually does. Instead, he drew on fragments from other storylines, which he had encountered in the media to sustain his

storyline about his decision to major in CS, for example, he mentioned that the army had a new branch called cyber command, which requires software developers or that maybe he could create an app, which would allow people to choose their clothes.

User Storylines

In addition to social mobility and opportunity storylines, participants also drew on user storylines to shape their decision to major in CS. In this study, the notion of user culture surfaced in students' storylines wherein they connected their use of computers with their decision to major in CS.

Interests storylines. User storylines often overlap with other storylines, for example, opportunity storylines and even sanctioned storylines, however, what differentiates user storylines from other storylines in these data is the influence of a wider, circulating storyline that connects the decision to choose a major with a students' interests, values, passions, and abilities (Eilers, 2018). Specifically, user storylines in this study reveal how certain participants connected interest in computers and technology related activities, for example, gaming, with choosing to major in CS.

Nofia, a biracial monolingual student, who had attended an early college high school, explained that this was his second time taking CS 1 because he had failed in his first attempt because of what he described as "overconfidence." When asked about the process of choosing a major, Nofia drew on the wider storyline that suggests choosing a major should be based on an individual's personal interests (Eilers, 2018) to explain that he wanted to be either a marine biologist because he loved shark week, a chemical engineer because they make things with plastic and plastic is used everywhere or to major in CS because he liked playing video games. Ultimately, by connecting the interest storyline with the user storyline, Nofia's dad and girlfriend helped him to narrow his interests and in turn, to decide to major in CS:

> Then my dad told me, "hey, you play video games all day, and you like computers and stuff. Why don't you be a computer scientist" and I was like, huh, and (. . .) yeah so my dad and my girlfriend too she kind of pushed it. She said that I'd be good at it.

Nofia's dad and girlfriend positioned him as a computer scientist because they saw him playing video games. They drew from a user storyline in the sense that they related Nofia's interest in video games to CS. As such, Nofia's account provides an important illustration of how family and friends assist in first, the reproduction of interest storylines as a primary rationale for choosing a major and second, the more recent storyline that connects recreational and/or personal use and interest in computers with choosing to major in CS.

Ability and belonging storylines. Like interest storylines, students also connected ability and belonging storylines with user story lines to author themselves into the figured world of CS. Specifically, ability storylines in these data involved "knowing-how" to install, organize, and maintain computer systems (Slyter, 2019) and, thus, were based on participants' prior experiences with fixing computers. Belonging storylines connected the ability to fix computers with a sense of belonging to CS based on the status family members and peers associated with the ability to fix computers. Ability and belonging storylines, represent storylines found in user culture that fall outside of the official or sanctioned "professional" storylines that constitute the figured world of CS academic degree programs.

RR, a self-identified Hispanic, bilingual student who had just transferred from a 2-year community college connected his participation in a relatively informal information technology (IT) group during high school with his decision to major in CS:

> It was just part like class, like, cause if you were like in the class, uh . . . and like during the, like that year, the freshman [year] were given laptops, that was kind of, the new thing, so then since we were in that class, they kind of integrated that, if someone needed help with figuring something out, if someone had to [unintelligible] something or needed some updating, then we would like, go and fix it out. It was like a group; we had like a name on it, we had like IDs cause we were like, actually like, faculty or [unintelligible] we were called the "Cyber Dogs."

Moreover, RR drew from a popular storyline that having the ability to fix computers is associated with power as evidenced in his reference to his membership in the "Cyber Dogs," from which, he further attempted to self-author himself into the figured world of CS by attributing faculty status to the group because of their specialized abilities.

