Comparing Boys' and Girls' Attitudes Toward Computer Science

RESEARCH

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ABSTRACT

Women are severely underrepresented in computer science (CS) degrees and careers. While student interest is a key predictor of success, little is known about how elementary students from underserved groups, such as girls, develop their interest in CS. To address this issue, we examined the differences in attitudes between upper elementary girls and boys towards CS after participating in a yearlong, inquiry-based CS curriculum designed for diverse learners. Pre-and-post surveys on students' attitudes towards CS (n = 108) were delivered before and after student participation in the curriculum. Results from the survey showed only two demonstrated significant differences between boys and girls, favoring girls talking more with friends and family about CS and boys believing that computer scientists make a difference in the world. Even for these two items, the differences were of marginal significance and that significance would not survive correction for multiple comparisons. Follow-up, semi-structured interviews with 18 students painted a different picture. Girls displayed decreased interest in CS compared to boys with regard to self-efficacy and overall identification with the discipline. These differences highlight the importance of early intervention programs in leveraging the strengths and interests of participating girls. Based on our findings, we provide recommendations for CS educators and curriculum designers on better engaging girls in the discipline.

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KEYWORDS:

computer science education; gender; identity; elementary; equity

TO CITE THIS ARTICLE:

Scott, D., Zou, A., Jacob, S. R., Richardson, D., & Warschauer, M. (2023). Comparing Boys' and Girls' Attitudes Toward Computer Science. *Journal of Computer Science Integration,* 6(1): 1, pp. 1–17. DOI: https://doi.org/10.26716/jcsi.2023.2.22.37

INTRODUCTION

Recent developments in Computer Science (CS) have shown the need for balance in gender representation. Today, an estimated 20% of CS professionals are women (Women in Computer Science, 2020). Over the past several decades, the amount of women in CS has decreased at an alarming rate. In the 1960s, CS was predominantly populated by women; however, the representation of women in the field has declined since then (Hicks, 2018). Men have grown to comprise the overwhelming majority of CS professionals due to cultural influences such as the lack of women in video gaming and robotics. Additionally, these trends were reified by popularizing the dominant stereotype of programmers in the media (Shapiro, 2017). In the early 2000s, the gender gap widened as college recruitment primarily targeted men using gaming courses to attract students (Kelleher & Pausch, 2007). In 2020, statistics indicated that 21.3% of the CS college graduates were women, and the percentage has been pretty stable over the past five years (National Science Foundation, 2019). In terms of girls' Advanced Placement exam enrollment, out of all Advanced Placement (AP) Computer Science test takers, 31% were girls, and this figure has been steadily increasing since 2010 (Computing for Everyone, 2020).

To combat the gatekeeping constructs that impact diversity and access in the field, CS education needs to connect to broader perspectives that develop positive attitudes and ability beliefs (Cheryan et al., 2009). Gender stereotypes that favor men are just one of the many mechanisms preventing women from exploring CS (Lewis et al., 2016). Providing early exposure is critical to preventing these gender stereotypes from manifesting. Studies have shown that gender differences in computing experience and interest can be seen as early as grades K-5 (Tsan et al., 2016). A 2020 report by Google and Gallup revealed that among the 1,402 seven to 12th-grade students surveyed, girls (31%) were also less likely than boys (49%) to agree that CS is important to learn (Google & Gallup, 2020). This likelihood was shown to increase for students that spent a minimum of one hour a week studying CS in school, regardless of the student's gender. Developing a better understanding of gender differences and factors that lead to equitable integration of CS into elementary grades will allow us to intervene appropriately to create a more diverse field.

In this paper, we examine the differences in attitudes between upper elementary girls and boys towards CS after participating in a yearlong, inquiry-based CS curriculum designed for diverse learners. Pre-and-post surveys on students' attitudes towards CS (n = 108) were delivered before and after student participation in the curriculum. Results showed only two demonstrated significant differences between boys and girls, favoring girls talking more with friends and family about CS and boys believing that computer scientists make a difference in the world. Even for these two items, the differences were of marginal significance and that significance would not survive correction for multiple comparisons. Follow-up, semi-structured interviews with 18 students painted a different picture. Findings revealed that boys and girls had positive feelings about computer science. However, the girls displayed decreased interest in CS compared to boys with regard to self-efficacy and overall identification with the discipline. These differences highlight the importance of early intervention programs in leveraging the strengths and interests of participating girls. Based on our findings, we provide recommendations for CS educators and curriculum designers on better engaging girls in the discipline.

We address the following research question:

1. What are the similarities and differences between upper elementary boys' and girls' attitudes toward CS after participating in a year-long, inquiry-based CS curriculum?

RELATED WORK

Student access to equitable computer science education is a societal issue. Several factors influence women's decisions to pursue computer science well before college. For example, social encouragement and positive social interactions are key factors that shape women's attitudes toward computer science (Vekiri & Chronaki, 2008). When girls receive encouragement from family, teachers, peers, and extended family, they develop greater identification with the field (Jacob et al., 2022; Vekiri & Chronaki, 2008). Furthermore, research indicates that young girls benefit from collaborative problem-solving (Lewis et al., 2016) and are more likely to pursue computer science if they view it as having broader social impact (Vekiri & Chronaki, 2008). Girls tend to perceive computer science as being associated with male interests (Cheryan et al., 2015). When it is placed in a broader social context, such as having the potential to positively shape society, women are more likely to develop positive attitudes toward the discipline (Wang et al., 2015).

Related to this, girls are more likely to pursue computer science courses when they view programming as a possible vehicle for creative expression (Wang et al., 2015). Efforts to integrate e-textiles and storytelling in computer science curricula have positively influenced girls' perceptions of the discipline (Kelleher & Pausch, 2007; Searle et al., 2019). Another strong indicator of whether girls would pursue further CS educational opportunities is their perceptions of their own abilities (Wang et al., 2015). Among high schoolers, girls who had positive CS ability beliefs were 15% more likely to claim that they were good at problem-solving and math than boys (Wang et al., 2015). Girls who did not have positive ability beliefs were less likely to enroll in future computer science classes. Taken together, these results indicate there is a constellation of factors that play a role in shaping young girls' attitudes toward computer science. What follows is a brief description of each key factor.

COLLABORATIVE EXPLORATION AND PROBLEM SOLVING

Studies have shown that girls specifically benefit from collaborative learning during introductory programming courses (Buffum et al., 2016). Collaborative learning can be worked into computing curricula, requiring students to work with their peers to learn and demonstrate CS concepts. This approach to education has been shown to increase persistence in girls and encourage them to incorporate key CS practices into their projects. Collaborative presentations of CS have also been beneficial in allowing students to see CS in a new context, as the competitive and asocial stereotypes associated with programming can impact their perceptions of the field. In a study where students' perceptions of CS were altered through challenging existing stereotypes, collaborative assignments were used to combat the notion that programmers are competitive and asocial (Lewis et al., 2016).

