Bridging the Gap: Promoting and Retaining Adolescent Girls in Computer Science

by

Lauren E. Varacalli

Bachelor of Arts, Duquesne University, 2004

Master of Science, Robert Morris University, 2011

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This dissertation was presented

by

Lauren E. Varacalli

It was defended on

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and approved by

Emily Rainey, Assistant Professor, Department of Teaching, Learning, and Leading

Richard Fuller, Director, Robert Morris University Center for Innovative Teaching

Dissertation Director: Cassie Quigley, Department Chair and Associate Professor, Department of Teaching, Learning, and Leading

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Lauren E. Varacalli, EdD

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For the past forty years, under-represented girls in computer science have been a worldwide issue. Research has indicated strategies and practices teachers can implement to help shape adolescent girls' identity in computer science. These strategies include inclusive curricular practice, collaborative learning opportunities, and supportive learning environments. This study aimed to explore how a student's computer science perception influenced their identity and how incorporating art into coding can shape their identity. Using qualitative data collection, the findings from this study were used to develop further a curriculum unit that can shift adolescent girls' computer science identity. The following research questions were used for this study: How have the identity-based curricular interventions shifted my teaching? Over the course of the focal unit, how and to what extent do adolescent girls in the Applications (Apps) and Gaming course indicate a change in their computer science identities? This study aimed to determine if a computer science curriculum that incorporated art into coding can help develop adolescent girls' identity in computer science.

The study design incorporated an analysis of lesson plans, classroom observations, reflective open-ended questions, and teacher journals to determine an identity development in computer science for adolescent girls. The participants included five high-school aged girls from a Mid-Atlantic urban high school. Over the course of five weeks, the students participated in the study that including drawings of what a computer scientist looks like to them, open-ended reflective questions, and other various everyday classroom tasks. The drawings of the computer scientist and open-ended reflective questions were analyzed to determine a change in their computer science identity over the course of the five-week study. The findings from this study indicated a shift in identity for some participants and may also be interpreted as a basis for elementary and middle schools to incorporate identity-based curricular activities into the classroom to help shape adolescent girls' computer science identity.

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Preface

This journey would not be complete without the support of family and friends throughout the years. While there are far too many to name, please know I am forever grateful for each of you.

To Dr. Quigley: Thank you for bringing your passion in STEM to the University of Pittsburgh and advising me over the last three years. Without your guidance I would not be here or believe my work is valuable.

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To my STEM ARCO: We did it and during a pandemic! Thank you for the countless hours of support, laughs, and tears during our time at Pitt. I know this isn't goodbye, but I'll see you later. I love you all.

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I dedicate this dissertation to all the girls who feel they do not belong in computer science. You are smart. You are creative. You are unique. You belong.

1.0 Naming & Framing the Problem of Practice

1.1 Broader Problem Area

Computer science (CS) is often described as "the study of computers and algorithmic processes, including their principles, their hardware, and software designs, their implementation, and their impact on society" (Tucker, 2003). For the past thirty years, the percentage of women in CS has dropped from 35%-26% and continues to decline (ComputerScience.org, 2022). The underrepresentation of women in computer science careers is similar to other STEM (Science, Technology, Engineering, and Math) career fields. As of early 2021, roughly 21% of computer science bachelor's degree recipients were women (National Center for Education Statistics, 2021).

Given the stark underrepresentation of girls and women in STEM and the seeming relationship between underrepresentation and learning opportunities, policymakers have prioritized K-12 STEM learning, including computer science. Presumably, if more computer science courses were offered in the elementary schools, retention throughout students' years of education could improve. Notably, during the White House Science Fair in 2013, President Barack Obama stated the following:

> One of the things that I've been focused on as President is how we create an all-hands-on-deck approach to science, technology, engineering, and math . . . We need to make this a priority to train an army of new teachers in these subject areas and make sure that all of us as a country are lifting up these subjects for the respect that they deserve. (PCAST, 2010)

In response to Obama's call to action, Title 1 schools added STEM programs and teachers to prepare students equitably in these subjects. The prioritization of K-12 STEM teaching and learning is also reflected in the United States Department of Education's stated commitments and the *Next Generation Science Standards*. However, the worldwide problem with adolescent girls not participating and remaining in CS classes still exists due to several factors like course exposure and stereotypes.

For this research study, computer science refers to as any technical skills utilized in computer science. Examples of this include but are not limited to programming, debugging, software development, and data analysis. Computer science identity refers to any student who perceives themselves as someone in computer science in the future (Bell-Watkins et al., 2009). Another term utilized throughout this paper, STEM, incorporates all science, technology, engineering, and mathematics careers, skills, and classroom experiences from kindergarten to twelfth grade (K-12) levels of schooling. Finally, another term used throughout this paper is "adolescent girls," which refers to high school-age girls aged 14-18. This term also means those who identified as transgender girls, non-binary, or gender-fluid. I chose adolescent girls as the participants of this study because adolescence is a crucial time in girls' lives for identity development (Harter, 1990).

1.2 Organizational System

Currently, I am a part-time business teacher for Cedar Public Schools (CPS) at Parkway High School, located in a Mid-Atlantic region of the United States. Parkway is a large urban high school with approximately 717 students, 341 of whom are female. I teach in the Career and Technical Education (CTE) department.

Before my current position, I was a full-time substitute at two other high schools, which are part of Cedar Public Schools. CPS offers STEM courses throughout its schools; however, the course offerings vary at each school, and some schools do not offer any STEM-related courses at all.

Seen here through the lens of its mission statement, Cedar Public Schools claims to commit to ensuring equitable access to a high-quality public education for all students and holds themselves accountable for achieving this illustrious goal through innovative approaches:

> Cedar Public Schools will be one of America's premier school districts– student-focused, well-managed, and innovative. We will hold ourselves accountable for preparing all children to achieve academic excellence and strength of character so that they have the opportunity to succeed in all aspects of life.

CPS is home to 54 schools and 22,859 students throughout its city. While there are 1,108 English Language Learners, 53% of the student body are African American students, 33% are white, and 11% are other races not defined. There are 57 countries represented in the district and 95 native languages spoken by students. With this diverse background in mind, the district developed a 100-page "On Track to Equity: Integrating Equity Throughout CPS – An Implementation Plan" to ensure equitable access and outcomes are available to all students. Unfortunately, equity is far from a reality for the thousands of children from minoritized backgrounds and communities who attend CPS.

Even though CPS offers STEM courses throughout its district, not every school will provide STEM related courses. For the past five years, the district has emphasized STEM integration, with arts now included. Recently, the community announced their formal partnership with Discovery Education. This partnership will allow district professionals to gain access to professional development and training, plus digital curriculum to add to their classrooms. In addition, Discovery Education will allow all schools in the district to transform into STEAM (Science, Technology, Engineering, Arts, and Math)-centered learning environments. By having the partnership with Discovery Education and the $35,000 grant the district received as part of the ASmart initiative, schools will have the necessary tools and resources needed to offer students more STEAM opportunities. The ASmart initiative aims to bring computer science and STEAM education to elementary, middle, and high schools with professional development for their teachers. With this type of change, Parkway and other CPS schools could increase in computer science course enrollment. However, failure to increase enrollment could find CPS out of compliance with federal regulations, specifically the Carl D. Perkins Career and Technical Education Act of 2006 (Perkins IV). According to the U.S. Department of Education, Office of Career, Technical, and Adult Education:

> The Carl D. Perkins Career and Technical Education Act of 2006 (Perkins IV) is a principal source of federal funding to states and discretionary grantees to improve of secondary and postsecondary career and technical education programs across the nation. The Act's purpose is to develop more fully the academic, career, and technical skills of secondary and post-secondary students who elect to enroll in career and technical education programs. (Perkins Collaborative Resource Network, n.d.)

Parkway High School created their mission statement using the feedback from various faculty meetings, both in and out of school, and meetings with community leaders such as police, judges, businesses, and families. During the 2017-2018 school year and the accreditation process, the middle states team and staff established this mission statement. The Parkway mission statement says: "We will provide students with **rigorous academic programs, equitable**

opportunities, and inclusive experiences to prepare students to become college and career ready." Despite offering various courses and programs to students there are still myriad challenges. Guidance counselors work with students on their schedules for the next year in the spring. Usually, when students make their course selections their schedules are set in stone and cannot change. So, if a student learns about other courses that spark their interest when school begins in the fall, they are not permitted to change. This often leads to disappointment and disinterest in a class they do not want to take anymore.

Currently, Parkway offers the following two advanced placement (AP) courses, computer science and introductory to computer science, all electives. In addition, students can enroll in Apps and Gaming, another elective that allows students to learn block-style programming using Microsoft's MakeCode Arcade. Parkway also received a STEM grant that added one elective class, Innovation Lab Development and Design, awarded to another CTE teacher who will teach that STEM course for the upcoming year. There are currently two sections offered with twenty girls enrolled, approximately 6% of the female population.

Since Spring 2021, I have been teaching Parkway's applications and gaming course. This course is game-based learning, allowing students to be creative and struggle while learning block-based programming through gaming. According to Stephen Noonoo (2019), "games are an effective way to learn because they stimulate adventure and keep our brains happily engaged." These applications are designed for business, gaming, education, and the multimedia sectors. This course will allow students to explore the current app market and will enable students to identify the elements that have made some apps more successful than others. After completion, students will apply graphic, animation, sound, and device technologies to introductory application development concepts that can ultimately lead to the design of their apps. A male teacher previously taught this course. His 2019-2020 roster was roughly 37% adolescent girls.

1.3 Stakeholder Description & Analysis

Numerous stakeholders influenced this research study The Power versus Interest grid (Eden & Ackermann, 1998) was used for the stakeholder analysis. Stakeholders include:

- Underrepresented girls in computer science (e.g., Asian, African American, Caucasian, Native American)
- School guidance counselors
- High school computer science faculty
- Career and Technical Education (CTE) Staff
- High school administrators

1.3.1 Underrepresented girls

In general, girls are underrepresented in computer science education and careers. Stakeholders include all female students who aspire to become someone in the computer science industry and also girls who might not have a computer science identity. These female students are the most critical stakeholders. The students have a high interest in computer science; however, they have little power. These students know they want to pursue computer science but often fall short on how to get there.

Furthermore, these students often drop out of computer science, through no fault of their own, either in high school or shortly after reaching their secondary education institution, mainly because they feel they lack identity in computer science. By allowing girls to develop their computer games, Stewart-Gariner et al. (2013) believe adolescent girls can build their own identities that can influence how they perceive themselves in computer science. Outside of selecting their elective computer science courses, these students are dependent on guidance counselors and their teachers to help guide them in bridging the underrepresentation gap in computer science. Through an empathy interview with a female student, I discovered that she could relate to having a computer science identity because of previous coursework, as she is an undergraduate student. She did not feel that there was one teacher or class that helped her stay with computer science; however, she mentioned she would love to mentor high school computer science students, specifically girls. She said it would help retain more girls in computer science if there was a role model for them, other than their teacher.

1.3.2 Parkway High School guidance department

School guidance counselors are tasked with:

1. developing a plan that relates to the student's interests and skill level;
2. facilitating communication between students, parents, and administration regarding academic issues; and sometimes
3. supporting school programs and events.

These counselors are trained individuals but may not have expertise in all academic areas. Counselors are often responsible for scheduling and can place students in classes they do not want to take or need the credit to graduate. Sometimes, certain academic classes, like computer science, are not offered at their respective school. In that case, guidance counselors could steer students away from pursuing those classes if their schedule does not allow it. On the other hand, some counselors find ways for students to pursue those classes at another school within the district or provide outside school opportunities so students can participate.

