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Exploring the Intersectional Development of Computer Science Identities in Young Latinas

by Sharin Rawhiya Jacob, Jonathan Montoya & Mark Warschauer - May 02, 2022

Background: *There has been a dearth of research on intersectional identities in STEM, including the fields of computing and engineering. In computing education research, much work has been done on broadening participation, but there has been little investigation into how the field of computer science (CS) presents opportunities for students with strong intersectional identities. This study explores the strengths and connections among the unique identities and the symbiotic relationships that elementary Latina students hold in CS identity attainment.*

Purpose: *The aim of this article is to better understand how predominantly low-income, multilingual Latina students experience identity development through the lens of diverse group membership. We examine how young Latinas, through their participation in a yearlong culturally and linguistically responsive CS curriculum, leverage their intersecting identities to rewrite the formula of what a computer scientist is and can be, leaving space to include and invite other strong identities as well.*

Research Design: *An explanatory sequential mixed-methods design was used that analyzed data from predominantly low-income, multilingual Latinas in upper elementary grades, including pre- and post-CS identity surveys (N = 50) delivered before and after implementation of the curriculum, and eight individual semi-structured student interviews.*

Findings: *We found that Latina students developed significantly stronger identification with the field of CS from the beginning to the end of the school year with regard to their experiences with CS, perception of themselves as computer scientists, family support for CS and school, and friend support for CS and school. Interviews revealed that perception of their CS ability greatly influenced identification with CS and that girls' self-perceptions stemmed from their school, cultural, and home learning environments.*

Conclusion: *Our results highlight the wealth of resources that Latinas bring to the classroom through their home- and community-based assets, which are characterized by intersecting group membership. Students did not report on the intersection between language and CS identity development, which warrants further investigation.*

Latinx students have steadily increased their participation in the field of computer science (CS) in recent decades. The percentage of Latinx students earning bachelor's degrees in CS nearly doubled, from 5.2% in 1996 to 10.1% in 2016 (National Center for Science and Engineering Statistics, 2019). At the same time, there has been a decline in women's CS degrees, from 27.2% in 1997 to 18.7% in 2016 (Snyder et al., 2016). Student interest is a key predictor of persistence and opportunities to learn (Hidi, 1990). However, both boys and girls lose interest in computers as they get older, with girls' interest declining more rapidly than boys' (Snyder et al., 2016). Gender disparities are evident in Advanced Placement (AP) CS courses, which are only 20% female, and in non-AP CS courses, which are only 30% female (Wang et al., 2015). Early intervention is critical to increasing participation and combating female attrition, which increases over time and reduces interest in and attainment of CS degrees and careers (Wang et al., 2015).

Addressing lack of diversity and inclusion in CS is not novel. With recent initiatives like Computer Science for All (CSforAll) (Smith, 2016), there is a push for inclusion of underrepresented groups such as young Latinas. However, little research has been done to understand how these young girls identify with CS, become computer scientists, and increase the diversity of these careers. Furthermore, researchers have not investigated how young Latinas' intersectional identities merge with and contribute to overall CS identity.

At the national level, there has been a lack of discussion about intersectional identities in STEM, including the fields of computing and engineering (Holloman et al., 2018). In a systematic review of national reports on broadening participation in STEM, Holloman et al. (2018) found 29 documents in which 13 were focused on issues of gender and 13 on issues of race, while only three were intersectional in focus. Similarly, in computing education research, much work has been done on broadening participation among particular groups of students (i.e., students of color, women, students with disabilities (Goode & Margolis, 2011; Ryoo, 2019), but there has been little investigation into how the field of computing presents unique opportunities and challenges for students with strong intersectional identities. Furthermore, few studies address the strengths and connections among these unique identities or the symbiotic relationship that such positions hold in CS identity attainment.

This research study follows a yearlong CS curriculum, rooted in effective practices for engaging linguistically and culturally diverse students in STEM (National Academies of Sciences, Engineering, and Medicine [NASEM], 2018), that was introduced to seven classrooms serving predominantly Latinx multilingual students from low-socioeconomic backgrounds. Using a mixed-methods design, participating Latina students ($N = 50$) took pre- and post-CS identity surveys, before and after curricular implementation. Two female students from four classes were chosen for interviews ($n = 8$) to understand further how their participation in the curriculum shaped their identification with CS. The surveys showed that Latina students developed significantly stronger identification with the field of CS from the beginning to the end of the school year with regard to their experiences with CS, perceptions of themselves as computer scientists, family support for CS and school (e.g. "my family thinks CS is important to learn" and "my family thinks CS is interesting"), and friend support for CS and school (e.g., "my friends like computer science" and "my friends think computer science is cool"). Interviews revealed that perception of CS ability greatly influenced identification with CS and that girls' self-perceptions stemmed from their school and home learning environments. These results highlight the wealth of resources that Latinas bring to the classroom through their home- and community-based assets, which are characterized by intersecting group membership.

RESEARCH QUESTIONS

The research questions were: (1) What shifts occur in students' identity trajectories after participating in a yearlong computational thinking curriculum designed to meet their linguistic and sociocultural needs? (2) What are possible explanations for these shifts? How are multilingual students' intersectional identities shaped by participation in school, home, and informal learning environments?