Race and gender intersect in this instance as children from predominantly Latine cultures value community and collaboration (Huerta, 2011). For example, young Latinas are strongly motivated by sharing their work with their peers, families, and extended communities (Jacob et al., 2022; Denner & Bean, 2018; Rodriguez et al., 2021; Wang et al., 2015). Unfortunately, these students attend classes where they frequently see science activities presented as individualistic and noncollaborative, which leads to a lack of interest and cultural validation (Garcia & Lee, 2008). Collaboration and interdependence are emphasized in culturally responsive instructional approaches, which equip diverse learners for real-world challenges of creative thinking and teamwork in subsequent CS coursework and jobs (Berenson et al., 2004).

Another affordance of collaborative learning is that it promotes exploratory approaches to computing (Beckwith et al., 2006). Both collaboration and exploration have been shown to build students' motivation and increase their ability to solve problems (Beckwith et al., 2006). An important yet understudied approach to CS involves the concept of playful exploration. When students tinker and explore, they are often acting on curiosity and are comfortable interacting with CS in novel ways that were not explicitly prescribed by the teacher (Beckwith et al., 2006). Adolescent girls have been observed to be less likely to explore computers beyond the specific instructions provided to them, leaving them feeling less knowledgeable and confident than their peers (Zimmermann & Sprung, 2008). Providing hands-on experience can equip girls with the confidence they need to succeed, as comfort levels have been shown to increase with exposure (Webb & Miller, 2015).

BUILDING COMPUTATIONAL ARTIFACTS AS A VEHICLE FOR EXPRESSION

Teaching girls introductory programming through story-based tools can increase interest in CS (Kelleher & Pausch, 2007). Kelleher et al. (2007) examined how middle school girls develop stronger connections with CS when concepts were presented in a more relatable fashion. The treatment group that worked with Storytelling Alice, an interactive, block-based programming tool, showed increased interest in continuing to program in the future. Girls using the software with a storytelling focus were three times more likely to continue their projects in class than those using the software that lacked a storytelling focus.

Storytelling has several affordances for both girls and students from Latine communities. As explored in Jacob et al., (2022), Latine communities benefit from the storytelling features embedded in media-rich programming environments such as Scratch (Resnick et al., 2009). In Latine cultures, oral language is widely used in the form of storytelling as a mechanism for imparting cultural histories and knowledge to future generations. This practice is rooted in indigenous cultures where it is used to pass along cultural community wealth (Reese, 2012). Jacob et al. (in preparation) find that Latine and multilingual students in K-2 grades leverage their knowledge of oral storytelling to practice key computational thinking concepts such as abstraction and decomposition. Taken together, these findings show that Latina's diverse group memberships intersect around the practice of storytelling to shape their interests in computing.

LEARNING THROUGH BUILDING CONTEXTUAL UNDERSTANDING

In addition to self-expression, contextualizing CS can help students realize the extent to which it permeates their everyday lives. Though CS has a significant impact across various industries (Lee et al., 2015), students are often unable to comprehend the social relevance of computing. Girls who view programming as a potential career path that has considerable influence, rather than just an isolated course subject, feel motivated in their studies (Kelly et al., 2013). Presenting CS as a discipline that is associated with multiple domains allows girls to build upon existing confidence, gives them the chance to express themselves, and provides them with additional sources of motivation (Zimmermann & Sprung, 2008). Programs such as Art2STEM, CREATE Lab, and The Digital Mirror project have successfully taught computing skills by intertwining them with history and storytelling, art, design, and identity politics, providing participants with a sense of familiarity and an outlet for self-expression (Lee et al., 2015).

While women may feel hesitant to consider pursuing CS due to not identifying with the programmer stereotype, for those who do identify with the discipline, the environment in which it is presented can impact their sense of belonging and, thus, their interest in the subject (Cheryan et al., 2009). Presenting CS in a way that allows students to express themselves could help make the subject more inviting.

ABILITY BELIEFS

CS courses that focus on skills development perpetuate the stereotype that CS is an innate ability possessed by only a talented few (cite Margolis). A seminal study of university students in an introductory CS course explored the ways in which stereotypes impact how students evaluate their abilities (Lewis et al., 2011). Many of the participating girls doubted their abilities and expressed their belief that talent in programming is innate rather than a learned skill. In a previous study where exposure and experience levels of CS course participants were close in equivalence, performance levels were consistent across genders (Moroh & Sturm, 1995). Despite this, girls have frequently underestimated their abilities compared to their more confident peers. Ability beliefs have been shown to also have an impact on retention, particularly when it comes to marginalized groups (Steele,1997). When applying this concept to women in computing, the adverse effects of seeing computing as an inherent skill could leave course participants vulnerable and perhaps more likely to write CS off as a possible career path.

Webb et al. (Webb & Miller, 2015) discovered similar results after surveying middle school students' confidence in solving computational problems. Results indicated that boys were more likely to believe they were skilled, while girls less often expressed the same confidence in their abilities. Ideologies that consider CS ability to be a fixed quality have been shown to leave women more susceptible to believing stereotypes and more likely to give up when faced with complex challenges (Good et al., 2012). This ideology, however, is malleable and can be changed with targeted interventions. As seen in a study by Blackwell et al. (2007), junior high students in a treatment group raised previously low math scores after learning how intellectual skills are improved with each attempt at learning. Furthermore, discrediting the belief that CS is reliant on natural abilities has been shown to increase interest and promote retention for women entering the field of CS (Lewis et al., 2016).

Ability beliefs are further influenced by who students perceive to be competent members of the field. Integrating role models into course curricula represents a mechanism for providing opportunities for students to see computer scientists who look like themselves. The curriculum implemented in this study integrates stories about diverse women in CS who have pioneered the field, such as *Ada Byron Lovelace & the Thinking Machine* and *Rosie Revere, Engineer*. Research indicates that when Latine students see professionals in STEM who look like themselves, they strengthen their disciplinary identification (Tukachinsky et al., 2017).

THEORETICAL FRAMEWORK

Inquiry-based learning and Constructionism. The curricular implementation examined in this study integrates inquiry-based learning to engage diverse learners in complex computational problem-solving. Inquiry-based instruction emphasizes active, hands-on learning around a co-constructed problem or topic of inquiry. During inquiry-based learning, the child actively participates in scientific methods and practices and deploys problem-solving skills and approaches necessary to conduct investigations (de Jong & Van Joolingen, 1998; Pedaste & Sarapuu, 2006). Activities are more student-centered than teacher-centered and revolve around open-ended scientific investigations. Assessments are authentic and measure student engagement in scientific and often experimental methods and practices.