1.3.3 Parkway High School CS teachers

High school computer science teachers often teach elective-based courses. Students either choose to take these elective courses or enroll in the classes to fill a gap in their schedule. Computer science teachers play a pivotal role in whether students continue with CS courses in high school or college. As an elective course, teachers must promote their courses for current and future students of the district both in school events and out of school events. They often act as a role model for students and provide that needed push for those students to follow their dreams. For instance, a recent empathy interview with QM, a senior systems administrator for a global company, stated she believes if her high school teachers had sparked her interest in computers and programming, she would not have waited until sophomore year of college to pursue the degree. She had no one to guide her in the direction despite her high interest in computers. During a recent interview, a current computer science teacher felt that girls have the same opportunities as their peers but are unaware of course offerings unless mentioned by the teacher. He feels this could play a role in why female enrollment is lower than the national average. However, he does recognize that while not many adolescent girls enroll in introductory computer science courses, he has more girls than males in his advanced placement computer science courses.

1.3.4 CPS career and technical education staff

Career and Technical Education (CTE) staff develop a curriculum for every program and elective class offered within the district. In addition, they apply for grants that can enrich the lives of their students with new and exciting classes and provide professional development for their teachers. Like the high school computer science teachers, they must promote all CTE programs and elective classes. The CTE staff have an increased interest in all the schools within the district, their programs and courses, teachers, and students; however, some staff lack the power. With most of the CTE staff new to this district, their interviews were not as in-depth as others.

1.3.5 Parkway High School administration

High school administrators are stakeholders responsible for their entire school, all students, teachers, and other support staff. High school administrators support their school and create opportunities for students and teachers thus falling under *context setters*. In addition, these administrators bring new programs and courses to their school either from student and teacher interests or grants. Being in a leadership role, these administrators possess both high interest and high power; however, they have very little direct interest in the problem of practice. However, the interviewed principal is very interested in changing the dynamics of the computer science program. She noted that some teachers not certified in computer science were directed to teach because they were available. However, teachers are retiring over the next few years, and she would like to find someone to own and build the computer science program and improve the female enrollment and retention at Parkway.

One of the most incredible things the principal mentioned is that CPS has a partnership with Microsoft TEALS (Technology Education and Literacy in Schools) that she is hopeful will boost computer science enrollment and add more complex AP computer science courses. TEALS connects high school teachers with tech-industry volunteers to collaborate in the classroom for three years. During the first year of having TEALS in the class, the tech-industry volunteers will instruct about 90% while the teacher will assist and learn how to teach the content. Each year, the TEALS volunteers will do less teaching so that teachers will be teaching 90% of the time by year three. TEALS serves 10,000 students at 455 high schools in the United States (CSTA, 2021).

The stakeholders mentioned play a role in addressing the ongoing underrepresentation of girls in computer science. Girls will no longer be underrepresented in computer science when all stakeholders come together, use their voices to advocate, and share a common goal to gain more girls in computer science.

1.3.6 Positionality statement

As a white female growing up in a suburban middle-class home, the viewpoints and perspectives were often similar to those around me. However, my journey to becoming a certified teacher changed those viewpoints and perspectives. As an undergraduate student, I attended a private Catholic university where students often had similar upbringings as myself. However, while attending a private university for graduate school in education, most students came from diverse backgrounds and upbringings. During my graduate studies, I completed student teaching in Pittsburgh, at an upper-middle-class district, and in Aruba at their international school. Most students at the international school came from prominent families across the world.

I have spent my teaching career working with incarcerated adults, incarcerated juveniles, Title 1 schools, and inner-city students. Each experience, whether in a correctional facility or public school, help shaped my perspective on different backgrounds, cultures, and ethnicities. Every person I taught allowed me to appreciate the power of their voice and learn from their experiences, which permitted me to design culturally relevant lessons.

1.4 Statement of Problem of Practice

Globally females are underrepresented in computer science. By the fall of 2023, I aim to increase the number of adolescent girls participating in at least one computer science class at Parkway High School by 20%. Roughly 12% of the female population at Parkway are enrolled in a CS class, slightly below the national average of 16%. According to Goode (2008), the underrepresentation of girls and people of color occurs at the professional level, university level, and in K-12 education (p. 362).

Either girls do not know Parkway offers CS, are uninterested in CS due to no experience or identity, or have other determining factors for not taking computer science classes. Having a female teacher for CS could lead to more enrollment in those courses. The overall goal of this study was to help develop adolescent girls' computer science identity.

1.5 Review of Supporting Knowledge

1.5.1 Purpose of review

The purpose of the review was to examine the literature regarding identity formation among the underrepresentation of girls in STEM, particularly computer science. To read what exists in the literature, I pursued the following questions:

1. What factors deter STEM identity formation for adolescent girls?
2. What interventions can I bring into my classroom to help form a STEM identity for adolescent girls?

1.5.2 Roadmap

Even though I sought studies within the last ten years, there was an emphasis on using references from the past five years as STEM has evolved worldwide. The following key words in various combinations informed my search: computer science, computing, identity, sciences, curriculum, framework, girls, women, underrepresented, STEM, learning, minorities, K-12, engagement, retention.

In what follows, I address the themes in the literature about how girls may be best supported to form their STEM identity, emphasizing computer science. I conclude with takeaways from the literature review, including reflections on the problem of practice and potential next steps.

1.5.3 Contributing factors of STEM identity formation

1.5.3.1 Sense of belonging

As literature suggested, peer interactions and interpersonal relationships can deter adolescent girls' future in STEM (Master et al., 2016). Elisabeth Höhne and Lysann Zander (2019) conducted a study to examine three possible sources of belonging of undergraduate computer science students in Germany. Four hundred forty-nine (104 female) students participated in the study and completed questionnaires distributed during the mandatory programming classes. In addition, students were part of tutorial classes where they worked in pairs and had to complete weekly exercises. There were 26 tutorial groups, each assessed during the lecture period in week two or three and again four weeks later. The questionnaire measured students' uncertainty about their belonging within computer science using a Likert scale. Their study determined that when students do not feel a sense of belonging, especially in computer science, they are less likely to excel in computer science classes and are less likely to pursue additional classes.

Another study conducted by Sax et al. (2018) focused on students' sense of belonging in an introductory computing class at 15 universities across the United States. The institutions were part of the Building Recruiting and Inclusion for Diversity (BRAID) project which focused on improving recruiting and retention in computing for the underrepresented. The study included 1,355 undergraduate students; 595 were female. All students enrolled in an introductory computer class, with 48% in a computing major. Students completed pretest and post-test surveys developed by Computing Research Association's Center for Evaluating the Research Pipeline (CERP) that focused on computer contexts such as "I feel welcomed in the computing community." The study measured students' gender, parents' education level, parents' computing career, socioeconomic status, high school GPA, and prior programming experience. Sax et al. (2018) found differences in students' sense of belonging by gender and those underrepresented. Initially, women in general scored significantly lower than their male peers regarding their sense of belonging. On the contrary, underrepresented women (e.g., Latina, African American) reported a higher sense of belonging. By the end of the course, women's sense of belonging declined drastically, especially those without prior programming experience.

Together, these empirical pieces suggest that a girls' sense of belonging in computing plays a significant role for girls to continue in the computer science field.

1.5.3.2 Social environment

As adolescents shift from parental influences to peer influences, adolescent girls become more aware and sensitive to others' opinions (Beutel & Marini, 1995). One study conducted by Riegle-Crumb and Morton (2017) focused on the role of peers with both positive and negative sources of influence on girls' decisions to pursue male-dominated fields of computer science and engineering. This study examined the potential for male peers' biased beliefs to create messages of exclusion. In addition, this study also examined the female peers' science confidence to provide supportive messages of inclusion and belonging in STEM fields. Their study included 1,273 high school students (647 females and 626 males) from an extensive urban school district in the southwestern U.S. Their study found evidence that peer characteristics predict girls' future intentions to major in male-dominated fields of computer science and engineering.

Another study conducted by Leaper et al. (2012) investigated the impact of social and personal factors on girls' motivation in STEM versus non-STEM subjects. Leaper et al. defined social factors as support from parents and peers while personal factors included gender identity, gender-related attitudes, and exposure to feminism. Their study included 579 girls in middle schools, junior high schools, high schools, school-related programs, and summer schools in Georgia, northern California, or southern California. The participants ranged from 13 to 18 years old, with the majority reporting as Latina. As reported by the girls, their parents varied in education level, with 51% of mothers and fathers having no more than a high school diploma. Students completed the "What it means to be a girl" questionnaire by a female researcher in classrooms or similar settings. Students also answered demographic questions regarding their age, grade level and ethnicity. The researchers measured parents' education, academic motivation, academic grades, perceived academic support, gender identity, gender beliefs, and learning about feminism. Their results showed that girls' math and science motivation was associated with mothers' and peer support. On the contrary, when girls experienced peer support in math or science there was less motivation in English or vice versa. The study also determined gender identity and learning about feminism predicted girls' academic motivation in the fields often dominated by males.

1.5.3.3 Stereotypes

Stereotypes can act as gatekeepers to steer girls away from STEM fields like computer science (Master et al., 2016). A study conducted by Master et al. (2016) examined how stereotypes deter adolescent girls' interest in computer science and their sense of belonging. Their study included 165 (77 female) students at two high schools, one private, in the Northwestern United States. The study manipulated classroom environments using two photographs. These photographs included stereotypical or non-stereotypical items in a computer science classroom. For example, stereotypical objects had electronics, software, and computer games. The non-stereotypical things included art pictures, nature pictures, and plant. Students completed a survey to rate how much they associated each item with computer science. This study showed that girls were more likely to choose the non-stereotypical classroom to pursue computer science classes. Although, there was a greater interest in girls enrolling in the stereotypical classroom if they felt they fit the computer science stereotype. As Master et al. (2016) determined, computer science mainly appeals to those who hold the stereotypes about girls feeling like they do not belong and lack interest in enrolling in computer science classes.

Unlike most studies, Sylvia Beyer (2014) surveyed a small, public liberal arts university in the Midwest of the United States. In total, 1,319 first-year undergraduate students (872 female) participated. Most of the population from the university came from White, lower-middle-class and working-class families, many as first-generation college students. Beyer's study focuses on gender differences in first-year students' stereotypes about computer science and classroom experiences. She mailed surveys out to all incoming, full-time first-year students for three consecutive years. The survey assessed demographic information while using a Likert scale to evaluate statements on stereotypes about computer science, values, computer self-efficacy and experience, personality variables, and experiences in computer science courses. Her study found that women showed fewer negative stereotypes about computer science and computer science majors compared to men. Women in her study viewed computer science as a more promising career and showed more respect for students majoring in computer science. Even though her research did not find any gender differences dealing with stereotypes like the study conducted by Master et al. (2016), stereotyping computer science as a masculine field can affect interest and persistence in computer science especially when there is no sense of belonging in the field (Cundiff et al., 2013).

1.5.4 Approaches to support identity development

The literature pointed to three promising approaches to supporting adolescent girls' STEM identity development that I will address in the following sections. These approaches focus on inclusive curricular practices, collaborative learning, and supportive learning environments.

1.5.4.1 Inclusive curricular practice

Adolescent girls can form a computer science identity through identity-based programming. Identity-based programming enables girls to program games to fit their lifestyles and personality. By allowing girls to bring themselves to their programming, rather than requiring them to engage with games or programs that are "manly," adolescent girls may have a stronger interest in computer science thus allowing them to form their identity. In one study, researchers allowed students to customize their games and explore game design developmental environment (Akkuş Çakır et al., 2017). This study used a mixed methods approach and included 21 adolescent girls in grades five through eight who participated in a full day game design workshop. Through this study, the researchers determined that adolescent girls' attitudes were positive towards computer science careers. By providing the needed programming resources, the girls were able to engage in a meaningful and creative game-design.

