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The Impact of Collaboration, Problem Solving, and Creativity on Computer Programming Education for Middle School Girls

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Abstract

Despite high scores and abilities, girls lose interest in science and math throughout middle school. According to the Bureau of Labor Statistics, jobs in the computer science research field will grow 19% by 2026; however, only 18% of the bachelor's degrees in computer science are earned by women in the United States (ComputerScience.org, 2021). New technology and inventions are being created without the benefit of more diverse perspectives and input from females. There is a need to engage girls and maintain their interest throughout middle school and beyond. Additional research needs to be conducted about the impact and best practices used during out-of-school time programs to encourage and motivate girls to stay engaged in STEM, including computer programming (Koch, 2014).

This study investigated the relationship between middle school girls' interest in computer programming and the opportunities to collaborate, solve problems, and use their creativity while participating in computer programming activities led by female role models during the 4-H Girls Tech Challenge, an informal education program. Research questions are the following: 1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity and female role models, affect the attitudes of middle school girls towards computer programming? 2) To what extent did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?

Evidenced by other studies, experiences in which collaboration, problem solving, and creativity are present have been shown to increase knowledge about computer programming and engagement in STEM (Cooper & Heaverlo, 2013; Wu-Rorrer, 2019; Hayden et al., 2011). A qualitative study employing interviews with previous participants was utilized to determine how the components of collaboration, problem solving, and creativity of the 4-H Girls Tech Challenge affected the attitudes of middle school girls towards computer programming and careers in computer science. Educators will benefit from learning more about best practices that engage, motivate, and retain more girls in STEM. An increase in the number of women in the STEM workforce will maximize innovation, creativity, and competitiveness (Hill et al., 2010).

Keywords: computer programming, girls in computer programming, 4-H, STEM, collaboration, problem solving, creativity, female role models, community, informal education

Dedications

I dedicate this work to my grandparents, Joe and Rosetta Enochs, who have always believed in me and supported me. My grandpa's love for learning inspired me to persevere. Thank you to my husband, Glen, for your love and support during this journey. Thank you to all my family and friends who provided support and encouragement.

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Chapter 1

Introduction

Whereas women have made progress by increasing from eight percent of the Science, Technology, Engineering, and Mathematics (STEM) workforce in 1970 to 27% in 2019, men are still dominating the field with 73% of the STEM workforce but only 52% of the entire U.S. workforce **(**Martinez & Christnacht, 2021). The underrepresentation of women in STEM fields continues to be a concern that needs to be addressed. New technology and inventions are being created and used without the benefit of more diverse perspectives and input from females.

The gender gap in the STEM workforce stems from the same underrepresentation of women receiving undergraduate degrees in STEM majors. There are fewer women than men obtaining STEM degrees and entering the STEM workforce (Reinking & Martin, 2018). It can be intimidating for women to be outnumbered in STEM courses throughout their degree path. Under-graduate degrees begin with introductory STEM courses that tend to “weed out” students before they reach more advanced courses. In these introductory courses, students tend to earn lower grades than in other disciplines (Rask, 2010).

Women tend to be less confident about their STEM abilities compared to men who have the same grades (Cwik & Singh, 2021). As an example, Rask and Tiefenthaler (2008) found that women were more sensitive about receiving lower

grades in introductory economics courses and were more likely to leave the major than men. While this study was conducted with economics students, it relates to women in STEM who may already feel less confident about their abilities in a male-dominated major. As women receive lower grades in the introductory STEM courses, they tend to leave the major which feeds into the gender gap between women and men in STEM majors (Weston et al., 2019). Women typically see lower grades as an indication of abilities and do not credit it to the challenging nature of the course. Even when women are performing at a high level, they are still more likely than men to leave STEM majors after introductory courses (Seymour, 2019).