Inquiry-based learning is rooted in theories of constructionism. Constructionism moves away from transmission-based models of instruction to position the teacher as a mentor who engages the child in active research (Papert, 1980; Piaget, 1973). Constructionism contrasts with behaviorist views of learning, in which essential motor and verbal associations are reinforced until knowledge acquisition occurs (Mayer, 1992). In the view of learning as knowledge construction, learning is active and based on the assimilation of information. The teacher's role is to co-participate with the learner in the shared construction of knowledge. Learning is a distributive process, in which interactions are co-constructed between teachers and students as they design learning artifacts and reflect on their discoveries (Kafai, 2006). For the constructionist, outcomes are not measured by tests but by authentic assessments (i.e., design notebooks, artifact analysis, project portfolios, etc.) (Papert, 1980; Piaget, 1973).

Inquiry and sociocultural constructionism. Inquiry-based learning and constructionism do not view knowledge construction as consisting solely of changes in individuals' information structures, but instead view knowledge construction as connected to the personal and social world (Kafai, 2006). In response to cognitive theories of learning in which knowledge acquisition represents internal mental processes, sociocultural constructionist theory positions the individual into both the immediate activities and broader social communities and contexts (Berger & Luckman, 1966; Kelly & Chen, 1999; Schauble et al., 1995). In STEM education, the process of conducting investigations for the purpose of verifying scientific principles and revising explanations arises through communication and negotiation of meaning among peers (Kelly & Chen, 1999; Schauble et al., 1995).

Drawing from sociocultural theory, there are three dimensions across which inquiry-based learning is social in nature: 1) collaborative exploration and problem-solving, 2) building computational artifacts as a vehicle for expression, and 3) learning through building contextual understanding. Each of these aspects is briefly defined below.

1. *Collaborative exploration and problem-solving*. In inquiry-based learning, students and teachers jointly engage in exploration in open-ended investigations. The teacher's role in inquiry-based instruction is to mentor students through scientific experimentation and exploration. The teacher acts as a facilitator of student experimentation, promoting collective problem-solving among students and facilitating deeper reflection to avoid hasty solutions. During joint investigations, students engage in group or pair work to conduct investigations or apply their discoveries to new contexts.
2. *Building computational artifacts as a vehicle for expression* – Inquiry-based learning centers inductive approaches to learning in which students understand complex phenomena through social negotiation and construction of meaning. Constructionist theories in particular view building computational artifacts as a vehicle for expression that connects students to the broader community (Kafai, 2006).
3. *Learning through building contextual understanding*. Students' attitudes towards inquiry-based learning can be better understood by examining two propositions: 1) social realities are co-constructed, and 2) they are rooted in classroom practices and broader social structures (Langer-Osuna, 2011; Wortham, 2006). As students co-construct their social realities, they embody roles (i.e., group leader), and as their patterns of positioning emerge over time, they develop into identity trajectories that shape their ability beliefs (Davies and Harre, 1990). Furthermore, students' perceptions of a given discipline strongly influence how they themselves identify with the discipline. Students who study computer science may not be aware of how pervasive it is in our daily life. Even though CS greatly impacts a variety of sectors, students frequently struggle to understand the social significance of computing (Lee et al., 2015). Presenting programming as a lever for creating new technologies that have the potential to benefit or harm society helps students better understand its significance rather than presenting it as an isolated subject (Kelly et al., 2013).

METHODS

STUDY CONTEXT

Researchers at the University of California, IRvine (pseudonym) and educators in Santa Ana Unified School District, a large urban school district have joined together in a collaborative network of researchers and practitioners to iteratively develop, implement, and evaluate a year-long, inquiry-based CS curriculum designed to meet the needs of underserved students. The district has approximately equal numbers of boys and girls with high percentages of Latine (93%), low-income learners (89.7% receiving free or reduced-price lunch), and students designated as English language learners (62.7% in the elementary grades). Seven teachers piloted the year-long curriculum once a week for 50-minute lesson durations. This research study has been approved by the University of California, Irvine Institutional Review Board 20173675.

POSITIONALITY STATEMENT

The first author is a woman in computing that studied in a computing program comprised primarily of men and is now a software engineer in a company with a similar demographic. The author's first-hand experience as a woman in computing informed our research question and analytic techniques and provided additional context in understanding the role gender plays in CS education.

OVERVIEW OF THE CS CURRICULUM

Our project has addressed equity issues in CS by integrating the Creative Computing Curriculum (Brennan et al., 2014) with culturally and linguistically responsive materials to meet the needs of diverse learners. The year-long curriculum is divided into 5 units focusing on algorithms, events, electricity, and loops with a culminating unit on storytelling. It uses unplugged activities to teach key computational thinking concepts (sequencing, events, loops) in an inductive manner before engaging students in language and CT learning. After developing an understanding of concepts through inductive activities, students program projects in Scratch (Resnick et al., 2009) that integrate the key concepts taught in each of the units. The unit on electricity combines Scratch programming with the use of Makey Makeys (Collective & Shaw, 2012) to teach concepts of circuitry and conductivity. The final unit on storytelling incorporates all of the concepts and skills taught in the previous four units. A year-long implementation of the inquiry-based curriculum in eight classrooms showed student improvement in computational thinking skills (Prado et al., 2021; Jacob et al., 2020), computer science identity development (Jacob et al., 2020; Jacob et al., 2022; Jacob et al., 2022), and literacy learning (Jacob et al., 2022).

Gender-inclusive adaptations. The Elementary Computing for All curriculum has the affordances of Scratch for storytelling genres to develop students' computing and literacy skills simultaneously (See Jacob et al., 2022). Through creating stories and animations, students engage in self-expression, which has a positive impact on girls in computing (Kelleher & Pausch, 2007).

Collaboration represents a second pillar of the curriculum that is beneficial to girls in computing (Buffum et al., 2016; Zimmerman & Sprung, 2008). Students work in groups on collaborative unplugged activities, practice pair programming, and engage in peer feedback. Students from marginalized communities tend to prefer relational learning over other more competitive approaches that lead to isolation and disengagement (Anderson & Adams, 1992).

Teachers also spend a considerable amount of time describing the role of computer scientists through the reading of the storybook of diverse pioneers in the field of CS during class discussions. In this way, students are better able to realize the potential of CS to transform society and the dispositions that breed successful computing professionals (Jacob et al., 2022).

Culturally and linguistically responsive adaptations. When STEM content is disconnected from the lives and interests of historically marginalized students, they can lose interest in the field (Duschl et al., 2007). Making computer science relevant by using the students' personal contexts and stores of knowledge is critical to implementing the key to successful intervention for these students (Basu & Barton, 2007). Culturally responsive pedagogies affirm students' identities, beyond merely imparting the scientific model of thought, by acknowledging the value that students from diverse backgrounds bring to formal learning contexts.