At the same time, during the interview, RR also struggled to define what is a major in CS actually involves, stating, "it's something that, I knew, that was there, but I never knew how it worked," RR's example is one more illustration of how students' decision to major in CS is often based on their prior experiences about what CS is, and, the attendant idea that a degree in CS is synonymous with the ability to use computers Beaubouef and Mason's (2005). In another example, Arturo, a transfronterix student, who completed his K–12 schooling in both Mexico and the United States, connected first his interest with computers to using computers, and then ultimately, to his decision to major in CS,

> *Pues realmente siempre me atrajo mucho este las computadoras y todo este desde que tenia 12 años desde que estaba en 6to de primaria fue cuando me compraron realmente mi primer pues dispositivo electrónico para mi este y fue cuando empece a experimentar con el software y fue que me di cuenta que me gustaba mucho no me decidi um sabia que quería estudiar algo parecido pero no me decidí por CS en especifico hasta hasta que ya estando en prepa me metí mas en lo de la universidad me di cuenta que CS era mas lo que a mi me gustaba, a mis intereses*. Well actually, I've always been attracted to computers and, since I was 12 years old. I was in 6th grade that's when they bought me my first electronic device, and for me, that is when I started to experiment with the software, I found out that I really liked that. I didn't decide, I knew I wanted to study something similar, but I didn't decide in CS specifically until I was in high school. I looked more into like college, and I found out that CS was the one that was more interesting to me, to my interests.

Arturo's narrative involves a user storyline based on interest because of the way that he talked about his "attraction" to computers to which he attaches an ability storyline by narrating examples of experimenting with software, like "hacking" his iPod.

In addition to his ability storyline, Arturo also drew from sanctioned storylines in CS to describe his decision to major in CS. The summer before starting his undergraduate studies, Arturo, on the advice of a friend, enrolled in an online introductory course at Harvard. According to Arturo, the online course was his first "formal" experience in CS; a point which he drew on to distinguish

his ability—user—storyline from what he knew to be a more sanctioned—professional—storyline in CS degree programs.

Underrepresentation Storylines

Underrepresentation storylines are about recruitment and retention of women, in particular women of color in CS (Convertino, 2019). These storylines are tied to efforts to broaden participation in CS. These storylines also intersect with other storylines such as social mobility, opportunity, interest, and user storylines. However, what differentiates underrepresentation storylines from other storylines in these data was the role of high school personnel and mentors on women's students' decision to major in CS.

Daniela, a self-identified Hispanic and bilingual student, recalled how she was enrolled in a CS course in high school; a course that she had not elected to enroll in but was placed in all the same. In the context of this course, Daniela's high school teacher advised her to major in CS because she was a female and not necessarily because she expressed any interest in it. About this, Daniela stated, "he motivated me to be in computer science and that being a female, which makes it easier to me to have more jobs and more opportunities." As such, Daniela's teacher drew from underrepresentation and opportunity storylines to recruit her to the world of CS. In turn, when prompted during the interview to explain what she thought the teacher's opportunity storyline meant, she drew on an underrepresentation storyline to suggest, and reproduce, the teacher's underrepresentation storyline; a storyline, albeit a largely problematic one, that suggests being a women in CS automatically guarantees women with more opportunities because so few women major in CS (Convertino, 2019).

While Daniela was a sophomore in high school, she joined a CS club that was coached by that same teacher and participated in some competitions. In this club, Daniela was one of only three women in the club. She mentioned that the male students would make remarks like, "why is she playing, you know, or like we're gonna beat her easily, you know." Daniela further explained that those comments made her feel "very uncomfortable . . . I felt like I wasn't supposed to be there for some reason, but I mean, I still did it." Daniela's accounts of her experiences in the CS club revealed tensions between her and other male members of the club. Similar tensions also happen in CS classrooms in college, where women, in particular women of color, have positioned as outside of and/or not belonging in the male-dominated arena of CS (Convertino, 2019). Despite the harassment from male peers, Daniela authored herself into CS based on the intersecting storylines of underrepresentation and opportunity that she learned from her high school teacher.

Daniela also talked about how the same teacher advised her to enroll in more mathematics courses. Hence, in addition to using underrepresentation and opportunity storylines, Daniela's teacher also drew from sanctioned storylines about the importance of mathematics to succeed in STEM degrees (Crisp et al., 2009) and more so in CS (Beaubouef & Mason, 2005). In total, Daniela's decision to major in CS was motivated by her teacher's storylines about underrepresentation, opportunities as well as sanctioned storylines about the significance of mathematics courses in high school to a 4-year college degree in CS. Teachers and mentors often play a significant role in recruiting students in engineering fields (Mein et al., 2020).