While some gains have been made in the STEM workforce, women have not made the same gains in computer science and engineering occupations. Although the number of women in computer occupations is higher now than in 1970, the number of women in computer occupations decreased between 1990 and 2019 **(**Martinez & Christnacht, 2021). A report from the American Association of University Women (2000) shared that only 17% of high school students taking the advanced placement exam in computer science were female while 28% of the undergraduate degrees were earned by females that year. In 2013, women accounted for 26 percent of the computing field, which was substantially smaller than 30 years ago and the same percentage in 1960 (Corbett & Hill, 2015).

STEM professions account for nearly seven percent of all occupations in the workforce, and those professionals play a key role in advancing America's innovative capacity and global competitiveness **(**Martinez & Christnacht, 2021).

While the two fields make up 80% of the STEM workforce, women are filling only about 25% of computer occupations and 15% of engineering positions **(**Martinez & Christnacht, 2021). According to the Bureau of Labor Statistics, computer science research jobs will grow 19% by 2026; however, only 18% of computer science bachelor's degrees are earned by women in the United States (ComputerScience.org, 2021).

The fact that there are too few female professionals in the STEM workforce is influenced by girls' selection of their college major or career path in high school. Before they reach the point of making that decision, they are having experiences in middle school, defined as grades 6-8, that determine if the STEM career field will be an optional career path for them or not. The majority of middle school girls are not sustaining an interest in STEM, which is contributing to the global issue of the underrepresentation of women in the STEM workforce (Hill et al., 2010).

Statement of the Problem

As girls rise through the grade levels, their motivation to pursue STEM interests begins to wane. The literature strongly supports this trend. Girls who had enjoyed participating in STEM and STEM-related activities during the elementary grades begin to lose interest by the time they reach middle school (Ofori-Boadu, 2018; Dasgupta & Stout, 2014). According to Ofori-Boadu (2018), this situation is often attributed to the false stereotypes perpetuating STEM as a male-dominated field. "Popular media have played a crucial role in the

construction, representation, reproduction, and transmission of stereotypes of STEM professionals" (Steinke, 2017, p. 716).

Many females have steered away from STEM careers because of the cultural stereotypes of STEM careers, including the type of people, values of the field, and the work involved. According to research by Reinking & Martin (2018), informational technology, computer science, and other STEM professionals seemed more male-oriented and socially isolated. When asked to draw or describe STEM professionals, adolescents typically describe them as white, middle-aged men wearing lab coats and glasses who are socially awkward and work alone (Christidou et al., 2016). That is not an accurate image of today's STEM professionals who are overcoming challenges and working collaboratively to face worldwide issues (Popov et al., 2016).

Females may be more interested in careers related to STEM if the perceptions about the culture of STEM professions are changed to reflect their characteristics and values, such as socialization and work-life balance. Gender stereotypes typically encourage girls to be socially helpful, focused on family and having children, and participate in activities that focus on interpersonal relationships (Konrad et al., 2000). Meanwhile, gender stereotypes form a foundation for boys to develop mastery and skills, figure out how things work, and participate in activities that focus on problem solving, status and financial gain (Dasgupta & Stout, 2014).

The differences in the gender stereotypes influence future career choices. From a young age, girls may believe that boys are more suited for science and

technology (Beede et al., 2011). Additionally, popular cultural representation of math and science portrays the career fields as not people-oriented and not related to real-world concerns (Buck et al., 2002). These misconceptions and gender stereotypes are playing a role in the underrepresentation of women in STEM professions.

The school climate plays an important role in how STEM is portrayed to girls. If there are not many females portrayed as STEM professionals in the textbooks, videos, visual aids and materials used in the classroom, some girls may be discouraged or feel that they do not belong in the STEM profession. Girls may assume that jobs such as scientists, engineers, and chemists are designed for males (Milgram, 2011a). In many cases, educators may principally encourage boys to play with blocks, work on projects that involve the engineering process, or disassemble objects to see how they function (Bush et al., 2020). While boys tend to gravitate towards those activities, girls need to be equally encouraged to develop those skills that can build a foundation that promotes an interest in STEM projects and majors.