To make the curriculum accessible to culturally and linguistically diverse students we integrated five effective practices for engaging multilingual students in STEM as outlined by the National Academies of Sciences and Engineering, including 1) engage students in disciplinary practices, 2) engage students in productive discourse and interaction, 3) encourage students to use multiple registers and modalities, 4) leverage students' multiple meaning-making resources, and 5) provide explicit instruction on disciplinary language functions (NASEM, 2018).

To **engage students in disciplinary practices,** we provided multiple opportunities for students to participate in the kinds of activities that experts regularly engage in. For example, the curriculum taught not only computational thinking skills but also computational thinking practices and perspectives as outlined in Brenan and Resnick (2012). We also applied the five stages of inquiry-based instruction: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee, 1997) to provide an inductive approach to learning. To this end, teachers leverage students' inductive reasoning and everyday sense-making abilities to engage multilingual students in computational thinking, which has been shown to improve disciplinary outcomes for these students (Jacob et al., 2022).

The curriculum **engaged students in rich and productive discourse** by providing multiple opportunities for collaborative activities, such as pair programming and peer feedback activities. Additionally, the curriculum's professional development emphasized teacher noticing of peer-to-peer talk which promotes productive discourse and learning for Latine and multilingual students (Rosebery & Warren, 2008).

To more effectively teach computational thinking skills and terminology, a variety of visual and physical activities were incorporated into the curriculum to **provide multiple modalities for learning**. These included written and verbal modalities as well as non-verbal modalities such as gestures, pictures, and symbols (Lee et al., 2019).

The curriculum **builds on students' existing resources** mainly through unplugged activities. These unplugged exercises utilized the semiotic and common knowledge of the students so they could deploy their own resources in service of CS learning. Leveraging students' multiple meaning-making repertoires through instructional approaches such as translanguaging has been shown to increase computational thinking and literacy skills for Latine and multilingual students (Vogel et al., 2020). Teachers were also provided recommendations for using "talk moves" (Michaels & O'Connor, 2015), such as soliciting elaboration and using students' natural sense-making abilities to better understand disciplinary language and complex CS concepts.

Finally, the curriculum provides **explicit teaching of disciplinary language functions**. Teachers taught explicit CS language using sentence frames to allow students to analyze and replicate language patterns (Halliday, 1973). These were used specifically during reflection activities so as to not stifle interaction.

It is important to note that this paper is part of a larger, more extensive study. The curriculum was initially designed to engage predominantly Latine and low-income, multilingual students in CS instruction. To this end, much of the research on this curricular intervention has focused on the linguistic and sociocultural factors that promote success for culturally and linguistically diverse students in computing. In this paper, however, we shift our attention toward comparing how boys and girls engage in the curriculum and how their engagement influences their attitudes toward CS. As this study represents the exploratory phase of a larger attempt to evaluate, and scale the curriculum, we will use findings from this study to make iterative refinements to the Elementary Computing for All curriculum so that it becomes more accessible for underrepresented students, including women. For more information on the Elementary Computing for All curriculum, see Jacob et al. (2018).

RESEARCH DESIGN

To address the research question, the current study adopts an explanatory mixed methods design (quan + QUAL) in which qualitative data samples were collected and analyzed to provide insight into the quantitative data (Creswell & Clark, 2017). Qualitative results were emphasized while addressing the research questions (Morse, 2003). The quantitative strand was implemented to develop a better understanding of the extent to which girls' and boys' attitudes toward computer science differed after receiving an inquiry-based computer science curriculum. The qualitative strand was implemented to provide explanatory insight into how and why differences may have occurred, as well as to highlight differences that may have not been detected by the survey.

Utilizing an explanatory mixed methods design provides 1) a better understanding of the contextual factors that shape boys' and girls' attitudes toward computer science; 2) a broader view of the types of identities students formed as a result of engaging in the curriculum; 3) an integration of findings and perspectives that lead to recommendations for how to revise the curriculum to best meet the needs of the target population.

Furthermore, the data from this paper is part of a larger year-long ethnographic study (Wolcott, 1994) that uses multiple points of data collection to interpret the sociocultural and linguistic processes that underlie multilingual student participation in computing. Data collected as part of the larger study included weekly observations conducted by researchers, student interviews, pre-and-post tests, teacher interviews, and student and teacher artifact analysis. All researchers who conducted interviews visited classrooms once a week for a year and acted as complete participants (Creswell & Poth, 2016), extensively engaging with teacher and student participants during CS lessons. Acting as complete participants enabled the researchers to build greater rapport with participating teachers and students (Angrosino, 2007). In this paper, we use two sources of data from the larger study to examine the similarities and differences between boys' and girls' attitudes toward CS: CS identity surveys and follow-up interviews.

Participants: Based on their existing background and expertise in teaching upper elementary students computer science, seven teachers were selected to participate in the study. One taught a Gifted and Talented Education (GATE) class, another teacher taught a dual immersion class with large percentages of students with disabilities, and another worked with both general education and special education students who had mild to moderate disabilities in a full-inclusion special education classroom. The other four taught mainstream courses with large percentages of Latine students and students designated as English learners. All students in their classrooms participated in their study (n = 108) and the teachers selected four students from each classroom (n = 18) to participate in interviews. Student demographics at the classroom level broadly mirrored demographics at the district level.

QUANTITATIVE DATA SOURCE

An existing survey, Is Science Me? (Gilmartin et al., 2006), was modified by our team to learn more about students' interest in computer science and the impact that family and peer support have on students' CS identity development (Is Computer Science Me; ICSM). The survey consisted of 20 questions using three-point Likert scale items that were based on the following categories: (1) students' experiences with computers, (2) students' perceptions of computer science, (3) students' self-perception as computer scientists, (4) family support for computer science, and (5) friend support for computer science. Students had the option to self-identify as male or female on the survey. The survey was administered at the beginning of the year and then again at the end of the year after the curricular intervention to all students (n = 108) in each of the seven participating teachers' classrooms. Research on the influence of family support (Gilmartin & et al, 2006), school experiences (Osborne et al., 2003), and self-perceptions (Eccles et al., 2000) formed the bases of the survey constructs.

QUALITATIVE DATA SOURCE

We conducted semi-structured, 20–25 minute follow-up interviews (see Appendix A) to better understand students' attitudes towards CS. Interviews were audio recorded and transcribed. The interview questions were rooted in the aforementioned survey constructs including studies on the role that family plays in STEM identification (Gilmartin et al., 2006), how school experiences influence students' attitudes (Osborne et al., 2003), and how students perceived themselves as STEM professionals (Eccles et al., 2000). Teachers selected four students in each classroom (n = 18) and were asked teachers to select equal numbers of boys and girls.