CONCEPTUAL FRAMEWORK

Framework for Understanding the Development of Intersectional Identities

Acknowledging intersectionality in identity construction frames the experiences of marginalized students by issues of class, gender, language, culture, family, and race (Collins, 2008; Crenshaw, 1990; hooks, 1992). The broader public perception of these identities may contribute to the marginalization of students whose identities intersect with traditionally underserved groups. Prior research (Rodriguez & Lehman, 2017) indicates that Latinas' families have a large influence on STEM identity development. The concept of *familismo* refers to a strong attachment to nuclear and extended family that emphasizes cooperation and interdependence (Rodriguez et al., 2019) and its relation to STEM identities. The main contribution of this study is the inclusion of familismo—both nuclear and extended family—as a metric for identifying and maintaining a means of support for developing STEM identities. The authors are aware of the often problematic use of labels such as "Latina" and "Latinx" in perpetuating the erasure of indigenous communities and perpetuating anti-Blackness (Rosa, 2019). We are aware of the limitations of the use of such designations and follow the lead of Rosa (2019) in using "Latinx" as "a gender non-binary alternative to Latina, Latino" (p. xvii). "Latina" is used when referring to self-identified Latina students.

We define identity as the way in which students negotiate, construct, and perceive their roles in a given community of practice—in this case, CS (Burke & Stets, 2009; Tonso, 2006; Wenger, 1998). Recent research that draws on sociological perspectives views identity as dynamically negotiated and constructed through interaction (Buxton et al., 2005; Carlone & Webb, 2006; Gee, 2000; Holland et al., 1998; Wenger, 1998), and takes into account the roles that teachers, family, and peers play in its development. Taking a sociological approach to identity construction allows us to account for the structural factors that may shape the experiences of students from traditionally marginalized backgrounds (Rodriguez & Lehman, 2017).

The theoretical framework for our analytic techniques and discussion is built on Carlone and Johnson's (2007) science identity model, which frames identity through the three key points of competence, performance, and recognition. First, individuals with strong identities in STEM are competent: They possess the requisite science knowledge, skills, and attitudes to develop a deeper understanding of science content, and they are able to apply their content knowledge to real-world phenomena. Second, individuals with strong science identities are able to perform ways of doing science for others by proceduralizing ways of talking and acting scientifically and by displaying their grasp of scientific practices. Third, defining oneself as a science person is an act of recognition that is reciprocated by others (Carlone & Johnson, 2007).

Carlone and Johnson (2007) also borrowed from Gee's (2000) definition of identity theory to elaborate on students' desires to be perceived as a specific "kind of person" within the science community. This kind of perception is impossible at the individual level and requires participation in the broader community of practice (Buxton et al., 2005; Carlone & Webb, 2006; Gee, 2000; Holland et al., 1998; Wenger, 1998). Anderson (2009) appropriated positioning theory to examine how speech transforms our ideas of individuals as certain *kinds* of people, that is, how we develop a reified sense of the way a person participates in and across interactions (i.e., as a failure, as a competent actor). In particular, Anderson (2009) looks at how discourse contributes to the positioning of students according to notions of what it is to be a good student, a scientist, a person from a specific cultural background, a woman, etc.

Within the Carlone and Johnson (2007) identity model, the dimensions of science identity (competence, performance, and recognition) intersect with racial, cultural, gendered, and language identities for women throughout the process of identity construction (Carlone & Johnson, 2007). For example, someone may self-perceive as a competent actor within the scientific community of practice but not be recognized by others as such. Ethnographic studies conducted at an elite engineering program found that women who were highly competent and exceptionally high performers did not receive recognition as legitimate scientists (Tonso, 1999, 2006). Recognizing gender barriers for young women in STEM pathways clarifies the need to counter the threat of stereotype (Steele & Aronson, 1995) and to combat marginalization, while imparting confidence in women in STEM (Montoya et al., 2020).

METHOD

THE CURRENT STUDY

Western University (all names and research sites are pseudonyms) partnered with a county department of education and a large urban school district to form a collaborative network of university and K-12 researchers and practitioners with the aim of promoting computational thinking for students in Grades 3–5. This network functioned through principles of design-based implementation research (DBIR), designing interventions to implement, study, and refine alongside the county and district. The district in which the study is situated had among the highest percentages of low-income students (91%), Latinx students (96%), and students designated as English learners (63% in elementary grades) in the nation. This study took place in seven upper elementary (Grades 3–5) classrooms across the school district. Student demographics at the classroom level broadly mirrored those at the district level.

RESEARCH DESIGN

We utilized an explanatory sequential mixed-methods design to explore how the yearlong computational thinking curriculum supported the development of CS identities for culturally and linguistically diverse students. Through the integration of quantitative and qualitative methods, mixed-methods research accommodates the diversity of classroom conditions that characterizes our partnering district's multifaceted educational landscape better than either method alone (Johnson & Onwuegbuzie, 2004; Morse, 2003). Data collection included a pre- and postprogram survey on student identification with the field of CS, administered before and after students participated in the yearlong curriculum, and open-ended interview questions to further probe their survey responses.

A total of seven teachers and their classrooms were selected for the partnership program based on their prior experience and interest in teaching CS to upper elementary students. All the female students in their classes (total $N = 50$) participated in the project and thus were part of the study.

OVERVIEW OF THE CURRICULUM

Researchers and teachers collaborated to adapt an existing Grade 3–5 curriculum created by a path-breaking initiative that seeks to normalize CS education in a large urban K–12 district. The computational thinking curriculum, which aligns with the Computer Science Teaching Association K–12 Computer Science Standards, was adapted to meet the needs of the district's diverse students. Design-based implementation research was used to integrate theory and practice into curriculum design.