The adults present in the lives of youth have a huge influence over them as they are growing and developing (Meadows, 2016). Along the way, youth are making important decisions that determine their career paths. Role models and mentors play a significant role in developing girls' interest in STEM (Kekelis et al., 2005). When there are fewer females in STEM fields, it contributes to a smaller number of female role models who can demonstrate their success in STEM fields to girls. This issue could directly be attributed to a lower number of STEM-trained

teachers who are able to be the role models needed to engage girls in STEM (Watt et al., 2013).

Informal education and mentoring programs can help girls to see themselves in STEM fields. Mentors can teach girls that they can work hard to overcome barriers and take on new challenges as they expand upon their academic abilities (Meadows, 2016). These settings also offer another opportunity to connect girls with female mentors who are successful in science, technology, engineering and math fields. Mentors can have a positive impact on the lives of young people (Halpern et al., 2007). Informal education programs need to offer girls an opportunity to participate in tasks that are relevant to their lives and have social impact (National Center for Women and Information Technology, 2007; Eccles, 1994).

Curiosity has been shown to help to combat the issue of gender stereotypes towards math and science (Ogle et al., 2017). Educators can provide engaging activities that spark the curiosity of girls and then continue to build on their interest in STEM topics. Once youth are interested in a topic or content area, engaging them with interesting materials and activities can help to transfer that initial curiosity into long-term interest (Halpern et al., 2007). As youth continue to learn more about that topic and participate in related activities, they develop skills and expand their knowledge to build a foundation that can lead to future careers.

Middle school female students are losing interest in math and science due to social and environmental factors, the influence of bias, and the school climate

(Meadows, 2016). Additionally, some girls may become bored or disinterested in STEM if they are not able to collaborate with peers or engage in innovative activities and experiences. Class lectures and homework problems are not keeping them interested in STEM, which results in a detachment from STEM for many middle school girls (Reinking & Martin, 2018). When discussing careers, it is also imperative that educators and parents keep in mind that any career should be a possibility for both males and females. Youth should be encouraged to pursue the field that aligns with their passion and skills while not being restricted to consider only certain careers based on their gender (Reinking & Martin, 2018).

With the perception that they may not enjoy STEM careers that are socially isolating, many female students draw upon their tendency to want to help people and look for professions, such as nursing or healthcare, that fulfill that passion (Wiest, 2017). Since middle school girls may not view many STEM disciplines as helping professions, they may be less inclined to maintain an interest in STEM. Females are represented almost equally in biology because it is typically perceived as a helping profession (Miller et al., 2006).

Because factors such as female role models, skill development, and portrayal of STEM careers influence whether middle school and high school students sustain an interest, educators in a variety of settings must be cognizant of how they are teaching and educating students related to STEM topics and careers. As with many other aspects of education, teachers are not the only ones who are responsible for educating our students about STEM topics and careers.

Informal educators have a tremendous opportunity and responsibility to our youth to provide them with high-quality, enriching educational experiences to learn about STEM and careers in these disciplines. Enrichment programs and camps offered during out-of-school time can offer girls a chance to explore and experiment with STEM concepts outside the boundaries of the classroom (Mosatche et al., 2013).

Opportunities to collaborate with peers to explore creative solutions to complex STEM-related problems will be more appealing to girls for the social interaction, which may, in turn, increase their interest and hopefully ignite a passion for pursuing STEM careers. An increase in the number of women in the STEM workforce will maximize innovation, creativity, and competitiveness (Hill et al., 2010). The development of programs in which youth can understand the benefits of the STEM disciplines and nurture an identity associated with STEM could potentially attract more female students to pursue careers in the field (Ng & Fergusson, 2020).