DATA ANALYSIS

Quantitative data analysis. We used a Diff-in-Diff model to compare changes in mean pre- and post-test responses between boys and girls to the ICSM survey. For each gender, we calculated the mean post-test minus pre-test difference in student responses for the individual survey items as well as categorical aggregates. We then calculated the girls-minus-boys difference in these means. We calculated the standard error for the mean difference between groups using the pooled standard deviation. We evaluated the significance of this difference using a t-test for ease of presentation. For robustness, we also performed an unreported Mann-Whitney U-Test that yielded identical results.

Qualitative data analysis. Researchers conducted deductive and inductive qualitative coding (Alvesson & Kärreman, 2007), first assigning codes based on the extant literature and generating new codes when the remaining excerpts of text pertained to the research questions. Three researchers (first, second, and third author) coded 25% of the interviews and then met to combine, split, and consolidate codes. After consolidating the codebook (See Appendix B), the second author applied the reduced codebook to the remaining interviews. When all of the interviews were coded, two researchers (first and second author) selected 10% of the interviews to conduct an interrater reliability check. The two researchers reached interrater reliability of approximately 70% upon coding four interviews. When the two researchers met to discuss discrepant codes and clarify the codebook, the researchers were better able to define each of the codes. After applying the revised codebook to the interviews, researchers reached over 90% interrater reliability. The researchers reached saturation after conducting 18 interviews, which likely occurred due to the ethnographic nature of this study in which rich and extended exposure is combined with multiple sources of data (Fusch & Ness, 2015).

The researchers then quantified the results based on codes, categories, and gender. Upon coding all interviews, the first author entered the final codebook categories into a spreadsheet, grouping students by gender. Each row corresponded to a student, and each column corresponded to categories and codes. The spreadsheet was populated in the same order as the codebook, beginning with the categories, then moving to each code along the x-axis and entering a "1" in the row of each student referenced in the application of the code. Sums were derived for gender groups for each category, with the corresponding code defined along gender lines. Codes were then refined and narrowed down to simplify results based on the logical grouping of data and the frequency or infrequency of a code's application.

RESULTS

SURVEY RESULTS

Across all survey items, only two demonstrated significant differences between boys and girls. Even for these two items, the differences were of marginal significance and that significance would not survive correction for multiple comparisons.

In Experience with Computers, as reported in Table 1, Panel A, the only significant difference favored girls with respect to "talking with friends and family about CS" (*MDiff* = 0.24, $t(99) = 2.01$, $p = 0.05$). Survey results showed no significant difference between boys and girls in writing programs (*MDiff* = 0.14, $t(99) = 1.15$, $p = 0.25$) and using tools to build things (*MDiff* = 0.04, $t(99) = 0.34$, $p = 0.73$). Descriptive statistics showed girls reporting taking toys apart less than the boys, but there was no significant difference between responses (*MDiff* = –0.12., $t(99) = -0.87$, $p = 0.20$). The aggregate "Experience with Computers" showed no significant difference in change between groups (*MDiff* = 0.30, $t(99) = 1.30$, $p = 0.20$).

In Perceptions of Computer Science, as reported in Table 1, Panel B, no items showed statistically significant differences between boys and girls, with non-significant differences in student's belief that they are good at computer science (*MDiff* = 0.14, $t(99) = 0.96$, $p = 0.34$). Girls reported the following two items less than boys, but differences were not statistically significant: CS is interesting (*MDiff* = –0.18, $t(99) = -1.23$, $p = 0.22$), and computer scientists are respected (*MDiff* = –0.18, $t(99) = -1.32$, $p = 0.19$). Girls also reported that computer scientists make a difference less frequently than boys with a marginally significant difference (*MDiff* = 0.35, $t(99) = -1.92$, $p = 0.06$). The aggregate "Perceptions of Computer Science" showed no significant difference in change between groups (*MDiff* = –0.51, $t(99) = -1.47$, $p = 0.14$).

In Self-Perceptions as Computer Scientists, as reported in Table 1, Panel C, there were no significant differences between boys and girls with respect to the following items "I don't like to do things that are difficult to master quickly" (*MDiff* = 0.22, $t(99) = 1.02$, $p = 0.31$), "If people tell

PANEL A: EXPERIENCE WITH COMPUTERS									
	FEMALES		MALES		DIFFERENCE (FEMALES – MALES)				
	N	MEAN	N	MEAN	DIFF	ST ERR	T-STAT	DF	P
I talk with friends and fam about CS	50	0.40	51	0.16	0.24	0.12	2.01**	99	0.05
I write programs	50	0.08	51	–0.06	0.14	0.12	1.15	99	0.25
I use tools to build things	50	0.08	51	0.04	0.04	0.12	0.34	99	0.73
I take apart toys/computers	50	–0.02	51	0.10	–0.12	0.13	–0.87	99	0.38
Aggregate: Experience with Computers	50	0.54	51	0.24	0.30	0.23	1.30	99	0.20
PANEL B: PERCEPTIONS OF COMPUTER SCIENCE									
	FEMALES		MALES		DIFFERENCE (FEMALES – MALES)				
	N	MEAN	N	MEAN	DIFF	ST ERR	T-STAT	DF	P
I think CS is Interesting	50	–0.02	51	0.16	–0.18	0.14	–1.23	99	0.22
I am good at CS	50	0.08	51	–0.06	0.14	0.14	0.96	99	0.34
Computer scientists make a difference	50	0.06	51	0.35	–0.29	0.15	–1.92*	99	0.06
Computer scientists are respected	50	0.06	51	0.24	–0.18	0.13	–1.32	99	0.19
Aggregate: Perceptions of CS	50	0.18	51	0.69	–0.51	0.34	–1.47	99	0.14
PANEL C: SELF PERCEPTION AS COMPUTER SCIENTIST									
	FEMALES		MALES		DIFFERENCE (FEMALES – MALES)				
	N	MEAN	N	MEAN	DIFF	ST ERR	T-STAT	DF	P
I * don't* like to do things that I can't master quickly	50	0.18	51	–0.04	0.22	0.21	1.02	99	0.31
If people tell me I can't do something it makes me try harder	50	0.12	51	0.06	0.06	0.18	0.33	99	0.74
I enjoy trying to understand difficult things	50	0.06	51	0.08	–0.02	0.17	–0.11	99	0.91
I can learn CS	50	0.22	51	0.04	0.18	0.13	1.39	99	0.17
Aggregate: Self Perception as Computer Scientist	50	0.22	51	0.22	0.00	0.44	0.01	99	0.99
PANEL D: FAMILY SUPPORT FOR COMPUTER SCIENCE AND SCHOOL									
	FEMALES		MALES		DIFFERENCE (FEMALES – MALES)				
	N	MEAN	N	MEAN	DIFF	ST ERR	T-STAT	DF	P
It's important to my family that I get good grades	50	0.12	51	0.10	0.02	0.11	0.19	99	0.85
It's important to my family that I try my best	50	0.10	51	0.12	–0.02	0.08	–0.21	99	0.83
My family knows how well I'm doing in school	50	0.18	51	0.27	–0.09	0.13	–0.73	99	0.47
My family thinks CS is important to learn	50	0.12	51	0.08	0.04	0.14	0.30	99	0.77
My family thinks CS is interesting	50	0.10	51	–0.04	0.14	0.15	0.91	99	0.36
Aggregate: Family Support for Computer Science	50	0.62	51	0.53	0.09	0.41	0.22	99	0.83
PANEL E: FRIEND SUPPORT FOR COMPUTER SCIENCE AND SCHOOL									
	FEMALES		MALES		DIFFERENCE (FEMALES – MALES)				
	N	MEAN	N	MEAN	DIFF	ST ERR	T-STAT	DF	P
My Friends like CS	50	0.40	51	0.22	0.18	0.23	0.82	99	0.41
My friends think CS is cool	50	0.38	51	0.06	0.32	0.21	1.51	99	0.13
My friends encourage me to do well in school	50	–0.14	51	–0.25	0.11	0.28	0.42	99	0.68
Aggregate: Friend support for CS	50	0.64	51	0.02	0.62	0.51	1.21	99	0.23