In another example, Elsa, a transfronterizx student who did her K–12 schooling in both the United States and Mexico, spoke similarly about a high school mentor,

> Well, in high school I was never sure about what I wanted to do, and my teacher, my math teacher he was my geometry and algebra II teacher he kept asking me what I was going to major in when I went to college, and I didn't know, and he always suggested me to do something in engineering, 'cause he said that I will always have a job in engineering, but I didn't, I was not really interested in mechanical, or industrial, or electrical and then once senior year came around, and we had to do all these projects about what we wanted to do, I started doing research about other areas in engineering, and I found computer engineering and CS since I started researching and I looked at kind of the skills that you needed, and I thought maybe I could do it, and also I didn't know what else to do, so it was kind of a last minute thing that I found.

Elsa explicitly made connections about her decision to major in CS, and her mathematics teacher in high school. Like Daniela's teacher, Elsa's teacher drew from opportunity storylines by telling her that she will "always" have a job in engineering, which in turn, motivated her to research different engineering majors. While she did not explain the type of research she conducted, an Internet search about computer science skills shows "detail-oriented" and "mathematical skills" as necessary in CS (Purdue University, 2018). Thus, she attempted to author herself into the sanctioned storylines of CS by matching her skills to a major. For instance, she said that she was detailed-oriented because she notices things others do not and that math has always come easily to her.

In summary, both Daniela and Elsa were advised to take more mathematics courses during high school, following a storyline about mathematics as a predictor for completion of a STEM-related degree (Trusty, 2002). Research suggests that encouraging women of color to pursue advanced math and science courses in high school helps them to author themselves in the figured world of STEM but that they also additional resources and supports navigate STEM spaces successfully (Allen & Eisenhart, 2017). For both Daniela and Elsa having a mentor in high school provided the opportunity to author themselves in the world of CS. Their statements reflect that high school mentors used different storylines of CS to recruit them but provided them with limited knowledge about the sanctioned storylines of CS.

Discussion

In this article, we used sociocultural theories of identity and self to examine the nuanced ways in which diverse students talked about their decision to major in CS. Carter (2006) found that often, students do not know what a degree in computer science is about. In contrast, findings from this study show that while students may not draw from the official storylines of CS, the participants drew on different storylines about CS stemming from multiple sources in an attempt to author themselves into the figured world of CS. In particular, participant accounts illustrated the nuanced ways in which family, friends, and school personnel influenced students' storylines. Family and friends used social mobility and opportunity storylines to encourage the participants to major in CS. Such findings confirm other studies that have documented the strong influence of family of Latinx students in their decision to major in engineering (Charleston, 2012; Garibay & Vincent, 2018; Lent et

al., 2011; Mein et al., 2020). Lent et al. (2011) also found that among underrepresented students, social supports are related to goals through self-efficacy when choosing computing degrees. Similarly, our study shows that family and friends play an important role in how diverse students author themselves into the world of CS.

Participant narratives also revealed that the decision to major in CS was influenced by user storylines, wherein an interest or an ability to work with computers is weighed heavily when choosing to major in CS. However, when entering the introductory CS course, we begin to see how user storylines were in conflict with the official storylines of faculty. Related to this, Ben-David Kolikant (2011) argues that "[u]sers become accustomed to working at the interface level and are less interested in the underlying mechanisms" (p. 546) while in the official storyline in CS "there is greater appreciation of abstract knowledge of data structures, algorithms, network protocols and computational models, as well as of formal development activities such as analysis, design and documentation" (p. 546). This was further evident in our observations of CS-related activities, where we observed the official storyline that highlighted the importance of problem solving, using pseudo code, and computational thinking.