Computer Science vs. Computer Programming

While the terms “computer science” and “computer programming” are used quite a bit interchangeably, there is a significant difference between them. Computer science is defined as the study of processes that interact with data and represented as programs (Brooks, 2020). Algorithms are used to manipulate, store and communicate digital information. Computer science is a broader term that includes technology, such as artificial intelligence and computer-human interactions, database systems, and software engineering (Brooks, 2020).

On the other hand, computer programming is the process of designing and building programs for a computer to complete a task (Gordon, 2019). Computer programming is commonly referred to as coding. Sreejith Omanakuttan, open source team leader at the software developing company Fingent, described the focus of computer programming as designing, creating, writing, and testing code for software applications and operating systems (Brooks, 2020).

Background

As an organization that provides positive youth development and leadership opportunities for nearly 6 million youth ages 5-18 globally through informal education, 4-H strives to help youth to develop life skills to create positive change in their lives and communities (National 4-H Council, 2023). Caring adults work with youth to provide positive learning experiences as they empower youth to become confident, determined, responsible, and compassionate young people (National 4-H Council, 2023). 4-H provides unique opportunities for youth to meet others from around the world through trips and conferences focused on leadership, citizenship, agri-science, healthy living, and more (National 4-H Council, 2023).

4-H has three national mission mandates: Citizenship, Healthy Living, and Science (National 4-H Council, 2023). In August 2017, 4-H launched a new partnership with Google in an effort to reach 1 million young people with computer science through new Computer Science clubs, camps, in-school, and after school programs (National 4-H Council, 2023). As the largest youth

organization, 4-H saw an opportunity to help fill the need for young people to know how to create technology rather than only consuming it. 4-H computer science programs teach youth programming languages, such as Scratch, Python, and Java, while developing essential life skills like problem solving, critical thinking, and teamwork. These skills will not only prepare youth for future careers, whether it be in computer science and STEM or other fields, but also equip them to become tomorrow's leaders, innovators, and problem solvers (National 4-H Council, 2023).

The demand for computer science skills is growing across most of today's workforce with the widespread impact of technology (Montoya, 2017). Many youth are not prepared for the opportunity, or in many cases, they do not have access to the tools and resources needed to learn computer science skills (National 4-H Council, 2023). As stated by Computerscience.org (2021), the demand for computer science careers will grow 19% by 2026. Therefore, 4-H is striving to provide new opportunities for youth both locally and nationally to develop the skills needed by collaborating with non-profits, businesses, community leaders, and schools to prepare our future leaders (National 4-H Council, 2023).

As one of the recipients of the Google CS Accelerator grants, Missouri 4-H expanded its computer science program to reach new audiences. Computer science activities were included in 4-H summer camps, schools, 4-H afterschool programs, and state events, such as Show Me Robots Day at the State Fair. 4-H members learned computer programming skills through their robotics and coding

projects, which they showed at the county and state fairs. Additionally, the Missouri 4-H STEM Extravaganza, a statewide event at the University of Missouri campus, provided members an opportunity to demonstrate and compete in challenges to showcase their skills through computer science, robotics and STEM contests.

Because of several grant opportunities and its proximity to several STEM-related corporations, the county 4-H program has been focused on STEM programming since 2010. The 4-H Robotics program introduced youth to building and programming LEGO robots in a variety of settings: school, after school, summer camp, clubs, and workshops.

4-H Girls Tech Challenge

As a way to spark interest for girls in computer programming and connect girls from both urban and rural settings, two county 4-H programs in the Midwest partnered to implement the 4-H Girls Tech Challenge in 2017. The National Center for Women in Technology (NCWIT) provided opportunities for funding and a connection to female high school and college students who served as program leaders for the computer science programs for girls. Through their AspireIT program, NCWIT encourages female high school and college students who possess strong leadership skills, excellent technology, and computing skills to apply for these awards and for designation as an AspireIT program leader (National Center for Women & Technology, 2023). Award winners were matched

with community organizations and youth group leaders who want to host programs for younger girls to learn computer programming and technology skills.