Table 1 Post-Minus-Pre Test Differences in ICSM Survey Responses by Gender.

me I can't do something, it makes me try harder" (*MDiff* = 0.06, $t(99) = 1.02$, $p = 0.31$), "I can learn CS" (*MDiff* = 0.18, $t(99) = 1.39$, $p = 0.17$), and "I enjoy trying to understand difficult things" (*MDiff* = 0.08, $t(99) = -0.11$, $p = 0.91$). In creating the categorical aggregate "Self-Perception as Computer Scientist," which and demonstrated no significant difference in the change between groups (*MDiff* = 0.00, $t(99) = 0.01$, $p = 0.99$), the item "I don't like to do things that are difficult to master quickly" is entered negatively.

In Family Support for Computer Science, as reported in Table 1, Panel D, there were no significant differences in the importance that families place on grades (*MDiff* = 0.02, $t(99) = 0.19$, $p = 0.85$), the importance families place on students trying their best (*MDiff* = –0.02, $t(99) = -0.21$, $p = 0.83$), students' families knowledge of how well they are performing is school (*MDiff* = –0.09, $t(99) = -0.73$, $p = 0.47$), families thinking CS is important to learn (*MDiff* = 0.04, $t(99) = 0.30$, $p = 0.77$), and families interest in computer science ($d = 0.14$, $t(99) = .91$, $p = 0.36$). The aggregate "Family Support for Computer Science" showed no significant difference in change between groups (*MDiff* = 0.09, $t(99) = 0.22$, $p = 0.83$).

In Students' Friend Support for Computer Science, as reported in Table 1, Panel E, there was no significant difference between boys and girls regarding friends liking computer science (*MDiff* = 0.18, $t(101) = 0.82$, $p = 0.41$), friends believing that computer science is cool (*MDiff* = 0.32, $t(101) = 1.51$, $p = 0.13$), and friends encouraging them to do well in school (*MDiff* = 0.11, $t(101) = 0.42$, $p = 0.68$). The aggregate "Students' Friend Support for Computer Science" showed no significant difference in change between groups (*Mdiff* = 0.61, $t(99) = 1.21$, $p = 0.23$).

INTERVIEW RESULTS

Despite the lack of differences detected by the survey, the interview revealed key differences between boys' and girls' attitudes toward CS. Boys and girls differed with respect to their approaches to learning, their attitudes towards the discipline, and their overall attitude towards CS.

APPROACHES TO LEARNING

Collaborative exploration and problem-solving. While in the survey girls showed marginally significant results in favor of talking with friends and family about CS, the difference in change was small. The interviews, however, painted a different picture. Based on the interviews, a key difference in the way that students approached learning centered on collaboration. Three of the participating girls identified collaboration as contributing to their positive experiences in learning CS. Perhaps significantly, none of the boys reported that they enjoyed collaboration. One of the girls mentioned how collaboration makes coding more enjoyable:

> **Interviewer:** *What's fun about it?*
> **Student:** *You could build whatever you want and... and how you could teach others to work [sic] how they're doing.*
> **Interviewer:** *Mhmm.. the community?*
> **Student:** *Yeah. The community is a lot of fun too.*

Another theme that emerged from the interviews involved students' approaches to learning. We analyzed how students approached learning programming concepts by identifying the extent to which they stayed within the course requirements or ventured outside of them. We labeled the latter as 'exploration,' a term used to describe instances in which students act out of curiosity and choose to try new things on their own. In analyzing the student interviews for exploratory behavior, we found that most boys demonstrated exploratory behavior while only one girl exhibited this behavior.

Five of the girls and one of the boys demonstrated reluctance to explore. Below is an excerpt from a girl who did not exhibit exploratory behavior:

> **Interviewer:** *How do you practice computer science outside of school, if at all?*
> **Student:** *...Like if I had already done at school, if I'm like already at home like I would like to take some notes in class and then like read my notes and then remember them, try to take them away from my myself and then I'll try to remember all this stuff that happened during class. Like in computer science, then I got the hang of it.*

The respondent above revealed how she approached programming from home. She mentioned that she reviewed notes from class after school and made sure she understood the material. This decision to remain within the confines of the instruction reveals her disinclination to explore. On the other hand, one of the boys reported a learning experience that exemplifies exploratory behavior:

> **Student:** *I have school; I am usually at school and home. We usually do a lot of* [computer] *science stuff like when I'm bored I usually do like....(inaudible), like build a project on my own. And I learned like how to do it cause we have to um, go Google and I'm like, Oh I have to read this whole entire article of it. And I used to do like a little bit of like other, other websites of coding and it's really fun.*

This student demonstrated exploratory behavior through his examples of building projects independently and outside of the classroom by leveraging search engines and coding websites to expand his knowledge further.