The curriculum was developed according to effective practices for engaging multilingual students in STEM as outlined by report conducted by the National Academies of Sciences (NASEM, 2018). According to this report, the following findings have been shown to be effective in increasing academic and affective outcomes for multilingual students in STEM: (1) engage students in disciplinary practices, (2) encourage rich classroom discourse, (3) build on students' multiple meaning-making resources, (4) encourage students to use multiple registers and modalities, and (5) provide explicit focus on how language functions in the discipline. Given the dearth of empirical evidence supporting the engagement of multilingual students in CS education in particular, we hosted a weeklong summer institute to codesign with practitioners a theoretically sound curriculum while tailoring materials to meet the needs of the district's diverse learners. This was achieved by (1) aligning the curriculum with CS and literacy standards, (2) integrating inquiry-based approaches, (3) providing multiple opportunities for collaboration, (4) providing culturally responsive pedagogy and materials, (5) presenting multimodal options for learning, and (6) providing intensive linguistic scaffolding. For a more in-depth description of the curriculum, see Jacob et al. (2018). The teachers participating in our study implemented the yearlong five-unit computational thinking curriculum in their classrooms once a week for a lesson duration of 50 minutes.

DATA COLLECTION AND ANALYSIS

Pre- and Postsurvey on Student Identification With CS

We adapted an existing survey titled "Is Science Me?" (ISM; Gilmartin et al., 2006) to capture students' attitudes toward CS disciplines and careers, and the influence of their families and peers on their identification with computing (our adapted survey is renamed "Is Computer Science Me?" [ICSM]). The survey included mostly 3-point Likert scale items and comprised 20 questions categorized according to student identification with CS based on (1) students' experiences with computers, (2) students' perceptions of CS, (3) students' self-perception as computer scientists, (4) family support for CS, and (5) friend support for CS. Categorical aggregates were calculated by summing the individual item responses within each category, then normalized by the maximum possible score to lie on a scale from 0 to 1. The ICSM survey was administered at the beginning of the academic year, before the curricular intervention, and at the end of the year, after students had completed the curriculum.

Follow-Up Interviews on Student Identification With CS

To develop the semi-structured interviews, we constructed open-ended questions based on the constructs underlying the ICSM survey with the aim of gaining a more in-depth understanding of student responses. We paid special attention to how interview findings might relate to the quantitative survey findings. For the interviews, we asked four teachers to select two female students from each classroom ($N = 8$): one with proficient programming experience and English language skills, and one with emerging programming experience and English proficiency. These selection criteria were created as part of a larger study and did not factor into our data analysis.

ANALYTIC METHOD

RQ1: What shifts occur in students' identity trajectories after participating in a yearlong computational thinking curriculum designed to meet their linguistic and sociocultural needs?

To address the first research question, we compared pre- and posttest responses to the ICSM survey. We calculated the mean posttest minus pretest difference in student response, its standard error, t statistic, and effect size for each individual survey item, as well as categorical aggregates. We evaluated the significance of mean-differences using a t test for ease of representation, presenting results for categorical aggregates graphically with individual items reported in tabular form. Because most survey responses consisted of 3-point Likert scale items and the sample size may not be sufficient to justify asymptotic approximations for the sample, we also performed Wilcoxon matched pairs signed-rank tests to evaluate the significance of differences across items and aggregates. Because the findings of the two testing approaches were identical, the Wilcoxon test results are unreported. The Wilcoxon signed-rank test applies to repeated measurements from a single population evaluating the null hypothesis that the measurement's distribution is unchanged from the pretest to posttest samples. As a nonparametric paired difference test, it applies even when the two samples' means are not assumed to be normally distributed.

RQ2: What are possible explanations for these shifts? How are multilingual students' intersectional identities shaped by participation in school, home, and informal learning environments?

We addressed our second research question through open coding of semi-structured student interviews, allowing students to elaborate when they wanted. Our interviews were conducted primarily in English, with clarification in Spanish when needed. Researchers identified emerging themes surrounding student identification with CS. We conducted top-down and bottom-up coding in iterative cycles (Hsieh & Shannon, 2005) (see Appendix). In the first cycle of coding, two researchers collaborated to assign preliminary codes to excerpts of text that pertained to student identification with CS as framed by the theoretical framework. After open coding four interviews, the two researchers convened to discuss and consolidate the preliminary codes. The lead author then applied the consolidated codes to the remaining interviews, generating new codes when excerpts of the text pertaining to the research questions did not match the existing codes. During the second cycle of coding, the researchers combined codes into categories and subcategories to reveal emerging themes of the study.

RESULTS

QUANTITATIVE CS IDENTITY SURVEY RESULTS

We address the first research question using the survey results to identify shifts in students' identity development through their participation in the CS curriculum. The quantitative analysis demonstrates a general trend supporting positive growth in students' perceptions of CS. Every category shows positive growth in students' identification with CS. We find one-sided significant differences in Experiences With Computers, Panel A: $Mdiff = 0.18$, $t(50) = 3.27$, $p < .01$; Self-Perception as Computer Scientist, Panel C: $Mdiff = 0.13$, $t(50) = 1.94$, $p = .03$; and Family Support for Computer Science and School, Panel D: $Mdiff = 0.12$, $t(50) = 2.43$, $p = .01$. The increase in Friend Support for Computer Science and School, Panel E: $Mdiff = 0.07$, $t(50) = 1.82$, $p = .04$, was marginally significant, while the difference in Perceptions of Computer Science, Panel B: $Mdiff = 0.05$, $t(50) = 0.98$, $p = .17$, was not significant. Table 1 presents the postsurvey minus presurvey averages for individual items in the ICSM, with nearly every item showing positive (though not necessarily statistically significant) growth from pretest to postsurvey results. Note that even though a categorical aggregate may show statistically significant growth, some subitems are not statistically significant, and a few subitems report a decline. Further, though evaluating significance with multiple items may suggest multiple comparison adjustments, we present unadjusted p values for transparency and ease of interpretation with qualitatively similar results.