The program leaders collaborated with 4-H faculty and volunteers to write the grant to receive the funding. As program partners, the 4-H faculty and volunteers helped with logistics for the program, including recruiting the participants, training the program leaders about teaching youth, and supporting them as they planned and implemented the program. The program leaders taught a variety of computer programming activities. Female 4-H teen leaders served as program assistants who helped the program leaders and supported the girls while they solved any issues they encountered during the computer programming activities and the community issue projects.

The study population consisted of 25-30 participants during each program year. The urban and rural female youth benefited from gaining new perspectives from their peers with different backgrounds. This program is unique from other programs with its affiliation with 4-H, a positive youth development organization that promotes life skills development, youth-adult partnerships, and three mission mandates that include science (National 4-H Council, 2023). Additionally, 4-H strives to equip youth with college and career readiness skills to prepare them for the future to become caring, contributing, and competent citizens.

Throughout the 4-H Girls Tech Challenge, the girls learned computing and problem solving skills through various activities, including coding apps through AppInventor; writing code for websites; working with micro:bits, tiny computers; and building robots, taught by the AspireIT program leaders. The girls worked in

pairs, often matched with someone from a different county, to think creatively about potential solutions or ways to bring awareness to a community issue of their choice. The girls selected issues including animal homelessness, access to clean water, reducing waste, social injustice, and pollution. The girls presented their solutions and ideas through websites, apps, or posters and presented them to their peers. The program activities featured stories about women in STEM who have made an impact. The girls researched additional female professionals to highlight and created posters about their accomplishments.

Throughout the program, the girls learned about STEM careers, including computer science and robotics, from female professionals who were currently working in the field. The guest speakers shared information about their career paths, the disciplinary expertise necessary to pursue a STEM career, and career advice related to identifying their passions and being successful during their journeys. In 2017, Intelligrated Systems, a robotics company, hosted a field trip where they showed the girls the robots that companies like Amazon and Wal-Mart are using to fulfill their orders.

Through three different problem-solving instructional methods, including anchored instruction, problem-based learning, and project-based science, youth learn problem solving skills that also foster critical thinking skills and creativity, all of which are identified as critical 21st-century skills (Cooper & Heaverlo, 2013). Many activities through informal education, such as math clubs, 4-H, state science fair, provide girls with experiential learning experiences that incorporate problem solving and creativity and design skills while providing opportunities for

academic areas that are not part of school. The activities played an important role in sparking youth's interest in STEM areas and careers (Cooper & Heaverlo, 2013).

Purpose

This study investigated the impact of opportunities to collaborate and solve complex problems while working with female role models through informal educational settings on middle school girls' attitudes towards computer programming and potential careers in computer science and technology. A qualitative approach employing interviews with previous participants was utilized.

Research Questions

The following research questions guided this qualitative research to explore the change in attitudes of the previous participants:

1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity and female role models, affect the attitudes of middle school girls towards computer programming?

2) In what ways did the 4-H Girls Tech Challenge experience affect the attitudes of middle school girls towards potentially pursuing careers related to computer science and technology?

Informal education delivered through out-of-school time programs can be an ideal opportunity for youth to explore STEM (Eshach, 2007). The youth are

able to devote more time to projects, and they can be connected with unique opportunities as a result of establishing relationships with caring adults (National 4-H Council, 2023). Youth tend to be more willing to try new things without the fear and stress of receiving a failing grade (Mosatche et al., 2013).

Significance

Girls who enjoyed participating in STEM and STEM-related activities during their elementary school years begin to lose interest by the time they reach middle school (Ofori-Boadu, 2018). To combat this problem, more research needs to be conducted about the impact and best practices used during out-of-school time programs to encourage and motivate girls to stay involved in STEM, including computer programming (Hill et al., 2010). As educators incorporate those strategies to help girls maintain interest, there is hope that more females may pursue STEM majors and careers in the future and in turn, increase female representation in the STEM workforce (Martinez & Christnacht, 2021).