CONNECTIONS WITH THE DISCIPLINE

Learning through building contextual understanding. While there was a slight increase in the boys' reporting that computer scientists make a difference in the world, the difference in the change was negligible. We examined students' connections to the discipline more in depth in the follow-up interviews. The students answered questions about the role of computer scientists, providing us insight into how they connect their Scratch lessons with real-world applications of programming. When asked about the role of computer scientists, a similar number of boys and girls described computer scientists as people who work with computers. However, four of the girls and none of the boys reported that a computer scientist's role is to fix things. Below is an excerpt from one of the four girls who mentioned the troubleshooting aspect of the profession:

> **Interviewer:** *And what do computer scientists do?*
> **Student:** *They try to fix stuff like stuff [sic]. Like if they just need to fix a little tiny thing, they just move the thing and put something else that they want to put it on.*

In contrast to this, more boys than girls reported using CS as a vehicle for creating new technologies.

Two of the boys envision themselves using CS to make their own games:

> **Interviewer:** *Could you imagine doing anything related to computer science?*
> **Student:** *Yeah.*
> **Interviewer:** *Yeah. Like what?*
> **Student:** *Making Games.*
> Interviewer: *Um, do you feel like everyone should learn computer science?*
> **Student:** *Yeah. Yeah.*
> **Interviewer:** *Do you feel like it's really important?*
> **Student:** *Yeah because it's kinda a big role model [sic], because maybe someone likes games and they want to create their own games.*

Viewing CS as a means to create new technologies rather than as a troubleshooting process empowers students to become active participants in the field. Additional research is warranted on the ways in which teachers can reinforce elementary students' development of a broader understanding of CS.

All of the students were asked to reflect on their mistakes while coding in Scratch, providing insight into how troubleshooting impacted each of their experiences. All six girls could recall an example of a specific mistake they made in Scratch compared to four boys. The interviewers probed students to describe the resolution to the problem they encountered. Five of the girls explained the solution, compared to three of the boys. The comment below illustrates how one student recalled a mistake and how she resolved it.

> **Interviewer:** *And give one example of a time when you made a mistake and how you fixed it.*
> **Student:** *When I was coding with code.org and I had to do a 360 like kind of like circle with just using the lines that go like this. It took me a while to find out that you needed to, that you needed to use a, you needed to repeat those lines 360 times. I usually put the speed up cause I don't want to wait 360 hours.*

While we anticipated that students' discussion of mistakes would provide insight into their learning processes, mistakes became a more salient topic during our analysis. We noticed that girls who spoke more frequently about debugging were the same students who described it to be a core element of coding in the previous theme above regarding the role of computer scientists.

Building computational artifacts as a vehicle for expression. In addition to students' perceptions of mistakes, self-expression emerged as a theme that played a significant role in students' connections with CS. Five girls and three boys discussed how programming provided them with the opportunity to express themselves.

The Scratch projects in our program provided students with the freedom to bring their ideas to life through images, music, words, and animations, encouraging them to showcase their personalities and interests. Among the students who valued self-expression, storytelling resonated with three girls and one boy. In the example below, one of the girls describes a project that provided her the opportunity to express herself:

> **Student:**...*and try to make games that include what I like. Like right now I'm making a game... oh I already made a game, it's like a unicorn going to different backgrounds and it plays music and... and I included that because I like unicorns. It's like a way to express like what I like, when I'm not like telling it in words, but showing it.*

In the excerpt above, the student spoke positively of the project that gave her the chance to create something uniquely her own. Several students valued the act of self-expression as a mechanism for developing interest in their CS learning.

OVERALL ATTITUDES TOWARDS CS

Interviewers asked students how they felt about their ability to succeed in CS to gauge their levels of self-efficacy. Both boys and girls expressed similar levels of confidence in their abilities. We define confidence as the expression of positive beliefs in one's abilities. Lack of confidence was typically observed by the verbal admonition of one's abilities, or expression of difficulty in learning CS. Of the five students that expressed confidence, three were boys, and two were girls. However, three students hesitated to express confidence, all of whom were girls. For example, one interviewee responded that she felt confident, but this statement was delivered reluctantly and paired with a disclaimer that CS is difficult:

> **Interviewer:** *How do you feel? Do you feel confident that you're good at learning computer science? Do you feel like…*
> **Student:** *Yeah.. I feel good at it.. but… yeah, I feel good.. but.. but it's kind of hard…*
> **Interviewer:** *It's kind of hard, but you keep trying?*
> **Student:** *Mhmm.*

Similarly, another girl was hesitant to express her confidence in her CS abilities:

> **Interviewer:** *How do you feel about your ability to learn computer science?*
> **Student:** *Mhmm… not sure.*
> **Interviewer:** *Do you feel confident?*
> **Student:** (paused) *…I feel confident about it.*
> **Interviewer:** *I know you feel better cause you said, in the beginning, you were a little bit scared, and then you felt like you could do it. You feel pretty good about it?*
> **Student:** *Yeah…*
> In contrast to the hesitation shown by the three girls, three boys expressed their confidence without pause.
> **Interviewer:** *Do you feel confident when it's time to go code in scratch?*
> **Student:** *Yeah, I feel confident.*
> **Interviewer:** *You feel confident?*
> **Student:** *Yeah I feel confident in what I do.*

Interviews also revealed overwhelmingly positive attitudes toward the discipline. When asked about how they felt about CS, the majority of students responded positively, with eleven out of twelve completing the program reporting that CS is fun. These results did not vary by gender, with six girls and five boys expressing these attitudes.

DISCUSSION

OVERVIEW OF THE FINDINGS

Even though the boys and girls had similarly positive feelings toward CS, a more careful analysis of the follow-up interviews revealed differences in attitudes around their ability to succeed. Girls appeared less confident in their abilities than boys. Unlike the boys, the girls indicated that collaborating was a positive aspect of the CS learning environment. The girls also tended to stay within the confines of instruction rather than choosing to explore. There were also differences in how the boys and girls connected to programming, with girls placing a higher value on the opportunity to express themselves through their projects. When it came to their understanding of the role of computer scientists, the girls considered debugging to be a defining aspect in contrast to the boys who considered the primary purpose to be the creation of new technologies.

COLLABORATIVE EXPLORATION AND PROBLEM SOLVING

We noticed the girls reflecting positively on particular aspects of their learning environment, such as the ability to collaborate with others. Collaboration and teamwork have been recognized as a learning approach that often is more appealing to girls (Zimmermann & Sprung, 2008). Furthermore, providing a social setting for girls to learn fosters positive reinforcement, including social encouragement (Wang et al., 2015). Engaging students with collaborative programming experiences have proven effective in discrediting the asocial and competitive stereotypes associated with computer scientists (Lewis et al., 2016).