Other studies have found similar results. For example, Stewart-Gariner et al. (2013) believe that having adolescent girls develop their games influenced how they perceived themselves in computer science. Their study included 57 students (41 girls, aged 11-14) in an afterschool program at Roselle Park Middle School in New Jersey. With only 50 accessible computers, some students had to share a computer for this study. The game, Grams Grocery Shop, was adaptive to students' skills and learning levels. The researchers found that, when designed appropriately, adolescent girls tend to gravitate to game titles. Still, the study showed that games can influence the capability girls have for creating computer games. By allowing girls to customize their games, girls could see themselves designing computer programs in the future.

Another version of an inclusive curricular practice is EarSketch, a "learning environment that combines computer programming with sample-based music production" (Magerko et al., 2016). Built by two educators, Professor Jason Freeman (School of Music) and Professor Brian Magerko (School of Literature, Media and Communication) from Georgia Tech University, this learning environment allows students to use both text-based programming and block-based programming. Text-based programming is where the user writes lines of codes to create a program while block-based programming is where the user drags and drops blocks to develop a program. Incorporating EarSketch into the curriculum would allow the underrepresented to participate more in computer science due to its embedded curriculum. EarSketch engages students through culturally relevant technology to make their own musical identity and learn computer programming. This study was conducted at the largest high school in Georgia with 98 participants, 26 female, the majority (i.e., 71%) in the ninth grade. Even though the study took place over two semesters, spring and fall, the research found that EarSketch is effective across gender and ethnicity. In fact, by incorporating EarSketch into the curriculum, students are more interested in pursuing computer science.

While this change idea is still not definitive, other studies have not found the same positive results for girls (Robertson, 2013). And, somewhat different from the studies that sought gendered exploration of programming, other studies have advocated for gender-neutral design. Many studies (Carbonaro et al., 2010; Denner et al., 2005) revealed that if games are designed appropriately with a gender-neutral approach, these games could potentially increase children's skills, confidence, and motivation for coding and programming.

One study that used a gender-neutral approach studied the effects of the Girls Creating Games (GCG) program (Denner et al., 2005). This program linked activities and outcomes through *Learning by Design, Scaffolding and Modelling, Collaborative Learning and Identity Formation.* The research team answered two questions: (a) Did participants increase the capacity to pursue and persist with computer technology? and (b) What aspects of the program can be improved? Researchers conducted the study over 12 weeks, two times a week, during the school year, plus two summers over six weeks, four times a week. A total of 126 girls from two middle schools participated in GCG. Most of the girls were White, but more than a third of the participants spoke another language other than English at home. Denner et al. (2005) found that the participants' expected success increased concerning computer skills and knowledge about computers. However, they found that the girls in this study did not have negative stereotypes about who works with computers, nor did they believe boys are better at computers than girls. Activities like GCC can help build friendships and support adolescent girls' interests in computer science by allowing them to work in an environment that encourages pair programming.

Meanwhile, Carbonaro et al. (2010) used the ScriptEase tool that helps define interactions between the player character and game objects. This tool allows the user to design a completely customizable game. Their study included two tenth-grade high school classes that used ScriptEase from different suburban middle-class high schools in Edmonton, Canada. A total of 50 students, 24 females, participated. Roughly 28% participants spoke a language other than English. Both classes attended a two-day workshop and spent six hours working through tutorials, then constructing an interactive game for two more hours. The researchers found that ScriptEase promoted higher-order thinking skills while also having fun and learning computer science. Finally, female students can develop higher-order thinking skills and learn computational concepts through game design by having fun in a gender-neutral activity.

As this line of research suggests, developing an identity through gender-neutral approaches is something adolescent girls need in computer science to improve participation throughout their schooling.

Together, these empirical pieces suggest that, at the very least, learning opportunities should be gender-neutral if they are effective for girls. There may be particular potential in extending gender identity exploration that is explicitly "girl positive" for girls' computer science learning.

1.5.4.2 Collaborative learning

Another promising intervention for supporting adolescent girls' identity in computer science is through collaborative learning. Through collaborative learning, students paired with another student, often called pair programming. Pair programming is when two students share one computer. One student drives the keyboard and mouse while the other navigates during this time.

Multiple studies have found that successful pair programming can help promote practical problem solving and critical thinking skills. Bransford et al. (1999) found that cognitive science shows the importance of metacognition when students are paired to perform operations involving metacognition. An example of this from Palincsar and Brown (1984) indicates that when students summarize and explain what they know, respond to feedback, work through what they do not understand, and ask questions, they all emphasize high-level thinking skills to improve performance. This is all evident in pair programming.

Pair programming may appeal to girls because of their social interests. Students tend to enjoy pair programming and have better success when paired with their friends of the same sex. According to Hartl et al. (2015), friends learn more in a collaborative environment. This finding is consistent with studies done by MacDonald et al. (2002) and Miell and MacDonald (2000).

Pair programming can also promote computer programming learning for both partners (Hartl et al., 2015). This study involved 160 students with 80 same-sex pairs recruited from eight classrooms and four extended learning programs in seven public middle schools in four lower- and middle-class communities in Northern California. Students participated for ten weeks averaging almost 23 hours. Participants completed the same assessments at the beginning and end of the project. Students worked with several different chosen partners for the first two sessions. After, students privately ranked three students they wanted to work with, and the teachers assigned partners according to their rankings. Students learned programming skills and concepts by playing games in the first five weeks. They also completed tutorials and step-by-step written instructional materials. Students designed and programmed their interactive computer games in the last five weeks. Their research indicated that students who liked their partners ended up liking programming. Thus, this study showed that pairing with friends helps the learning process.

Studies have shown that students with similar social skills allow the pair to be more effective when collaborating than students with opposite social skills (Hartl et al., 2015). One thing research lacks are the studies where teachers decide the pairs compared to student choice. One of the first programmers, Jean Bartik, stated: “I believe that the best programs and designs are done by pairs because you can criticize each other, and find each other’s errors, and use the best ideas” (Hartl et al., 2015, p. 37).

While most studies included the general population, one study by Lindsay and Hounsell (2017) took a different approach to pair programming, which was a first of its kind. Their study represented not only underrepresented females but also youths with disabilities. Unlike the other studies that included the general population, this study included youth with physical or developmental disabilities who were clients at a pediatric hospital. This study allowed teachers, parents, administrators, and students to see firsthand that with a few adaptations computer programming through robotics can be implemented for special education students due to the positive influences it has on the students working together in pairs. However, the problem with this type of study is the lack of research geared around special education students. Studies involving special education students and computer science. By doing more research similar to this study, computer science could see more participation from underrepresented females and other underrepresented students.

1.5.4.3 Supportive learning environments

In addition to making substantive shifts in instruction, many studies discussed the need to change the appearance of classrooms. Many computer science and technology classrooms have Star Wars and Star Trek items, computer parts lying around, and even computer and science fiction magazines throughout the room (Master et al., 2016). This atmosphere often makes adolescent girls less willing to take computer science courses because they perceive them as spaces where they are not welcome or do not belong.

Master et al. (2016) suggest that to make classrooms promote girls' sense of belonging, teachers can place more nature and art pictures throughout the room, have a coffee maker and water bottle on a desk, and have general magazines. Providing this atmosphere in a classroom allows girls to have a sense of belonging and even sparks interest in computer science without generating the male stereotype (Master et al., 2016). Master et al.'s first experimental study involved 165 students from two high schools in the Northwest United States, with 54 students enrolled in a co-ed private school. In total, 77 participants were female. Research answered the following questions: (a) Does belonging mediate gender differences in interest in the stereotypical classroom? and (b) Does belonging predict interest after controlling for other variables? First the students read a statement about classes they were interested in taking during high school and information about the different classrooms for those classes. After reading the statement, students were then given two photographs of the two classrooms. The researchers' first experiment found that after a classroom environment was altered not to fit high school students' current stereotypes of computer science, girls' interest in enrolling in computer science classes increased. Additionally, classrooms with a greater sense of belonging increased girls' enrollment.

The second experimental study selected 104 students from the same public high school and had 48 girls. This study answered the following questions: (a) Does belonging mediate the gender effect on enrollment interest? and (b) Does belonging predict interest after controlling for other variables? The researchers had students read a computer science course description with a randomly assigned, male or female teacher. Students then read one definition of a classroom. This study revealed that girls reported more interest in enrolling in a computer science class with a non-stereotypical classroom. Diversifying stereotypes can help reduce some barriers that prevent adolescent girls from enrolling in computer science (Master et al., 2016).

Non-stereotypical classrooms can gain more participation in CS for adolescent girls, but having female teaching programming can also ignite interest. A recent study by Berg et al. (2018) showed the importance of having a female teacher for CS. This study dealt with picturing and how stereotypes play a role in the computer science industry. The exciting part of this study showed the perceptions students have towards female computer scientists through physical appearance, personality type, and digital ability. Their study showed that teachers can break down barriers to education, language, and culture through picturing. In 2019, Sullivan and Bers conducted a study using an all-female teaching team to teach programming. While having an all-female teaching team for programming would be difficult in schools, one thing is certain: it has a positive impact on girls' performance in programming (Sullivan & Bers, 2019). Having a female computer science teacher ignites and changes adolescent girls' attitudes, interests, and feelings for computer science. In both studies, researchers believe there needs to be more done to show adolescent girls need more female teachers in computer science to gain interest and participation.

1.5.5 Summary

I have identified three effective approaches for supporting girls' identity development in computer science: inclusive curricular practices, collaborative learning, and supportive learning environments.

My review of the literature suggests a few fundamental principles for designing inclusive learning opportunities that have the potential to disrupt inequitable gender outcomes in computer science. First, girls need opportunities to explore and integrate their gender identities. Adolescent girls need support to help form an identity in computer science. The research suggests it is essential to develop an identity early in an adolescent girls' schooling to help change the perception of who pursues STEM courses and careers.

Second, girls need opportunities to work with peers. In addition to identity support, adolescent girls need access to social opportunity to work with their peers in computer science. Studies have shown the benefits of pair programming among females. For instance, a 2000-2001 study at the University of California, Santa Cruz found that females taking an introductory computer science course performed better working with another student than students who worked individually (Werner et al., 2004).

Third, girls need welcoming and inclusive learning environments in computer science classrooms. When females have a sense of belonging in a classroom, they will fit in with the people, materials, and activities within that environment (Master & Meltzoff, 2017). Additionally, when girls feel like they belong, they can transform their experience in male-dominated industries (Walton et al., 2015).

1.5.6 Synthesis

Reviewing the literature provided a more comprehensive picture regarding why adolescent girls do not participate in computer science and lack a computer science identity. Research suggested barriers that adolescent girls often face when forming an identity. Those barriers often included a sense of belonging, social environment, and stereotypes. To help adolescent girls form their computer science identity, research offered a variety of interventions. However, there was a focus on inclusive curricular practices, identity-focused activities, collaborative learning, and supportive learning environments. These interventions allowed the researcher/teacher to change and modify them to fit the needs of their classroom and students. These interventions helping adolescent girls develop their computer science identity indicated a shift in interest in computer science and participation in additional computer science classes.