Also, noteworthy is the finding that the two participants who drew from underrepresentation storylines were both female and that it was a male high school teacher who introduced them to this particular storyline by also drawing on other storylines such as opportunity and social mobility. The ways that Daniela and Elsa talked about their decision to major in CS sheds light on some of the ways that Latinas are being recruited into CS. It can also help us to understand that while high school teachers might position themselves as members of the sanctioned storylines of CS, they fail to provide diverse students with a better understanding of what a major in CS actually entails. This finding aligns with other research, which suggests that efforts to recruit women in CS in K–12 should provide them with opportunities to explore their interest in CS (Scott et al., 2016).

We used figured worlds as a theoretical framework to show how storylines are about identity and power; they organize and sort identities around exclusion and inclusion. In so doing, we suggest that if newcomers are not made aware of the official storyline that creates and sustains that figured world of CS, official members—faculty—can position students' efforts to self-author an identity as unrecognizable—outside—"the official" storyline. This is a particularly important for first generation students of color who are woefully underrepresented in CS. At the same time, in highlighting the multiple storylines that diverse students draw from to self-author themselves into the figured world of CS, we can learn more about the agentive ways that students of color figure who they are relative to CS and in turn, build on this knowledge to make CS more inclusive of diverse newcomers. We think that this finding provides an important contribution to the discourse on diversity in STEM because the emphasis is on cultural processes that need be changed to diversify who is recognized as belonging in the figured world of CS. In total, findings highlight first, how different, and sometimes competing storylines shape diverse students' decision to major in CS and second, the ways in which students' storylines are often outside of sanctioned storylines found in the figured world of CS academic degree programs.

Limitations and Future Research

There are several limitations to this study. First, we did not collect data about the students' grades since the interviews were conducted before the semester ended. In addition, we did not collect any data about previous courses related to CS either in high school or in college other than what the students told us during interviews. Furthermore, it should be noted that the findings of this study are based primarily from student interviews; future studies should examine the official storylines by interviewing faculty and other stakeholders such as department chairs and companies. A longitudinal study that follows students through their years in college may reveal whether and how students' storylines change overtime. Concurrently, a study that examines storylines from students who exit CS before completion might provide further insight into the disconnect between official storylines and students' storylines and in turn, help us to better understand how newcomers gain recognition from established members of that cultural world. Finally, although our data allowed us to examine Latinx students' storylines about CS, it did not allow us to look at the storylines of other underrepresented students in CS (Black students, Native American students), we encourage future work to include greater representation of racially and ethnically diverse college students to make CS more inclusive.

Conclusion

Implications for policy are that initiatives to broaden participation in CS need to pay attention to students' storylines. By paying attention to students' storylines, policymakers, and faculty can better understand students' preconceived notions about the major as well as students' prior experiences and interests (S. L. Rodriguez & Lehman, 2017). Students' preconceived ideas about engineering fields play a crucial role in retention as students often change majors because their ideas about an engineering major do not align with what is actually involved in the degree (Prieto et al., 2009). Faculty and teaching assistants need to be more aware, and curious about the storylines that shapes students decision to major in CS, bearing in mind that students bring valuable "computer-related capital" to the figured world of CS degree programs and even though it might not represent sanctioned-professional-capital is essential that teachers take into account that capital (Ben-David Kolikant, 2011), especially if they hope to successfully broaden participation. Future research should continue to explore sociocultural factors that mediate the decision to major in CS and engineering education among racially, ethnically, linguistically, and gender diverse students (Garibay & Vincent, 2018).

Engineering and computer science departments can partner with high schools, university academic advising as well as department-level advising to develop robust outreach efforts to better inform students' about how to select a major and to provide adequate advising before students decide to major in CS; this is particularly important since most students, especially those that are first-generation college students (Ishitani, 2006) decide to leave the CS major in the first years because of a lack of understanding about the degree (Beaubouef & Mason, 2005). In addition, once students enroll in CS, department-level advising should continue to focus on helping students to become familiar with the sanctioned storylines of CS (i.e., what ABET constitutes as student outcomes) and what the figured world of CS entails.

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