Table 1. Post-Minus-Pre Test Differences in IsCSMe? Survey Responses

Panel A: Experiences With Computers					
$n = 50$	Mean diff	Effect size	*SE*	*t* statistic	*p* value
I talk with friends and fam about CS	0.40	0.75	0.08	5.29***	.00
I write programs	0.08	0.13	0.08	0.94	.18
I use tools to build things	0.08	0.13	0.08	0.94	.18
I take apart toys/computers	-0.02	-0.03	0.10	-0.21	.58
Aggregate: Experience With Computers	0.18	0.15	0.05	3.27***	.00
Panel B: Perceptions of Computer Science					
$n = 50$	Mean diff	Effect size	*SE*	*t* statistic	*p* value
I think CS is interesting	-0.02	-0.04	0.07	-0.30	.62
I am good at CS	0.08	0.10	0.11	0.73	.24
Computer scientists make a difference	0.06	0.10	0.09	0.68	.25
Computer scientists are respected	0.06	0.12	0.07	0.83	.21
Aggregate: Perceptions of CS	0.05	0.03	0.05	0.98	.17
Panel C: Self-Perception as Computer Scientist					
$n = 50$	Mean diff	Effect size	*SE*	*t* statistic	*p* value
If people tell me I can't do something, it makes me try harder	0.12	0.13	0.13	0.90	.19
I enjoy trying to understand difficult things	0.06	0.08	0.11	0.55	.29
I can learn CS	0.22	0.43	0.07	3.07***	.00
Aggregate: Self-Perception as Computer Scientist	0.13	0.09	0.07	1.94**	.03
Panel D: Family Support for Computer Science and School					
$n = 50$	Mean diff	Effect size	*SE*	*t* statistic	*p* value
It's important to my family that I get good grades	0.12	0.23	0.07	1.63*	.05
It's important to my family that I try my best	0.10	0.27	0.05	1.94**	.03
My family knows how well I'm doing in school	0.18	0.34	0.07	2.44***	.01
My family thinks CS is important to learn	0.12	0.18	0.09	1.29	.10
My family thinks CS is interesting	0.10	0.14	0.10	1.00	.16
Aggregate: Family Support for Computer Science and School	0.12	0.07	0.05	2.43***	.01
Panel E: Friend Support for Computer Science and School					
$n = 50$	Mean diff	Effect size	*SE*	*t* statistic	*p* value
My friends like CS	0.40	0.37	0.15	2.60***	.01
My friends think CS is cool	0.38	0.35	0.15	2.47***	.01
My friends encourage me to do well in school	-0.14	-0.10	0.20	-0.69	.75
Aggregate: Friend Support for CS and School	0.07	0.03	0.04	1.82**	0.04

In Experiences With Computers, as reported in Table 1, Panel A, the most significant growth occurred in students' talking with family and friends about CS, $d = 0.75$, $t(50) = 5.29$, $p < .01$. Survey responses showed statistically nonsignificant growth in writing programs, $d = 0.13$, $t(50) = 0.94$, $p = .18$, and using tools to build things, $d = 0.13$, $t(50) = 0.94$, $p = .18$, and an insignificant decline in taking apart toys and computers to see how they work, $d = -0.03$, $t(50) = -0.21$, $p = .58$.

In Perceptions of Computer Science, as reported in Table 1, Panel B, no items showed statistically significant positive growth, with nonsignificant increases in students' belief that they are good at CS, $d = 0.10$, $t(50) = 0.73$, $p = .24$; computer scientists make a difference, $d = 0.10$, $t(50) = 0.68$, $p = .25$; and computer scientists are respected, $d = 0.12$, $t(50) = 0.83$, $p = .21$, and an insignificant decline in thinking CS is interesting, $d = -0.04$, $t(50) = -0.30$, $p = .62$. Within this last category, students' responses were affected by ceiling effects on the items "I think CS is interesting," affecting 86% of student responses, and "Computer scientists make a difference," affecting 76% of student responses.

In Self-Perception as Computer Scientist, as reported in Table 1, Panel C, the most significant growth occurred in students' belief in their ability to learn CS, $d = 0.43$, $t(50) = 3.07$, $p < .01$. Survey responses showed statistically nonsignificant growth in students' motivation when challenged, $d = 0.13$, $t(50) = 0.90$, $p = .19$, and enjoyment of challenging tasks, $d = 0.08$, $t(50) = 0.55$, $p = .29$. Within this category, we removed students' responses to "I don't like to do things that are difficult to master quickly" because of confusion in interpreting the embedded multiple negative qualifiers in the item.

Students demonstrated broad growth in Family Support for Computer Science and School, as reported in Table 1, Panel D. Statistically significant growth occurred in the importance that students' families placed on grades, $d = 0.23$, $t(50) = 1.63$, $p = .05$; the importance students' families placed on trying their best, $d = 0.27$, $t(50) = 1.94$, $p = .03$; and students' families' knowledge of their performance in school, $d = 0.34$, $t(50) = 2.44$, $p = .01$. Survey responses showed statistically nonsignificant growth in the importance that students' families placed on learning CS, $d = 0.18$, $t(50) = 1.29$, $p = .10$, and students' families' interest in CS, $d = 0.14$, $t(50) = 1.00$, $p = .16$.