2.0 Theory of Improvement & Implementation Plan

2.1 Theory of Improvement

Girls are underrepresented in computer science, whether it is participating in classes or majoring in computer science, to name a few. Research has shown that women accounted for 57% of all bachelor's degree recipients in 2019. However, only 21% of women earned their degree in computer and information sciences (National Center for Women & Information Technology, n.d.). Despite the challenges girls can face throughout their years of schooling, there need to be more girls participating in computer science classes. If more girls participate in computer science, it could help break the barrier of underrepresented girls in the field. A study conducted by the National Center for Women & Information Technology (NCWIT) found that prior experience with computer programming, such as coding, is the most important reason women pursue computer science or computer engineering (n.d.).

The problem of practice looked at disrupting the pattern of adolescent girls' under-representation in computer science at Parkway High School, emphasizing how to best support adolescent girls' computer science identity development. The theory of improvement involved knowledge and skill training for computer science teachers to help adolescent girls form their identity in computer science.

If Parkway High School can support adolescent girls' identity development in computer science, then more adolescent girls could participate in other computer science classes. The increased participation in computer science courses would be achieved through computer science instructional materials and instruction.

2.1.1 Driver Diagram

Perry et al. (2020) described the driver diagram as an improvement tool for accelerating learning that contains beliefs about what must change and what ideas might lead to improvement. The driver diagram consists of an aim statement that states what one is trying to achieve and drivers that are organized ideas that could help signal change.

By the fall of 2024, the number of adolescent girls' participating in at least one computer science at Parkway High School would increase by 20%. Researchers can focus on a variety of drivers; however, building relationships, CS curriculum, and classroom environment will be discussed (see Figure 1).

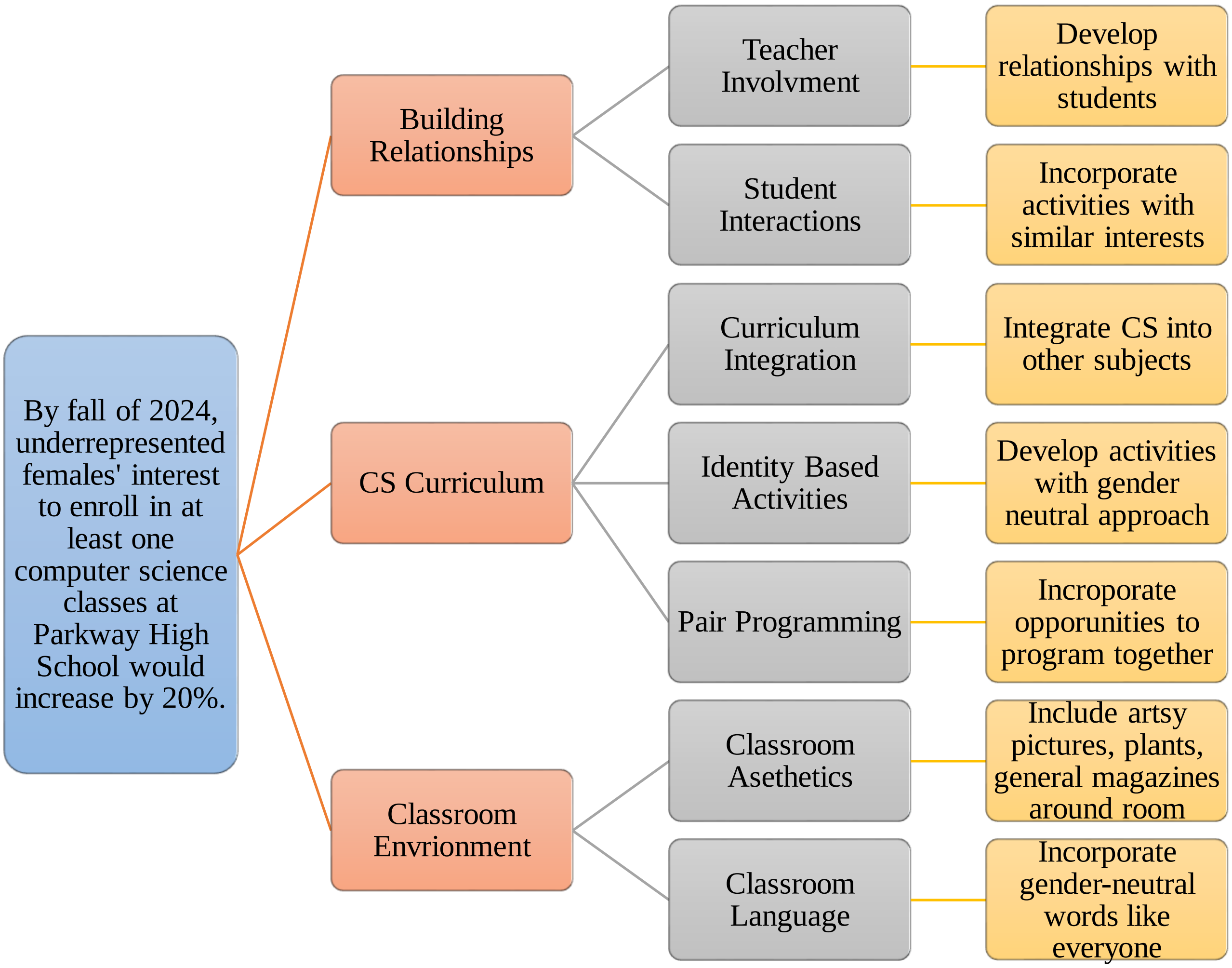


Figure 1. Driver Diagram

2.1.2 Driver descriptions

Building relationships, can play an integral role in adolescent female CS involvement. And retention. Building relationships refers to student to teacher relationships and student to student relationships. Teachers and students can interact with each other to develop a deeper relationship to help foster learning and identity development in computer science. Students can build relationships through activities focused on similar interests as their peers.

The computer science curriculum deems important and controllable, especially in my classroom. To integrate the computer science curriculum, teachers should attend professional development that instructs how to properly integrate the curriculum. Elementary classrooms should integrate this curriculum rather than waiting until middle and high schools. Finally, classroom environment is one of the most important secondary drivers. Currently, computer science teachers are encouraged to get certified. However, there is no mandate needed to teach. For teachers to know what to teach, I need to design monthly professional development workshops.

The final driver, classroom environment, is just as important as building relationships and CS curriculum. Classroom aesthetics is something teachers, including myself, can control and ultimately change if needed. By incorporating aesthetic methods into pedagogy, adolescent girls can experience a better learning environment. Resources assist in any educational setting. In computer science, including the history of women computer scientists through text and videos will benefit adolescents. The language in which teachers speak

2.2 Methods

The theory of improvement aims to help the development of adolescent girls' computer science identity. To create an environment, there needed to be a focus on adolescent girls' sense of belonging, achievement, and interest in computer science. This qualitative study only included those students enrolled in Apps and Gaming during the fall and spring semesters.

As literature suggested different strategies for teachers to help adolescent girls develop a computer science identity, this study focused on inclusive curricular practices, collaborative learning, and supportive learning environments. These strategies created a learning environment where adolescent girls felt a sense of belonging in computer science. This study utilized a qualitative approach guided by the following research questions:

1. How and in what ways have the identity-based curricular interventions shifted my teaching?
2. How and to what extent do the adolescent girls in the Apps and Gaming course describe the curricular interventions (i.e., choice and voice, culturally relevant pedagogy, inclusive learning environment, and collaborative problem solving) as influencing their computer science identities?

2.2.1 Qualitative study

2.2.1.1 Study sample

The study sample included all students in grades 9-12 enrolled in Apps and Gaming classes during the fall and spring semesters. In the four sections across two semesters, there were 80 total students, with 19 adolescent girls.

Participation was limited to only those enrolled in Apps and Gaming for the first time; students taking the class for the second time were not eligible for inclusion. Students who did not receive credit for their initial attempt at Apps and Gaming were not eligible. Regarding the welfare of research participants, special attention was given to their needs, fears, and concerns related to the requirements of the study.

2.2.1.2 Intervention

Langley et al. (2009) described the *Plan-Do-Study-Act Cycle* as an "efficient trial-and-learning methodology" (pp. 24–25). This cycle helped create a curriculum unit to determine how effective the following question was in developing female students' computer science identity: "How is computer science changing the world?"

First, students drew a computer scientist based on their own perceptions of what they look like, similar to the Draw a Scientist Test which David Chambers (1983) developed to investigate a child's perception of a scientist. The Draw-a-Computer Scientist Test (DACST) was designed to "gauge how students perceived computer scientists" and help "broaden their ideas about the activities and images of computer science" (Hansen et al., 2017, p. 279).

Next, students used The Ada Project (TAP) website to research the most notable female computer scientists and their specific contributions to the field of technology. These women included Ada Lovelace, the first computer programmer; Katherine Johnson, NASA mathematician; Megan Smith, the first female chief technology officer of the United States and roboticist Ayanna Howard. This unit lasted roughly five weeks. Each daily class period was 42 minutes in length with four sections taught. Every lesson highlighted a female computer scientist and their creation. For example, students learned what a robot is, read and talked about real-world examples of different kinds of robots, and had a discussion weighing the positive and negative impacts of robots on the world. By the end of this particular lesson, students were able to define the term "robot," name three ways people use robots today, and name one positive and one negative way robots are affecting the world. To promote deeper thinking and further discussion, the class divided in half and debated how robots help solve problems versus cause problems in today's society.

Before each lesson, students wrote and drew their ideas following the daily hook, also known as a warm-up. Students shared their ideas with a partner and class. After the hook, a video played emphasized a certain piece of technology, such as a robot. Each lesson for the unit broke into two sections: woman in tech spotlight and an activity. Students first read about female computer scientists and then watched the biography of the specific female computer scientist for the day. After students answered questions via the associated worksheet, students jumped into the activity. The worksheet presented three labeled sections: think, sense, and act. An example of the *think* section included decisions a robot would make; the *sense* section included how robots take in information; and the *act* section included the physical actions of robots. Students worked either in groups or independently for this activity. For this particular example of robots, students gathered into groups to discuss how robots are changing the world and the resulting positive and negative changes. After discussing in small groups, the class participated in a whole-class discussion regarding the same questions. Finally, students answered reflective open-ended prompts on Schoology, the district online management system. In summary, this curriculum allowed students to learn about women in technology, dig into real-life technology created by people currently living, and understand how this technology impacts the world.

Another part of the curriculum unit was adding art to coding by students completing their self-portrait using Khan Academy and Code/Art's JavaScript interfaces. Code/Art is a non-profit organization "whose mission is to increase the number of girls studying computer science by delighting and inspiring them with creative possibilities of computer programming" (CSTA, 2021). The self-portrait had two versions that took five weeks to complete. Version one had students create their self-portrait that replicated an alien-looking figure that provided students with basic knowledge of coding with JavaScript. Version two had students use their creativeness to add different features such as hats, clothes, and accessories to complete their self-portraits.

The inquiry questions for this change idea looked to determine if adolescent girls in high school computer science courses would gain a more robust computer science identity because of implementing the curriculum "how is computer science changing the world" and creating self-portraits in the curriculum:

1. What is the impact of game-based learning on adolescent girls' retainment in computer science?
2. How does incorporating art into coding shape an adolescent girl's computer science identity?

These questions helped further understand how identity-based programming can help shape an adolescent girl's computer science identity and encourage adolescent girls to continue their computer science journey. These questions connected to the four themes described in the literature review. The researcher predicted that creating a curriculum and classroom environment that makes adolescent girls feel like they belong in computer science would lead to more girls enrolling in courses. In addition, structuring curriculum that included a student-led approach would give students, specifically adolescent girls, confidence and the ability to demonstrate their knowledge and would increase their interest in computer science.