Based on our findings, we recommend that future K-5 CS programs integrate collaborative activities into their curricula since relational learning has been shown to challenge these asocial stereotypes (Lewis et al., 2016). Collaborative learning experiences can also promote exploration by allowing students to see how their peers approach a task (Vekiri & Chronaki, 2008). We also recommend that curriculum designers incorporate exploratory activities into instructional materials so that exploration becomes a practiced requirement rather than an action that only occurs when a student is naturally inclined to explore. Educators can support the self-efficacy of students with less computing experience by explaining the importance of exploration and providing exploratory assignments (i.e., interface scavenger hunts).

Our analysis also showed that the girls stayed within the confines of instruction rather than exhibiting exploratory behavior. Our observations align with previous research indicating that an affinity to explore is more common among boys than girls (Zimmermann & Sprung, 2008). Venturing outside the confines of course requirements provides several affordances, including generating new knowledge, improving self-efficacy, and increasing comfort levels through interacting with systems (Beckwith et al., 2006).

CONNECTIONS TO THE DISCIPLINE

While boys made the connection between computer scientists and game developers, girls may benefit from connecting CS with something else they identify with. This connection could provide the building blocks for understanding how programming underlies the bulk of technology we interact with in our daily lives. Prior research reveals that students often prefer to understand the greater context of the skill they are learning (Kelly et al., 2013), along with the practical benefits of building upon a subject with which they are already familiar and comfortable (Zimmermann & Sprung, 2008). We can see how this connection could provide both boys and girls with higher motivation to revisit CS in the future.

Students' perceptions of making mistakes. When considering why making and fixing mistakes would be a salient part of coding for the girls, we referred back to previous research on confidence and self-efficacy. Making mistakes can slow down the rate at which students complete their work, and speed of completion has been shown to influence how students perceive ability (Lewis et al., 2011). With the speed of completion being a metric often used by students to measure ability, running into obstacles may have more of a negative impact when self-efficacy is lower. Research has shown that students who believe that ability is malleable, rather than tied to specific performance indicators such as speed, may have more success in overcoming obstacles (Blackwell et al., 2007).

Students' perceptions of computer scientists. When it comes to their understanding of a computer scientist's responsibilities, the girls considered debugging to be a defining aspect of the role. In addition to the focus the girls placed on making mistakes, this observation could reveal a lack of understanding of the larger context of CS. Debugging and troubleshooting are necessary aspects of computing but not the primary function. This also speaks to our related findings that, when compared to boys, a higher number of girls were concerned about making mistakes while coding and recalled more specific solutions to their mistakes.

Based on these findings, we recommend that future K-5 CS programs integrate a more comprehensive depiction of the role of computer scientists into their curriculum so that students grasp the cultural relevance of the profession. Additionally, we recommend that instructors remind students that debugging and making mistakes is part of the process, not the main focus of the field. Teaching students to leverage resources around troubleshooting could reduce insecurities about making mistakes and help them recover faster. To emphasize this message, explaining how professional programmers leverage colleagues, search engines, and debugging tools to overcome errors could help students understand that debugging is not an isolated activity.

There were also differences in how the boys and girls connected to programming, with girls placing a higher value on the opportunity to express themselves through their projects. Research has shown that the vision and commitment involved in developing CS projects can provide girls with the needed motivation to succeed (Kelleher & Pausch, 2007). The ability to work on projects they found personally meaningful, such as creating their own stories, may have factored into their perseverance in the face of setbacks.

STUDENTS' SELF-EFFICACY

While some girls expressed confidence in their ability to do CS, we observed self-admonishing language and hesitation in many girls. These characteristics could be a clue in discerning where and why confidence gaps tend to form, as research has shown lack of confidence to be one of the deterring factors in women pursuing CS (Webb & Miller, 2015). For example, one student mentioned the speed at which she learned Scratch as justification for feeling confident, corroborating research that shows students tend to measure their ability to succeed in CS by their learning speed (Lewis et al., 2011). This association of rate with success can be detrimental to students' perceptions of their performance (Lewis et al., 2011).

Students' positive attitudes toward CS and their description of it as fun did not differ by gender. However, a difference was observed in students' confidence in their abilities to do CS. Therefore, we recommend future K-5 CS programs implement confidence-building exercises to counteract a possible gap in exposure to equitable CS learning.

LIMITATIONS

We acknowledge several limitations of this study. First, as the survey had no control group and the interviews were qualitative in nature, is difficult to make causal or broad generalizations based on our findings. However, our results could serve as a fulcrum for developing hypotheses for further analysis. Despite presenting gender in a binary fashion, we recognize that gender is a construct and future work should identify gender differences across heterogenous identity markers that signify a variety of gender identifications and expressions. Also, these girls' identities are shaped not only by gender but also by race, culture, language, and class. The purpose of this paper was to examine how the similarities and differences between students' attitudes with respect to gender, and an examination of how issues relating to intersectionality shape students' attitudes is beyond the scope of this paper. However, we have explored how issues of intersectionality helped to shape these students' identities in related work (Jacob et al., 2022). Finally, this study is exploratory in nature and part of a larger effort to test, refine, and scale the curriculum. While we did not initially develop the curriculum to increase participation for girls, we intend to use findings from this study to revise our curriculum to meet the needs of young girls in computing.

CONCLUSION

There are many strategies for addressing the gender gap at every stage in students' academic trajectories. Studies at the high school level and beyond have shown the benefits of providing equitable CS instruction regardless of prior exposure (Goode, 2008), but early exposure amplifies these benefits (Master et al., 2017). The subtle but critical differences in students' attitudes toward CS support the importance of intervening before these differences become more pronounced. This paper identifies these differences and provides recommendations for making CS curricula more inclusive for women in computing. Findings from this study will be used to make gender-inclusive refinements to the Elementary Computing for All curriculum.

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Appendix A.** Student Attitude Survey. DOI: https://doi.org/10.26716/jcsi.2023.2.22.37.s1
- **Appendix B.** Student Codebook Samples. DOI: https://doi.org/10.26716/jcsi.2023.2.22.37.s2

FUNDING INFORMATION

We would like to thank the National Science Foundation (Grants no. 1738825 and no. 1923136) and the US Department of Education (Grant no. U411C190092) for providing the funding that made this project possible. Findings expressed in this work are those of the authors and do not necessarily reflect the views of the National Science Foundation or the US Department of Education.

COMPETING INTERESTS

The authors have no competing interests to declare.

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TO CITE THIS ARTICLE:
Scott, D., Zou, A., Jacob, S. R., Richardson, D., & Warschauer, M. (2023). Comparing Boys' and Girls' Attitudes Toward Computer Science. *Journal of Computer Science Integration,* 6(1): 1, pp. 1–17. DOI: https://doi.org/10.26716/jcsi.2023.2.22.37

Submitted: 28 February 2022 **Accepted:** 15 January 2023 **Published:** 22 February 2023

Journal of Computer Science Integration is a peer-reviewed open access journal published by Armacost Library, University of Redlands.

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