In Friend Support for Computer Science and School, as reported in Table 1, Panel E, significant growth occurred in friends' affinity for CS, $d = 0.37$, $t(50) = 2.60$, $p = .01$, and in friends' belief that CS is cool, $d = 0.35$, $t(50) = 2.47$, $p = .01$. Survey responses showed a statistically nonsignificant decline in friends' encouragement to do well in school, $d = -0.10$, $t(50) = -0.69$, $p = .75$.

CS IDENTITY INTERVIEW FINDINGS

To address the second research question, we analyzed results from coded student interviews to present plausible explanations for shifts in students' identity development and to describe how their intersectional identities are shaped by participation in school, home, and informal learning environments.

Family Support for CS

Our findings indicated that family involvement is a cornerstone for a student acquiring and maintaining a CS identity. Through our interviews, we found that familial support is important not only for the well-being of these young Latina girls but also for the nurturing of their intersectional identities, including CS identity. This corroborates much of what we have learned from the sociological approach to identity development, including Wang and colleagues' (2015) finding that family plays a critical role in exposure to and support of CS, as well as research on family support by Rodriguez et al. (2019). Familial support and family interest in students' CS projects and identities were coded in interviews as necessary support for those young Latina students who were identified as having strong CS identities. The following quotations, from a few of the young Latinas who identified strongly with CS, are representative of the overall student responses to their identity interviews. These students described their interactions with their parents and their parents' interest in their CS projects and in their identity as future computer scientists.

Amaia, a student who participated in the CS curriculum, was very excited to talk with the researcher and began to discuss how she and her family spoke about CS projects.

Interviewer: Do you talk about computer science with your parents, with your family?

Amaia: I talked to my mom and my dad. How fun it is and sometimes if we can do projects together.

Interviewer: So what do you think your parents think about computer science?

Amaia: I think they like it too 'cause it's helping me, like creating my ideas and stuff like that, so they like it a lot!

Amaia's response illustrates seeking and receiving approval and recognition for her CS work. These observations are in line with Carlone and Johnson's (2007) work on science identity. It is apparent that family support and recognition may contribute to the development of CS identity. This observation is supported by the pre- and postprogram survey data, which indicated significant growth for family support and CS self-perception. The interviews revealed that these two pieces are connected: Students seek recognition, and families affirm that recognition. Without this family support and recognition, students may not receive the support that contributes to achieving CS identity.

The following conversation was conducted with Andrea, a young Latina identified by her instructor as having a strong CS background. She discussed her parents' interest in and support of her CS learning. A common theme in our interviews was the students' eagerness and willingness to discuss how their families viewed them as competent computer scientists. These questions started more generally about their families' opinion of computer science; however, students quickly described their parents' support for their CS projects and, ultimately, their identity as computer scientists.

> Interviewer: What does your family think about computer science?
>
> Andrea: They feel glad . . . I'm like, I want to be a scientist when I grow up. And my mom's like, it's great . . . since you're already learning it, when you get the hang of it and when you're an adult you already get the hang of it. And you're already going to be like, oh, I already learned this in one grade and then if I learn it in fifth grade and oh . . . I already learned it in each year.

Andrea's mother has reinforced her cumulative learning and expertise, aligning with Carlone and Johnson's (2007) science identity framework as it relates to competence, and especially to the building of competence through parental support. Andrea's mother describes how Andrea's competence may increase through years of study, helping her to better understand her own competence as a computer scientist. This is a crucial point: A student's family contributes to attaining and nurturing a CS identity while maintaining her various intersecting identities that have traditionally come into conflict with CS identity. These seminal instances of identity development were identified as crucial instances of identity formation by Rodriguez et al. (2019) in their study of STEM identities and familismo. These familial supports bridge the cultural gaps that Rodriguez et al. (2019) found with Latina students, who experience difficulty viewing themselves as potential scientists. Through our interviews, we found that CS identity, family support, and Latina identity are intertwined and grow stronger together. These relationships provide a key to identifying and leveraging these intersecting identities, which may lead to greater identification with CS. The mother-daughter relationship, coupled with affirming strong Latina identity, paved the way for this student to identify heavily with CS. This positive trend is also evident in the pre- and postprogram surveys; the category for family support showed significant growth. These affirmations are often needed to combat the deficit-based narratives (Flores & Rosa, 2015) that students face in their schools and society. Furthermore, this recognition and self-confidence may work to guard against the lack of recognition that Tonso (1999, 2006) found in her studies. Through our analysis, we found familial support and recognition to be tied to CS identity. These findings are in line with what Rodriguez et al. (2019) referred to as the interdependence between family members and the support for their STEM journey. These students were very confident in their CS abilities, and when their parents took a real interest in their CS studies, their confidence grew.

Siblings and Informal Learning Environments

We coded interviews for parental involvement and importance for nurturing CS identities. However, sibling support also revealed itself as a strong indicator for building and nurturing CS identities, given that many of the interviewed students displayed and shared their competence through interactions with their siblings about CS. These informal learning interactions took place outside traditional classroom lessons. By bringing their CS learning outside the classroom to informal learning environments, siblings supported one another, enabling them to share resources and build on one another's formal CS learning. The following student, Angelica, describes doing extracurricular coding projects with her 10-year-old brother who was not in her classroom. She describes sharing formally and informally learned CS expertise. Computer science with family and friends was a theme among our interviews. Angelica was very excited to tell the researcher about the computer literacy she practices with her brother. This response was very common in our interviews.