2.2.2 Data sources

This study utilized a variety of data sources that helped determine changes in teacher practices and influences on adolescent girls' computer science identities. These sources included teacher reflection journals, student feedback on instruction, lesson plans, classroom observations, Draw a Computer Scientist Tool, reflective open-ended questions, and code your self-portrait.

2.2.3 Data collection procedures

I collected data throughout the unit through the pre- and post-test drawings from the Draw a Computer Scientist Tool, weekly progress on coding your self-portrait from the master tracker, daily classroom observations, daily teacher reflection journal entries, daily student feedback on instruction and reflective open-ended questions after each weekly project.

2.2.3.1 Teacher reflection journal

I wrote notes down after each instructional class period to indicate what part of the lesson was engaging versus less engaging based on teacher observations. In addition, these journals told what happened during the lesson that could interfere with learning (see Appendix D). I analyzed these journals to determine how the teaching practices in place were effective or not effective for students. Based on the analysis, I adjusted and/or changed these practices for each section.

2.2.3.2 Student feedback on instruction

After each day of teacher instruction, students provided feedback by answering two questions on Schoology. Every student enrolled in the course completed the questions; however, only responses from students who identified as adolescent girls were used. Students answered the following questions: (a) What is one thing you would like me to explain more clearly? and (b) What is one piece of advice you would like to give me to help improve my teaching? Feedback from both questions allowed adjustments to teacher practices for future instruction and determined any patterns of struggle among students. Furthermore, the feedback allowed for small group instruction and/or a reteach of the lesson when multiple students were struggling with the same concepts.

2.2.3.3 Lesson plans

After each class period, I wrote down notes to explain what parts of the lesson were effective and engaging for students. These notes also indicated what parts of the lesson were less effective and engaging. For instance, students were more engaged creating their characters for their game compared to creating a projectile. In addition, these notes indicated the part of the instruction which ignited an interest to learn more about coding. I analyzed these notes to determine how each lesson was focused on identity strategies that support student learning and identity development.

2.2.3.4 Classroom observations

I wrote down notes after each class period that indicated what transpired in the classroom during instruction. These notes showed what occurred during the time students worked independently (see Appendix E). These observations showed possible changes in adolescent girls' computer science identities. Finally, the observations investigated the issues, such as pacing, during instruction that allowed adjustments for future classes.

2.2.3.5 Student assessments

The Draw a Computer Scientist Tool helped make inferences about the beliefs and stereotypes students held about scientists (Chambers, 1983). Before the curriculum unit, students enrolled in Apps and Gaming drew a picture of a computer scientist that showed what they knew about computer scientists and their work. Students also explained in writing their picture and why they drew their computer scientists the way they did. After the curriculum unit, students again drew a picture of a computer scientist and explained the similarities and differences from their first drawing at the beginning of the unit. This tool helped students understand computer science and possible career opportunities that they could envision themselves doing.

Students completed the Code Your Self-Portrait project on Fridays during every section. Students added a different self-portrait feature each week and completed their objective learning reflections after each class (see Appendix F). This project helped students start to develop their computer science identity by using their creativity and personality to code themselves.

2.2.3.6 Reflective open-ended questions

After each weekly project, students answered three to five questions used to determine if learning and/or change occurred. These questions were online through Schoology, and only the student and teacher had access to their responses. The questions rotated throughout the semester by the unit activities (see Appendix C). Data collected through these questions allowed for adjustments.

2.3 Measures

Tables 1 and 2 outline the measures used for this study.

Table 1. Measures Planned Research Question #1

Data Sources	Data Analysis
Teacher reflection journal	Analyze teacher notes for each class.
	Describe questions the students asked.
	Describe what went well.
	Did you notice something the students got stuck on?
	What questions did you notice the students asking?
	Review classroom behavior patterns (if any are present).
Student feedback	Analyze the similarities and differences from student responses.
	Analyze suggestions students offer.
Lesson plans (document changes)	Analyze the changes in the lesson plans.
	Analyze if the lesson plan represents student choice, collaboration, and/or student interests.
Classroom observations	Analyze the engagement of students.
	Analyze classroom interactions.

Table 2. Measures Planned Research Question #2

Data Sources	Data Analysis
Draw a computer scientist tool (student assessments)	Compare student drawings at the beginning of the unit and completion of the unit. Analyze the similarities and differences from student feedback.
Code your self-portrait (student assessments)	Analyze the Mastery Tracker to determine areas of struggle/mastery. Analyze the Mastery Tracker for emotions (e.g., excitement to draw a hat).
Reflective open-ended questions	Analyze the similarities and differences from student responses. Analyze student responses for interests to learn more complex coding/language. Analyze student responses for sense of belonging in computer science.
Classroom observations	Analyze the engagement of students. Analyze classroom interactions. Analyze student emotions when they coded a functioning game or struggled (e.g., feeling a sense of belonging).

2.3.1 Systems measures

In order to determine if the change worked, there is a need to define the types of measures implemented throughout the study.

2.3.1.1 Outcome measures

One outcome measure determined if the change worked– The Code Your Self-Portrait given to all students enrolled in Apps and Gaming at the beginning of the curriculum unit. Once the unit ended, students completed the same tool to measure the change.

2.3.1.2 Driver measures

Prior to the start of the curriculum unit, students drew what a computer scientist looks like to them. During a portion of the curriculum, students coded their self-portrait into two different versions. At the end of the curriculum, students again drew what a computer scientist looked like to them. These measures determined progress to improve the problem.

2.3.1.3 Process measures

At the end of each lesson, students answered open-ended reflective questions. These questions allowed students to share their feedback about what they learned and how this knowledge can be used in their future studies.

2.4 Data Analysis

I utilized a qualitative data analysis approach to answer my research questions. To answer, "How have the identity-based curricular interventions shifted my teaching?" I relied heavily on my teacher reflection journals, student feedback, lesson plans, and my classroom observations as my data sources. To answer, "How have the identity-based curricular interventions shifted my teaching?" I used the Draw a Computer Scientist Tool, Code Your Self-Portrait, reflective open-ended questions, and my classroom observations as my data sources.

2.4.1 How have the identity-based curricular interventions shifted my teaching?

The teacher reflection journals part of the data source helped answer this question. I analyzed the data to students' questions during instruction or while working independently and explained what areas students were more and less engaged in during instruction. The data identified what occurred during instruction such as fire drills and late students. The data also determined what adjustments to teaching practices needed addressing for future classes.

Another data source used to answer this question was the student feedback on instruction. I analyzed students' response similarities and/or differences to determine suggestions from students to re-teach the lesson or adjust for future classes. The student feedback on instruction data coded into the following categories: building relationships, classroom environment and curriculum.

A third data source used to answer this research question were the lesson plans. I analyzed the data to make changes for future lessons and to determine if the lesson represented student choice, collaboration, and/or student interest.

Lastly, the classroom observations were the final data source used to help answer this question and determined if students' computer science identities changed. All data sources were coded and archived in Microsoft Excel.

2.4.2 Over the course of the focal unit, how and to what extent do adolescent girls in the Apps and Gaming course indicate a change in their computer science identities?

Student assessment analyses as a data source helped answer this question. The first student assessment, Draw a Computer Scientist Tool, determined the differences and similarities from the beginning of the unit until the end and if student feedback changed over time. Furthermore, the data defined if students' computer science identity changed over time. The second student assessment, Code Your Self-Portrait, determined the areas of JavaScript students struggled or mastered and assessed student emotions, such as excitement to draw a hat on their head.

The second data source used to answer this question was analyzing the reflective open-ended questions. These data source determined students' response similarities and/or differences and assessed student interests to learn more complex coding and different programming languages. The data also determined if students envisioned themselves as computer scientists and if they formed a computer science identity. Finally, the data defined if students felt a sense of belonging in computer science.

The final data source used to help answer this question was the classroom observations analyses. The data determined if students' computer science identities changed over time due to the interventions and if students' confidence levels in computer science changed. All data sources were coded and archived in Microsoft Excel.

3.0 PDSA Results

In the following sections, I will revisit the inquiry questions to present the results from the PDSA cycle. I relied heavily on the teacher journals I kept throughout the process to record classroom observations, student engagement throughout the lessons, and student interactions. All students in the course participated in the Draw a Computer Scientist Tool, Code Your Self-Portrait, and the reflective open-ended questions. Still, only those who identified as adolescent girls contributed to the data.

I analyzed the Draw a Computer Scientist Tool for pre- and post-changes for each student. Students drew their perception of a computer scientist before and after the unit and their drawings were analyzed for their changes over time.

I also analyzed the Code Your Self-Portrait master tracker responses. After each lesson, students rated their mastery of the lesson's objective. For instance, the first objective was to code their head and eyes. Once students indicated their rating on the number line, from *I'm lost* to *total expert*, they explained their rating. Some students stated a number rating from one to ten rather than using the words.

Both the teacher journal and teacher observations were coded for analysis. Class notes taken during the time of intervention and after each class were analyzed for lesson engagement, student interactions, and happenings during the intervention.

Lastly, in the reflective open-ended portion, I analyzed student reflections through coding. These reflective questions included five open response questions analyzed for patterns. These reflective open-ended questions followed each lesson.

Table 3 summarizes the data collection activities completed during this study. All students enrolled in Apps and Gaming completed the same classroom activities; however, only the data from students who identified as an adolescent girl were reported. The findings show themes across each inquiry question in the following sections.

Table 3. Data Collection Activity

Component	Description	Frequency	Author
Drew a computer scientist tool	Drawing of perception of a computer scientist	Pre and post	Students
Reflective open-ended questions	Written responses by participants about class tasks	End of each week	Students
Teacher journal/classroom observations	Written responses by teacher/researcher about how class tasks went and other information regarding happenings in school	Each day class meets	Teacher/researcher
Lesson plans	Written plan of what happens in the classroom each day	Each day class meets	Teacher/researcher

3.1 Findings

The identity-based curricular interventions used for this study determined four categories derived from the data. Tables 4 and 5 indicate the categories, codes, and code definitions for each question. The sections that follow explain each theme in detail.

Table 4. Themes for Inquiry Question #1

How and in what ways have the identity-based curricular interventions shifted my teaching?		
Categories	In Vivo Codes	Code Definition
Building relationships	Teacher involvement	The code teacher involvement refers to any student I work with at their desk. This code refers to when students mention the teacher's involvement in supporting their learning or identity development. The students pointed specifically to the relationship as being an important part of having a female teacher teaching programming.
	Student interests	The code student interests refers to the task of working with a group of students with similar interests. This code refers to when students are collaboratively working on game design that are alike. The students pointed specifically to the relationship as being an important part of having other students like them learn programming.
	Collaborative struggle	The code collaborative struggle is the task of working with a group of students to complete higher level programming. This code refers to when students are experiencing challenges of not immediately knowing/understanding how to code. The students point specifically to the relationship as being an important part to learning programming.
Classroom obstacles	Technology access	The code technology access refers to issues for students who do not bring their laptop, must use phone (if phone has internet), or general internet problems. The code refers to teacher journal notes that prohibit students in their learning and identity development on any given day.
	Truancy	The code truancy refers to issues stemming from students arriving late, students absent for long periods of time for suspensions and/or medical, and students absent for classroom tasks. The code refers to teacher journal notes that prohibit students in their learning and identity development for an extended period of time.

Table 4 (continued)

Curriculum	Choice	The code choice allows students to choose and develop their own game style. This code refers to when students are tasked with creating their own game. The students point to this as an important part in forming their identity.
	Understanding	The code understanding allows students to gain knowledge of what a programmer does.
	Identity	The code identity is used to determine if there is a connection between programming and their gender identity.
	Reflection	The code reflection is used to allow students to write about the daily tasks that were completed and describe their comfort level for each task. The students point to this as an important part in learning programming and forming their identity.
Classroom environment	Collaborative	The code collaborative refers to allowing students to work together despite different skill levels. This code refers to when students work together (i.e., pair programming). The students point to this as an important part in learning programming.
	Confidence	The code confidence is used to express students asking questions during class without being intimidated to seek help. This code refers to when students mention the classroom as being welcoming. The students pointed specifically to the environment as being an important part to learning programming and forming their identity.

Table 5. Themes for Inquiry Question #2

How and to what extent do the adolescent girls in the Apps and Gaming course describe the curricular interventions (e.g., choice and voice, culturally relevant pedagogy, inclusive learning, environment, and collaborative problem solving) as influencing their computer science identities?		
Categories	In Vivo Codes	Code Definition
Building relationships	Teacher involvement	The code teacher involvement refers to any student that I work with at their desk. This code refers to when students mention the teacher's involvement in supporting their learning or identity development. The students pointed specifically to the relationship as being an important part of having a female teacher teaching programming.
	Student interests	The code student interests refers to the task of working with a group of students with similar interests. This code refers to when students are collaboratively working on game design that are alike. The students pointed specifically to the relationship as being an important part of having other students like them learn programming.
	Collaborative struggle	The code collaborative struggle is the task of working with a group of students to complete higher level programming. This code refers to when students are experiencing challenges of not immediately knowing/understanding how to code. The students point specifically to the relationship as being an important part to learning programming.
Curriculum	Choice	The code choice allows students to choose and develop their own game style. This code refers to when students are tasked with creating their own game. The students point to this as an important part in forming their identity.
	Understanding	The code understanding allows students to gain knowledge of what a programmer does.
	Identity	The code identity is used to determine if there is a connection between programming and their gender identity.

Table 5 (continued)

	Reflection	The code reflection is used to allows students to write about the daily tasks that were completed and describe their comfort level for each task. The students point to this as an important part in learning programming and forming their identity.
Classroom Environment	Collaborative	The code collaborative refers to allowing students to work together despite different skill levels. This code refers to when students work together (pair programming). The students point to this as an important part in learning programming.
	Confidence	The code confidence is used to express students asking questions during class without being intimidated to seek help. This code refers to when students mention the classroom as being welcoming. The students pointed specifically to the environment as being an important part to learning programming and forming their identity.

3.1.1 Building relationships

Many studies (Carlone et al., 2014; Christidou, 2011; Meyer & Crawford, 2015) have stated relationships with the classroom teacher are important. These relationships help students envision themselves as a computer scientist.

The most prominent theme analyzed from the reflective open-ended questions were the relationships built throughout that helped support students' learning and/or identity development. These relationships refer to teacher and student relationships and student to student relationships. During data analysis, three sub-themes formed: teacher involvement, student interests, and collaborative struggle.

3.1.2 Teacher involvement

According to the students, having a teacher actively engaged with them and their learning helps them succeed in the class. When completing the reflective open-ended questions, students answered, “While having a female computer science teacher is rare, in what ways do you think having a female teach computer science is beneficial for your learning?” Layla mentioned, “having a teacher that reminds me of my mom makes learning easier for me.” Margaret stated, “you listen to me and explain things differently.”

Another question asked, “What could I, the teacher, do different to help you learn?” Sara noted, “if I look like I’m struggling just ask if I need help.” Elissa stated, “one on one is the best way I learn so please help me when I struggle.”

Engaging with students goes beyond the lesson for the class; it also means learning about the student to build that rapport. During my observations, I noticed the facial expressions of Margaret and immediately knew she was struggling with the given task. I approached her and asked if she needed help. I observed a sense of relief, and we worked together through the task. Once completed Margaret had a huge smile on their face knowing they understood the objective better. Margaret said, “Thank you.” These examples illustrate how a female teacher can supports their female students’ learning and/or identity development.

3.1.3 Student interests

Throughout the intervention students grouped together based on their interests. This was especially important because it allowed students to collaborate to build a game with someone who enjoyed similar interests such as taste in music, sports, or classes. While analyzing the reflective open-ended questions, Kayla said, “working with someone like me made programming fun compared to doing it alone.” A few participants noted it was “interesting” to work with someone they did not know but have similar tastes in music or resembles them (i.e., female). This supports why students expressed learning programming with other students with similar interests helped make learning programming easier and/or identity development.

Not all groups had positive experiences though. During my observations, there were a couple of groups where some participants did the majority of the work while others sat there. A few factors as to why these participants were not actively engaged could be lack of confidence in the material, not knowing their partner(s), or something unrelated to the class. With regards to working with a partner(s) they answered, “What’s one positive from that experience?” Unfortunately, their answers were too vague to analyze and could not be used.

3.1.4 Collaborative struggle

Collaborative struggle is when students work in a group on higher level programming and are unsure how to program the code to function. Collaborative struggle allows students to work together to make learning how to code easier. This struggle gives students the opportunity to try to master higher level programming despite not fully understanding what is supposed to occur or what the lines of code mean. Elissa noted, “We thought we knew what we were doing but our code doesn’t run and we keep getting errors.” Layla noted, “This SUCKS. We did so good with our other games but this one is hard and frustrating but we like it.” This supports why students expressed collaborative struggle helped to learn higher level programming.

3.1.5 Classroom obstacles

After analyzing the teacher journals, classroom obstacles that the teacher and students faced daily were the most prominent. During data analysis, two sub-themes formed: technology access and truancy.

3.1.5.1 Technology access

Throughout the intervention a number of issues occurred that prohibited students from completing their work. At times students attended class without their district-issued laptop and had to work on a "loaner" computer and/or mobile device. Often times, these computers took longer to load student profiles and did not update automatically which caused a longer lag time to load programs. If students worked on their mobile device, they dealt with slower internet connectivity and a smaller screen which made it more challenging to program. Thus, technology itself can cause students to struggle to learn programming or develop their computer science identity.

3.1.6 Truancy

Handling truant students is an area that is almost normal these days due to the COVID-19 pandemic. In many situations, students were absent because of transportation issues and/or medical reasons. When students were absent for a day it was easier for these students to catch up and stay motivated to complete missing work. However, those students absent for longer periods of time had a more difficult time completing missing work and staying motivated. The students on medical leave were absent for a minimum of ten days, never logged into Schoology to complete assignments, and fell drastically behind. Once the students returned from medical leave, they shut down completely. There were also a few students who never returned from their medical leave. As Sara noted on her master tracker after being absent for the first few class days, “I couldn’t catch up.” This supports why students struggle to learn programming or develop their computer science identity.

3.1.7 Curriculum

While analyzing the lesson plans, curriculum was the most prominent theme. The curriculum allowed the teacher to adjust their strategies throughout the classes to allow more student voice for learning purposes and identity development. During data analysis, four sub-themes formed: choice, understanding, identity, and reflection.

3.1.7.1 Choice

The curriculum was set up to allow students to have a choice and a voice in their learning. During the intervention, students created their own game. The only requirements were the standard blocks needed to make their game function properly; any additional lines of code were optional. This allowed students to use their creativity and have input on their design. Some participants added music to their game where they created the tune. Some participants added other characters and projectiles, while others created a unique background. Regardless of the added features, the participants envisioned themselves as computer programmers. In sum, allowing students to choose the dynamics of their game can help develop their computer science identity.

3.1.7.2 Understanding

In addition to analyzing the lesson plans, I also checked for understanding by having students complete different tasks throughout the lesson. Checking for understanding means checking that student learning objectives have been met. Doing so ensured that students understood what a programmer does, how the programmer does it, and how a programmer's job related to everyday activities.

When analyzing the master tracker forms, there was progression from some participants from the first day through the fifth day. Sara stated after day one, "it's really new and different." She then noted after day five, "starting to understand and get the hang of it." Layla, who missed the first day quoted, "just not 100% with this" after their second day. She stated it was "easy" after day five though. On the contrary, Emily noted after day one, she was a total expert, "because I have some experience w/coding." However, there were times when she said the objectives were "more complicated" or "little confusing" but by the end she stated it was "kinda easy."

3.1.7.3 Identity

Each lesson plan was checked during data analysis to determine if the classroom tasks and activities showed a connection between programming and students' gender identity. There were times during the intervention that allowed students to create their main character, background, and/or other features for their game. Some participants drew characters that represented themselves, females. Sara and Elissa drew flowers on a hillside with the sun shining. This supports what classroom tasks and activities help support developing a computer science identity.

While analyzing the Draw a Computer Scientist Tool, pre-drawings of a computer scientist were expected: male, short, pudgy, wearing a lab jacket. However, by the end of the intervention, participants viewed a computer scientist differently. Layla stated, "this new drawing is me and I'm a black female.” Margaret noted at the beginning of the intervention, “I am terrible with computers.” By the end of the intervention, that same participant, noted on their Draw a Computer Scientist Tool, “I drew me.” This supports what classroom tasks and activities are needed to help keep developing a computer science identity.

3.1.7.4 Reflection

Lastly, the lesson plans were analyzed to allow students time to reflect on daily classroom tasks and activities. These reflections also allowed students to indicate their comfort level for the designated tasks and activities. This supports why students may struggle and understand how to learn programming or develop their computer science identity.

3.1.8 Classroom environment

While analyzing the teacher observations, the classroom environment was an important theme. The classroom environment helped students learn to program and/or develop their computer science identity. During data analysis, two sub-themes formed: collaborative and confidence.

3.1.8.1 Collaborative

The classroom was set up to allow students to work with their classmates despite different levels of programming among them. The students paired with another student during intervention, some groups with three depending on the class size. This allowed students to work with their classmates to understand programming better. This supports what students need to help learn to program.

Through the teacher reflection journal, the first part of the intervention was to create your head and eyes using the JavaScript language was successful. Despite this particular class being challenging for participants since it was brand new, the participants were able to seek help from their peers who sat next to them if they could not follow along during instruction. Some participants were able to demonstrate to their peers how to use a particular function to draw their heads and/or eyes.

3.1.8.2 Confidence

The classroom was set up to allow students to express themselves without feeling intimidated to seek help, ask questions or answer questions during the intervention. This allowed students to feel welcomed and safe among their classmates. Students answered, “how does the classroom make you feel?” Sara stated, “everyone’s chill and you are a very nice teacher” while Emily said, “I’m comfortable.” Lastly, Margaret stated, “it makes me not feel bad when I don’t know.” Increasing confidence encourages student progress to learn programming and develop their computer science identity.

4.0 Learning & Actions

4.1 Discussion

Overall, students learned programming that fit their learning style and created games that were unique for them. Allowing students to have this opportunity is meaningful as the unit connects to their creativity and identity. I expected some of the themes captured from my data (e.g., building relationships). One theme was unexpected: classroom environment. Over the years, I always felt I created a safe and welcoming environment for all students; however, having students tell me they feel welcomed and not feel intimidated to seek help was uplifting.

4.1.1 Discussion by Inquiry Question #1

This unit allowed my teaching to evolve throughout the study. Strategies in place before the COVID-19 pandemic and deemed effective are no longer relevant nor effective. Rather than planning, each class needed adjustments. These adjustments were better suited for the students and their learning needs. Some adjustments included more personal attention for struggling students and changing the verbiage from “guys” to “everyone.” Despite these adjustments helping my teaching, the identity-based curricular activities shifted my teaching and love for computer science.