> Angelica: I do it (CS) a lot of times with my brother. He's the one who showed me how to upload the image.
>
> Interviewer: How old is your brother?
>
> Angelica: He's in fifth grade . . . He's 10 years old . . . He helps me cause he knows a lot of things like better images.

As exemplified in Angelica's quote, students identified as having strong CS identity also tend to have strong familial ties and interactions with informal CS learning. For these young Latinas who identify strongly with CS, their CS learning is heavily embedded in their daily activities, far beyond a simple classroom lesson or a one-off after-school computer programming activity. Furthermore, this learning is taking place in informal spaces, such as home and the homes of extended families. Through these interviews, we see a counternarrative to the accepted wisdom around what is needed to attain and maintain CS identities. These young Latinas do not fit the prescribed definition of computer scientist, which left no room for their intersecting identities. Through this curriculum, youth are rewriting the formula of what a computer scientist is and can be, and leaving space to include and invite other strong identities as well.

Extended Families and Culture

Connected to familial support are the cultural connections many young people learn from their friends, community, and immediate and extended families—termed "community knowledge" by Pinkard (2019). The connection and support of family and friends, and the ability to share and teach each other nurture and build CS identities. When coding these interviews, we selected key components of CS identity that are associated with family and friends. These themes not only corroborated trends found in the survey, but expanded on and provided exploratory analysis of how these themes were operationalized in students' experiences. Many of the interviewees mentioned informal learning with immediate and extended family in which CS mixed with Latina and popular culture such as music, art, food, and fashion.

This interview is representative of those we conducted but warrants attention because there are many layers of informal learning with extended and immediate family. This student is very excited to discuss coding with her cousins and her little sister. She also begins to discuss coding projects relating to her culture. These data could not have been captured without the semi-structured interview format, in which the researcher thought it necessary to expand and ask more clarifying open-ended questions.

> Interviewer: Is there anyone outside of class that you code with? When was the last time you did a project?
>
> Alicia: Yeah. My cousins . . . showed me code.org. I showed them Scratch. . . . One of my friends, Jennifer, visits, and sometimes we do it [CS]. She knows about it.
>
> Interviewer: Do you ever talk with people about computer science when you're outside of school?
>
> Alicia: Oh yes! My little sister. I'm like, oh, we learned something new in class, and she's like I don't want to hear, I think it's going to be horrible. I'm like, no. It's new, I'm going to show you the program. She's like, okay, show me the program. And then she's like, oh, this is what you're doing in class! I'm like, yes. You know? And then she said, oh, sorry about saying that . . . she's like can we do Scratch? And I'm like sure. And she, she like, began to do a, like a blog. Then I showed her something you know, those dresses you can make even though the person is not wearing it, but like you could make the person wear it, yeah. Like you just make it the size that the person is. It was just really interesting.

This student, Alicia, has tapped into the cultural resources of other young Latinas with budding CS identities. They are sharing resources and doing CS projects outside of their classrooms, using the CS tools integrated into the curriculum to express themselves and share their voices. Discussing music, art, food, and fashion allows students both to elevate their identities as computer scientists and to affirm their various identities. As a result, we see a solidification of the intersectional identities originally laid out by Crenshaw (1990). While Crenshaw (1990) used the intersection as an analogy to reveal compounding marginalization, we see it as an opportunity. These findings are interesting because they also reveal what the pre- and postsurveys hinted at: When students' friends and family validate their CS work, it builds their CS identity. Through these interviews, it is evident that culture is embedded within these informal learning interactions with extended family and friends. Leveraging intersecting identities, these students magnify their CS learning and identity. Responding to Rodriguez and Lehman (2017), evidence demonstrates that including culture in curriculum may support young girls' development of strong CS identities. These identities rely on one another, so no longer do students have to choose between being a computer scientist and being Latina. These students are creating their own intersecting identities as Latina computer scientists. Achieving CS identity rests on affirming cultural identity, and through these interviews, we see that these intersecting identities must be fostered in informal learning situations with immediate and extended family and friends.

DISCUSSION

This study revealed that our yearlong intervention helped to amplify the asset-based ideologies and curricula that perpetuate positive CS identification in concert with the strong familial and cultural identities of young Latinas. The results of surveys and interviews corroborate the work of Rodriguez et al. (2019) and respond to Rodriguez and Lehman's (2017) call for enhanced, intersectional computing identity theory. We have illustrated that as early as fourth grade, an intentional CS curriculum with an awareness of intersectionality can be leveraged to build and maintain Latina CS identities, which they may carry into adulthood (Carlone et al., 2014). Through interviews and surveys, we observed young Latinas disrupting the prescribed definition of computer scientist, a definition in which there was no room for their intersecting identities. Through this curriculum, young Latinas are helping to write a new definition that allows for their flourishing as computer scientists by including other strong identities that will support them through their STEM journeys (Rodriguez et al., 2019).

Both the qualitative and quantitative results of this study follow Rodriguez and colleagues' (2019) concept of familismo, revealing family to be a cornerstone for attaining strong CS identity. Our findings reveal how these young Latinas are foundationally supported by their immediate and extended families. This family support is deeply rooted in culture, which can be leveraged and unlocked through culturally relevant pedagogy (Camangian, 2015). Our findings indicate that to nurture young Latinas' CS identities, we need to attend to Latina culture and other intersectional identities such as family, culture, and community (Rodriguez & Lehman, 2017). These intersecting identities are interdependent and necessary for social development. In our yearlong intervention, we found that intentionally including lessons and activities that foreground family and culture contributed to the students accommodating CS concepts in their out-of-school familial interactions and relationships.