These identity-based activities allowed me to envision myself as a computer scientist again, and that was not present for years. With this vision came more excitement to teach programming to my students. This excitement encouraged my students to be excited as well. For instance, while students were working on their self-portraits, I constructed my head to be larger than intended and asked a participant for their opinion. Layla stated, "why do you only have a half mask?" I told her it was a work in progress. I did this to show students that it is acceptable to try new things and more complex code, so coding a mask is extremely difficult. From that moment, some participants coded a hoodie with a logo on it while others coded a background.

These identity-based activities proved to be a valuable tool for students to gain confidence as computer scientists despite the tutorials providing the basics to construct a video game, which was more stereotypically male-focused. There were opportunities to design a game from a blank workspace which allowed participants to create a video game that suited their female identity.

4.1.2 Discussion by Inquiry Question #2

Today, women still are underrepresented in computer science as a career choice and in higher education (Cakir et al., 2017). Research cites self-perception and identity play an important role for adolescent girls' opinions of careers in computer science. Using the *identity exploration* framework allows learners to take on roles for experiencing possible identities (Cakir et al., 2017). As proposed by Kaplan et al. (2014), this framework is a central mechanism for identity formation associated with intense engagement, positive coping, openness to change, flexible cognition, and meaningful learning. Identity formation is a form of learning that changes in the self while self-efficacy, recognition, and interest are contributors that research suggests promotes identity formation in computer science (Foster & Shah, 2016).

4.1.2.1 Self-efficacy

There are two types of self-efficacy that deal with underrepresented girls in computer science: self-efficacy and academic self-efficacy. Self-efficacy is related to how people feel, think, motivate themselves, and behave. Academic self-efficacy is related to students' confidence in mastering academic subjects (Chemers et al., 2001). Chemers et al. continue by saying,

> Efficacy beliefs influence the particular courses of action a person chooses to pursue, the amount of effort that will be expended, perseverance in the face of challenges, failures, resilience, and the ability to cope with the demands associated with the chosen course. (2001, p. 55)

For students to succeed in computer science and in education they need to possess these beliefs.

In a study conducted by Kwasnik and Karwowski (2015), evidence found that girls have lower computer self-efficacy, higher computer anxiety, and negative attitudes towards computers. However, according to Berkant (2016), when students have a low computer self-efficacy the more time spent on a computer could gradually improve their self-efficacy. Introducing adolescent girls to computers at an early age could boost their self-efficacy with computers and computer science.

This study allowed students and participants to boost their self-efficacy through the classroom activities.

4.1.2.2 Recognition

Recognition refers to the beliefs that others see a person as a good STEM student (Godwin et al., 2016). However, gender stereotypes often overshadow the recognition adolescent girls receive in a classroom or career. Master et al. (2017) found that by first grade girls and boys believe boys are better than girls in computer science, specifically programming.

Research suggests creating spaces for all girls reinforces recognition and supports identity development (Kolker, 2021). However, not every school or out-of-school club can offer an all-girls classroom or club. Recognition can be enforced by adolescent girls' family, friends, and educators, both publicly and privately. In a study conducted by Hughes et al. (2020) also conclude that recognition could mean that someone comes to you for help.

This study allowed the researcher to provide the students and participants in the classroom recognition for their coding to them individually and in front of the class.

4.1.2.3 Interest

By the end of elementary school, student interests in science and technology are established (Maltese & Tai, 2010). This interest can be both *situational*, triggered by an immediate experience and may or may not last over time, or *individual,* which is the persistent inclination to engage with certain activities over time. For adolescent girls to increase their interest in computer science there needs to be a trigger to spark their interest (Master et al., 2017). An example of this trigger is robotics. Introducing girls to robotics at an early age allows them to learn programming which could lead to further interest in programming throughout their schooling.

Besides identity formation, adolescent girls need to have a sense of belonging in computer science from an early age. In order to help facilitate a sense of belonging in computer science literature has pointed to effective strategies and measures to recruit and retain girls in computer science education (Happe et al., 2021).

4.1.3 Collaborative work

One strategy the authors suggested is combatting wrong stereotypes which revises what a computer scientist does and how a computer scientist works. One way to do this is to provide opportunities to do computing activities as a group (Boston & Cimpian, 2018). Pair programming is one way students can work together to complete computing activities. I intend to continue allowing the classes to work collaboratively on certain activities in programming that will help combat stereotypes and allow for higher-level programming challenges.

4.1.4 Curriculum

Another suggested strategy includes motivating and sparking interest in computer science. One way to do this is by incorporating gaming and creative arts activities into the curriculum, which helps increase a sense of belonging. This will allow adolescent girls a steppingstone into computing. I intend to continue the self-portrait activity to help motivate and spark interest in computer science.

4.1.5 Learning environment

A final strategy includes making the learning environment less hostile. As Master et. al (2016) stated “if schools and teachers feel they can’t recruit girls into their computer science classes they should make sure that the classrooms avoid stereotypes and communicate to students that everyone is welcome and belongs.” One way to do this is by creating a non-competitive environment which will allow girls to broaden their skills and experiences gained in the classroom. I intend to continue to create a learning environment where students feel welcomed. In order to help students develop their computer science identities teachers need to understand how to design learning environments that support students from the underrepresented, “who learn and develop along racialized, gendered, and class-influenced learning pathways” (Bell, Van Horne, & Cheng, 2017, pg. 369).

As noted in the results, the intervention related to these strategies deemed beneficial for adolescent girls. Some participants started out stating they were terrible with computers and wanted to drop the class, and by the end, envisioned themselves as a computer scientist. Some participants came in with prior coding experience but gained the confidence needed to engage with classmates who struggled with a certain task.

Identity formation and a sense of belonging are known issues for the lack of adolescent girls represented in STEM and more specifically computer science. Over the years, research has provided different identity frameworks and strategies teachers can implement to promote identity formation and a sense of belonging in computer science through the curriculum. To this day, these frameworks and strategies have remained the same and so has the lack of underrepresented girls in computer science.

4.1.6 Change in identity

By the end of this study there was notable change for some participants, particularly for the freshman and sophomore students. At the beginning of the semester, the freshman student, Margaret, stated she is not very good with computers and has the desire to drop the class. I told her you do not need to be good with computers to succeed in this class. Extremely hesitant at first, she remained in the class and started to get comfortable with technology and programs used. As the semester went on, Margaret's confidence with programming started to increase so did her desire to exceed project requirements. Margaret began adding features to her game that were not part of the assignment, but it fit her identity. For instance, all of her characters in her games were girls of color rather than a generic stick figure. As we moved forward with the Code Your Self-Portrait project Margaret had all the confidence in the world however after the first day of the Code

Your Self-Portrait the look of frustration built on her face. She noted on the master tracker, “this is a lot harder than the MakeCode website.” Margaret started to understand JavaScript programming thus increasing her confidence and forming her computer science identity. After the last Code Your Self-Portrait lesson Margaret noted on her master tracker, she rated herself a near total expert and said, “this is easier than I thought it would be and it’s a lot of fun!” By the end of the semester, Margaret understood and enjoyed two programming languages and gained the confidence working with computers and programming. When she was asked to draw her perception of a computer scientist again, she drew a female which was a representation of herself.

On the other hand, the two senior participants, Sara and Emily, showed no change in their computer science development. Similar to Margaret, Sara struggled with the Code Your Self-Portrait at first mainly because she was absent for the first day. Though after each lesson Sara became more comfortable with programming in JavaScript as she indicated on her master tracker. There was no passion behind her Code Your Self-Portrait project, as she just kept the example as her final submission. Being a senior, it was difficult to gauge any change in her identity which I expected because she has no future plans of studying computer science after graduation.

Identity formation plays an important role for adolescent girls in computer science. To help adolescent girls develop their identity in computer science both teachers and students need to build a working relationship. Teachers will not only development relationships with their students, but students will also build relationships with each other. In addition to these relationships, the curriculum should include other subjects other than computer science, such as art and music, which can help develop adolescent girls’ identity. The computer science curriculum should include identity-based activities which have a gender-neutral approach and allows opportunities for students to program together. Finally, the classroom environment can foster identity formation.

The classroom should be free of stereotypical materials, decorations, and other items found in a classroom. Instead, classrooms need to be welcoming for all students, especially adolescent girls, so they feel a sense of belonging in computer science.

4.2 Limitations

While the study sought to investigate how adolescent girls' computer science identity formation can develop by adding art into the curriculum, there were limitations to the study in both data collection techniques and the actual design of the study. These limitations included the COVID-19 Pandemic, fluctuating enrollment, remote learning, and non-binary students.

4.2.1 Covid-19 Pandemic

The COVID-19 Pandemic changed the dynamic of teaching and learning over the past two years. With the current COVID-19 policy, students considered close contact and unvaccinated were not permitted to attend in-person schooling for ten days. Some participants were out the minimum number of days, while others were out for a month or longer. These participants did not log into Schoology to complete work. It was unknown whether these participants were too ill to complete work or did not have the technology to connect to the internet.

4.2.2 Fluctuating enrollment

Enrollment changes daily for several reasons. Some participants were suspended for ten-plus days and did not log into Schoology to complete work. Other participants were enrolled for some time and then were removed from the class and school. There were some participants on the roster who never attended. Regardless of why their enrollment status changed, the sample size dropped from 19 to five for this study.

4.2.3 Remote learning

After Christmas break, our school went to full remote learning due to the number of positive COVID cases among staff and students. During this time, attendance dropped drastically, completed work decreased, and changing the course structure was necessary. By the time we returned to the building, there were two days left for the semester, and participants had to prepare for their upcoming final rather than complete their self-portrait.

4.2.4 Gender identity

This study was designed to include non-binary, transgender, and genderfluid students; however, all of the participants identified as cisgender females.

4.3 Next Steps & Implications

This work is essential in helping underrepresented girls shape their computer science identity. Future studies can open doors for girls in areas of computer science but also other STEM/technology careers. Future studies on this topic should analyze elementary and middle school students in CS and COVID-19 learning to post COVID-19.

Conducting a similar study in elementary or middle school classrooms could allow students to have more engagement among their classmates. From personal observations and experiences, high school students are more focused on themselves than on interacting with their classmates. On the other hand, elementary and middle school students tend to gravitate towards their classmates and are more engaged with each other. This could allow for better results when students collaborate in pairs or small groups. Further study on how a curriculum unit is received by elementary and middle school students versus high school students would be interesting. Would there be any differences between high school and elementary? Would there be any differences between high school and middle school? Would there be any differences between elementary and middle school? Would middle school students be more interested? Would elementary students be more interested? Studies about high school students (Carlone et al., 2014) often pertain to career interests in STEM while studies about middle school and late elementary students are geared towards maintaining an interest in STEM (Aschbacher et al., 2009) rather than shifts in teaching from the classroom teacher.

The COVID-19 pandemic has shattered the world in which we teach, learn, and live—conducting this study a few years after the pandemic to compare results from students who learned during the COVID-19 pandemic to those after. Conducting this study could compare shifts in teaching during the COVID-19 pandemic and after. This pandemic has affected all levels of K-12 leaving students further behind; however, most recent studies cite the impacts on high education compared to K-12 education. The disparities in student learning were evident prior to the pandemic; however, the COVID-19 pandemic widened access, opportunities, achievement, and outcomes for students of all levels in education (Goldberg, 2021). This study could determine if the pandemic caused a learning gap for students and identity development at K-12. Also, this study could determine the shifts in teaching.

Collaboration with educators throughout Pennsylvania and the nation is necessary to examine whether this theory of improvement is successful in other types of educational settings. In addition, collaboration with organizations that specialize in promoting adolescent girls in computer science, and specializing in promoting adolescent girls in computer science is beneficial for educators to support adolescent girls in computer science and other areas of schooling such as art. With the help of Code Art, the self-portrait activity allows educators and students to inspire girls to code regardless of age and experience.

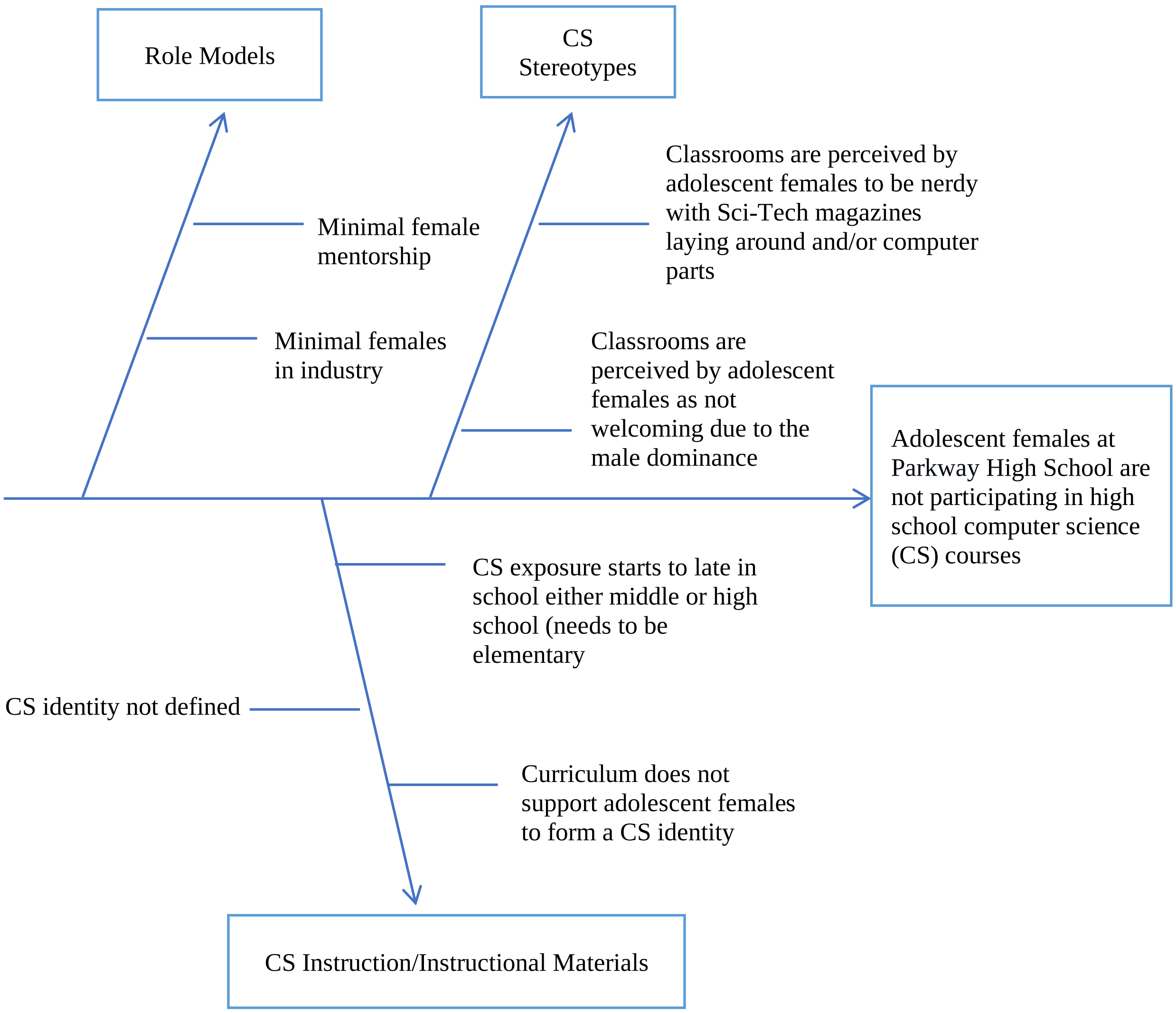
5.0 Reflections

Teachers have the power to make changes within their classrooms to help improve the outcomes of their students. Despite conducting the study within a short period, this study shows that teachers can gather data and learn more about their students to design an ideal curriculum and classroom for students to participate in computer science.

As the teacher and researcher, I reflected on what is done each day in the classroom while the classroom observations painted a better picture of daily occurrences. I made comparisons from each class period; however, seeing improvement takes time, something limited in this study. Even though there was minimal improvement among some participants, it is disappointing not to see better results. I learned that I need to lower my expectations for future studies from these results. As the teacher, I envisioned all the participants with an impactful voice; however, the revolving door of enrollment limited the sample size by half. Despite the lower-than-expected number of participants, their voices showed that these identity-based activities were effective. In the future, I would like to add another dynamic to these identity-based activities, music. I learned that adding art into the computer science curriculum promoted learning and identity development, while recent studies show that incorporating music could provide similar outcomes. One way to incorporate music is to introduce EarSketch into the curriculum. EarSketch allows students to write code in JavaScript, the same language used for their self-portrait. According to a study conducted by Magerko et al. (2016), EarSketch provides students the opportunity to create music in different styles and share it with their peers. This identity-based activity could spark interest and form an identity since it focuses solely on the user and their interests.

It is important to continue to push identity-based activities in computer science classrooms. However, these activities should start at the elementary level so students can spark an interest in computer science at a young age. As the next school year approaches, I will continue to include the self-portrait activities in the lesson plans and classroom activities to promote computer science identity development in adolescent girls.

Appendix A Fishbone Diagram



Appendix Figure 1. Fishbone Diagram

Appendix B Format of Intervention

Lecture

a. 42-minute Large Group Presentation
b. Describe Learning Objectives
c. State Standards
d. Provide Students With
    i. Worksheet
    ii. Video of Technology
    iii. Photo of Woman in Technology
    iv. Video of Woman in Technology Biography
e. Outline of Lesson
    i. Preview Lesson Vocabulary
    ii. Hook
    iii. Women in Technology Spotlight
    iv. Activity
    v. Reflective Exit Ticket

Appendix C Open-Ended Reflective Questions

1) MakeCode/CodeArt Projects
   a) Describe one thing about this week's project that surprised you
   b) What is one thing that you learned this week? Can you provide a specific example?
   c) What was the most challenging thing about this week's project?
   d) What could I, the teacher, do differently to help you learn?
   e) What is one thing you would like me to **start** doing in class?
   f) What is one question you still have about this project?
   g) Do you feel more or less confident with block-based programming? Can you describe why?
   h) Do you feel more or less confident with JavaScript programming? Can you describe why?
2) Pair Programming
   a) Today you worked with a partner. What's one positive from that experience?
   b) Why did you select your partner?
3) Student Choice/Voice
   a) What is one thing you changed on your remake project? Why did you pick that particular item?
   b) Did you enjoy creating a remake of this week's project?
   c) What is one feature you added to your self-portrait? Why did you pick that feature?
4) Inclusive Learning Environment
   a) How does the classroom make you feel welcomed?
   b) Is there anything I can do in the classroom to make you feel welcomed?
   c) Did you feel a sense of belonging in computer science?
5) Female CS Teacher
   a) Does having a female teacher make you more interested in computer science? Why or why not?
   b) While having a female computer science teacher is rare, in what ways do you think having a female teach computer science is beneficial for your learning?

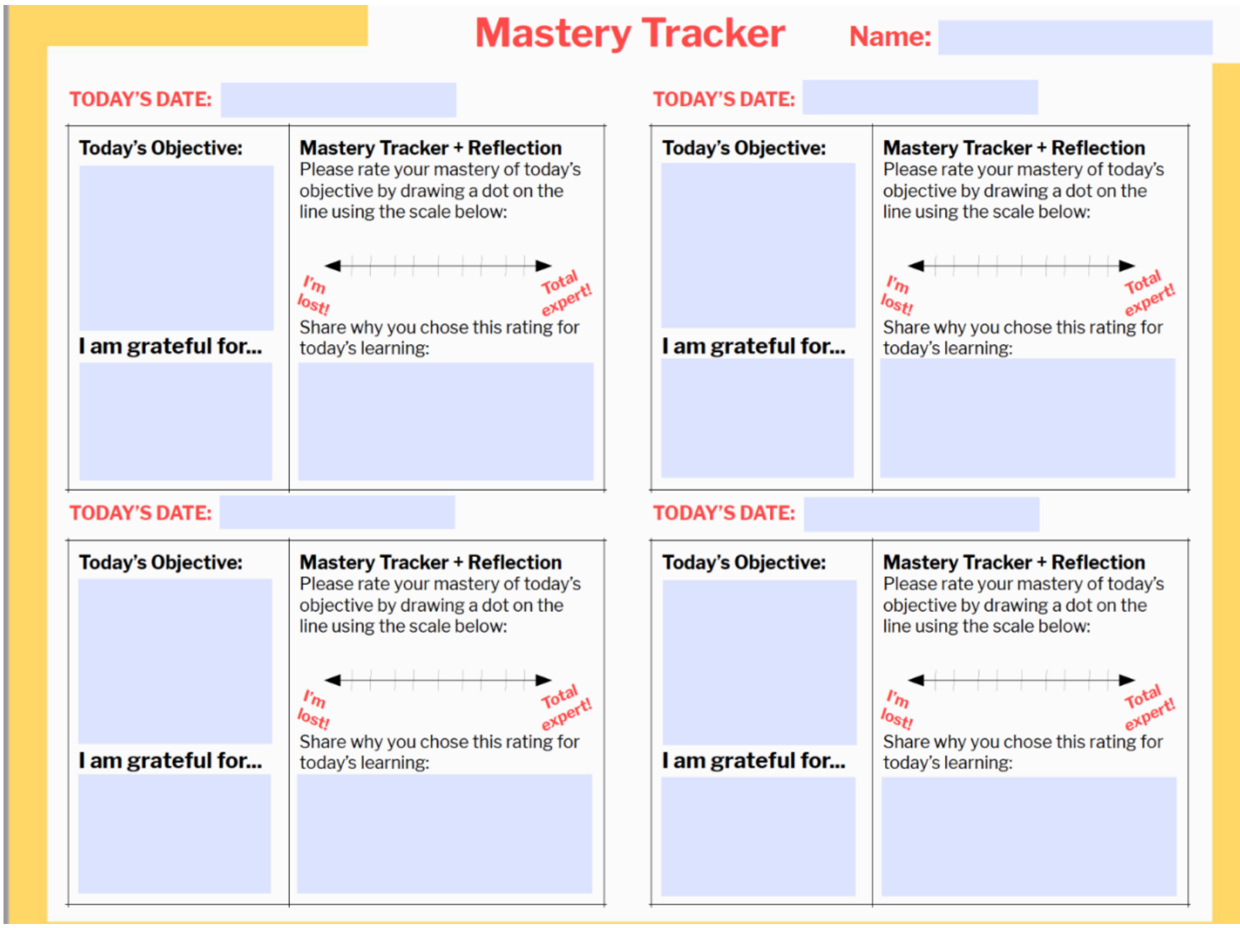
Appendix D Teacher Reflection Journal

By the end of class, students will be able to		
What part of the lessons did students lack engagement? What happened?	What part of the lessons were students engaged? What happened?	Was anything happening during the lesson? (ex: Were you worried or sick? Fire drill? Other disruptions?

Appendix E Classroom Observations

By the end of class students will be able to		
How do students respond when prompted about the function of different coding blocks?	How do students show excitement about their completed game? Do they offer to share their game link to the class?	How do the students seek help? Do they ask a classmate first?

Appendix F Master Tracker for Coding Your Self-Portrait



Appendix Figure 2. Mastery Tracker

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