Relationships with immediate and extended family mediate the various informal learning contexts (Pinkard, 2019) of young Latina students, helping them to fortify developing intersecting identities. Through our interviews, we found evidence that culturally and linguistically relevant CS curricula were effective in facilitating informal learning of CS outside the classroom, built on and strengthened by existing cultural and familial identities. These young Latinas were able to take their lessons home and use their new CS skills to build new projects and skills, simultaneously affirming cultural identity and strengthening their identification with CS. We identified unique instances of these intersecting identities working in unison to build not only strong CS identity but also strong Latina identities.

The building and nurturing of strong CS identities through leveraging culture and family encouraged these young Latinas to practice computer science learning in both their formal and informal learning environments. Through our interviews, we found evidence that they strengthened their CS identities as they took on the role of content experts in their families. The culturally responsive, inquiry-based projects in our intervention curriculum allowed for computer science learning that reached beyond their classroom lessons to informal learning environments such as their homes, and engendered student creativity, which in turn strengthened CS identity. These findings reveal that curating a Latina-positive curriculum with intentional implementation of culture may contribute to transferable skill building and the strengthening of intersectional identities, which contribute to an overall strong CS identity.

The leveraging of informal learning environments and community knowledge (Pinkard, 2019) also advances our understanding of what spaces of learning can be. Through our surveys and interviews, we found that out-of-school and other informal learning environments were large contributors to CS identity attainment. Through the interviews, we found that many students described situations in which they participated in coding with their family and friends at home, which they truly enjoyed and which helped to strengthen and nurture their relationships and their overall CS identity.

One limitation to this study is the small sample size. Because we chose to focus on just the female students, we had fewer participants. However, this choice may afford us further study focusing on issues of gender intersecting with language, class, race, and culture. Another limitation is the lack of a control group to compare the survey responses. This represents a common issue in elementary computer science education; there is no dedicated time for CS instruction during the school day, so it is difficult to compare an intervention to a control group engaging in business as usual. However, given that this pilot was the exploratory phase of a larger effort to test, refine, and scale the curriculum, we will be conducting a randomized controlled trial in the 2021–2022 school year. Additionally, the CS identity survey was adapted from a science identity survey, and going into the pretest, students may not have had as much knowledge about CS as they had about science. Thus, the results may have been skewed in the positive direction.

Further, heterogeneous responses to individual items on the survey require considering the results for each item individually as well as within the context of their collective presentation. While we present our results using appropriate and transparent statistical methods, further analysis may consider (1) identifying aggregate factors that account for the heterogeneity embedded in individual survey items and (2) applying statistical approaches such as the Bonferroni correction to explicitly account for multiple comparisons. Finally, because students did not explicitly state how language played a role in their CS identity development, more research into how language shapes students' identity development is warranted. Despite these limitations, these findings lead us to conclude that in order to view themselves as computer scientists, young Latinas must also be encouraged to affirm and build their multiple identities. If a curriculum does not include or leverage these identities, these promising young scholars may never actualize their potential as computer scientists, and the field will continue to suffer from their exclusion.

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References

Anderson, K. T. (2009). Applying positioning theory to the analysis of classroom interactions: Mediating micro-identities, macro-kinds, and ideologies of knowing. *Linguistics and Education, 20*(4), 291–310.
Burke, P. J., & Stets, J. E. (2009). *Identity theory.* Oxford University Press.

Buxton, C. A., Carlone, H. B., & Carlone, D. (2005). Boundary spanners as bridges of student and school discourses in an urban science and math high school. *School Science and Mathematics*, *105*, 302–312.

Camangian, P. R. (2015). Teach like lives depend on it: Agitate, arouse, and inspire. *Urban Education*, *50*(4), 424–453. https://doi.org/10.1177/0042085913514591

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218.

Carlone, H. B., Scott, C. M., & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching*, *51*(7), 836–869.

Carlone, H. B., & Webb, S. (2006). On (not) overcoming our history or hierarchy: Complexities of university/school collaboration. *Science Education*, *90*, 544–568.

Collins, P. H. (2008). Reply to commentaries: Black sexual politics revisited. *Studies in Gender and Sexuality*, *9*(1), 68–85.

Crenshaw, K. (1990). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, *43*, 12–41.

Flores, N., & Rosa, J. (2015). Undoing appropriateness: Raciolinguistic ideologies and language diversity in education. *Harvard Educational Review, 85*(2), 149–171.
Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education*, *25*, 99–125.

Gilmartin, S. K., Li, E., & Aschbacher, P. (2006). The relationship between interest in physical science/engineering, science class experiences, and family contexts: Variations by gender and race/ethnicity among secondary students. *Journal of Women and Minorities in Science and Engineering*, *12*(2–3), 179–207.

Goode, J., & Margolis, J. (2011). Exploring computer science: A case study of school reform. *ACM Transactions on Computing Education*, *11*(2), Article 12. doi:10.1145/1993069.1993076

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research*, *60*(4), 549–571.

Holland, D., Lachiotte, W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Harvard University Press.

Holloman, T., Lee, W. C., London, J., Halkiyo, A., Jew, G., & Watford, B. (2018, April). A historical and policy perspective on broadening participation in STEM: Insights from national reports (1974-2016). In 2018 *CoNECD-The Collaborative Network for Engineering and Computing Diversity Conference*. CoNECD.

hooks, b. (1992). *Yearning: Race, gender, and cultural politics*. Routledge.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*(9), 1277–1288.

Jacob, S., Nguyen, H., Tofel-Grehl, C., Richardson, D., & Warschauer, M. (2018). Teaching computational thinking to English learners. *NYS TESOL Journal*, *5*(2), 12–24.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14–26.

Montoya, J., Peterson, F., & Bonilla, S. (2020, August 16–18). Opportunity gap and women in the energy infrastructure workforce. In *2020 8th International Research Symposium on PBL*. Aalborg University, Aalborg, Denmark.

Morse, J. M. (2003). Principles of mixed methods and multimethod research designs. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed-methods in social and behavioral research* (pp. 189–208). SAGE.

National Academies of Sciences, Engineering, and Medicine. (2018). *English learners in STEM subjects: Transforming classrooms, schools, and lives*. National Academies Press. https://www.nap.edu/catalog/25182/english-learners-in-stem-subjects-transforming-classrooms-schools-and-lives

National Ceter for Science and Engineering Statistics. (2019). *Women, minorities, and persons with disabilities in science and engineering*. https://ncses.nsf.gov/pubs/nsf19304/digest

Pinkard, N. (2019). Freedom of movement: Defining, researching, and designing the components of a healthy learning ecosystem. *Human Development, 62*(1–2), 40–65.

Rodriguez, S. L., & Lehman, K. (2017). Developing the next generation of diverse computer scientists: The need for enhanced, intersectional computing identity theory. *Computer Science Education*, *27*(3–4), 229–247.

Rodriguez, S., Pilcher, A., & Garcia-Tellez, N. (2019): The influence of *familismo* on Latina student STEM identity development. *Journal of Latinos and Education.* doi:10.1080/15348431.2019.1588734

Rosa, J. (2019). *Looking like a language, sounding like a race: Raciolinguistic ideologies and the learning of Latinidad*. Oxford University Press.

Ryoo, J. J. (2019). Pedagogy that supports computer science for all. *ACM Transactions on Computing Education*, *19*(4), 1–23.

Smith, M. (2016, January 30). Computer science for all [Blog comment]. Retrieved from https://obamawhitehouse.archives.gov/blog/2016/01/30/computer-science-all
Snyder, T. D., De Brey, C., & Dillow, S. A. (2016). Digest of Education Statistics 2014 (NCES 2016-006). National Center for Education Statistics.

Steele, C., & Aronson, J. (1995). Stereotype threat and intellectual task performance of African Americans. *Journal of Personality and Social Psychology*, *69*, 797–811.

Tonso, K. L. (1999). Engineering gender—gender engineering: A cultural model for belonging. *Journal of Women and Minorities in Science and Engineering*, *5*, 365–404.

Tonso, K. L. (2006). Student engineers and engineer identity: Campus engineer identities as figured world. *Cultural Studies of Science Education*, *1*, 237–307.

Wang, J., Hong, H., Ravitz, J., & Ivory, M. (2015, June). Gender differences in factors influencing pursuit of computer science and related fields. In *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education* (pp. 117–122). Association for Computing Machinery.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge University Press.

APPENDIX

SAMPLE CODES, DEFINITIONS, AND EXCERPTS

Theory	**Code**	**Definition**	**Excerpt**
Competence	Cumulative learning	Students increase their CS learning over a period of cumulative experience and exposure.	*Since you're already learning [CS], when you get the hang of it and when you're an adult you already get the hang of it. And you're already going to be like, oh, I already learned this in one grade and then if I learn it in fifth grade and oh . . . I already learned it in each year.*
	Learning from peers	Students look at each other's code to learn how the project runs, reuse their peer's code in their own projects, or remix their peer's code by making it their own.	*I wanna see like how [my peers] did everything. Like how they do their project. Yeah. Like if it's on their projects, but I don't change anything, I just look what they put and try to figure it out.*
	Learning through teaching	Students learn by teaching peers and/or family and in doing so position themselves as experts.	*I would help people learn, like about coding out and tell them about the event blocks and about the characters and about how to change backgrounds and how to take care of the internet and put it [the Scratch project] on there.*
Performance	Leveraging family resources	Students leverage the knowledge and support of their families to practice computer science.	*I started to do a lot of outside programming with my Dad like games on Scratch. . . We do like really fun games. We tried making our own Fortnite game.*
	Leveraging cultural resources	Students embed cultural referents into their computational artifacts.	*Then I showed her something you know, those dresses you can make even though the person is not wearing it, but like you could make the person wear it, yeah. Like you just make it the size that the person is. It was just really interesting.*
	Out-of-school learning		*[I made] a racing game. . . [in] Mrs. Jeanie's Coding Club after school. One person can use the arrow keys, the up, down, left, and right arrow keys and the other one has used w, a, s, and d . . . and you had like a track and then whoever makes it first wins.*
Recognition	Peer support	Students practice or talk about CS with their friends and receive support and/or feedback and/or they work on projects together	*I talk with my friends about what I put in my project, and like ideas*
	Immediate family support	Students practice or talk about computer science with their parents/guardians or siblings and receive support and/or feedback	*I talked to my mom and my dad [about computer science] . . . how fun it is sometimes and if we can do projects together.*
	Extended family support	Students practice or talk about CS with members of extended family (i.e., grandparents, aunts, uncles, cousins) and receive support and/or feedback	*My cousins they showed me Code.org and I showed them Scratch. I show my cousins and sometimes my mom lets my friends come into my house.*

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