There has been some research conducted about informal education and programs that increased student interest in STEM (Greenfield, 2009; Mosatche et al., 2013; Wang & Frye, 2019). Unlike their programs, the research about the 4-H Girls Tech Challenge involved a program designed specifically for middle school girls and taught by female high school and college students. The program focused on computer programming activities. Middle school girls were offered unique experiences such as career panels and field trips with female professionals to learn more about computer science and technology careers. The program included a community issue aspect, in which pairs of female youth

identify and explore creative solutions to possibly solve or bring awareness to the issues.

Significantly, this research was conducted to determine how the 4-H Girls Tech Challenge affected the girls' attitudes towards computer programming and possibly pursuing computer science and technology careers in the future. There is a need to know about what research has been done to show that girls are more engaged in STEM when it includes opportunities to collaborate, solve problems, and be creative. It is helpful to learn the details about other programs that have increased girls' interest in STEM to identify the best practices to engage girls in STEM.

Theoretical Framework

American educational psychologist John Keller developed the ARCS (Attention, Relevance, Confidence and Satisfaction) model of instructional design in his work on motivation in educational settings (Simsek, 2014). Keller's ARCS Model of Motivation (1979) describes the strategies for stimulating and sustaining motivation that include attention, relevance, confidence, and satisfaction. Known for this theory, John Keller suggested that attention is obtained by either perceptual arousal gained by surprise, doubt, or disbelief or by inquiry arousal through challenging problems that need to be solved (Pappas, 2015). "In order to grab and hold learners' attention, a variety of methods could be employed, including active participation, use of humor, conflict, variety, and real-world examples" (Pappas, 2015, para. 3).

Learners will be more engaged if they find the new skills or knowledge meaningful and relevant to their interests or needs (Keller, 1987c). Keller recommends drawing upon previous experience, showing the worth of the new knowledge or skills, modeling success, and giving learners a choice of their own instructional strategy (Pappas, 2015). The component of confidence includes striving to boost and increase learners' confidence in their own abilities to perform the skills or obtain new knowledge. Confidence can be built by facilitating self-growth, communicating the goals and objectives to the learners, providing constructive feedback, and giving learners some control over their learning process (Pappas, 2015). Finally, the ARCS model presents a strong relationship between satisfaction and the level of motivation. Learners will be more motivated to learn if they are satisfied with the outcome (Kurt, 2021). Keller suggests using praise or rewards to motivate learners and encouraging them to utilize their knowledge or skills to solve real-world problems (Pappas, 2015).

Keller's framework is connected to the goal of encouraging sustained interest among middle school girls related to STEM for a longer period of time so that they consider the possibility of pursuing a STEM major. Educators have an opportunity to maintain girls' interest in STEM, which is a strong contributor to helping girls to potentially pursue STEM majors and careers in the future. As they prepare lesson plans and materials to teach girls, educators should consider to what degree they are implementing the components of attention, relevance, confidence and satisfaction to motivate their learners. The components of

Keller's ARCS Model of Motivation are combined with the program components of the 4-H Girls Tech Challenge in Table 1.1.

Table 1.1

Keller's ARCS Model of Motivation Applied to the 4-H Girls Tech Challenge

Attention
Engaging computer programming activities
Encouraging creativity
Field trips
Relevance
Current community issues
Current programming languages and technology
Learning about women in STEM
Confidence
Developing computer programming skills
Career panels with female STEM professionals
Program leaders servings as female role models to the girls
Satisfaction
Connecting computer programming skills to careers
Sense of belonging among their peers
Increased interest in computer programming

Definition of Terms

4-H: positive youth development program for youth ages 5-18 that teaches life skills in partnership with caring adults (National 4-H Council, 2023)

4-H community clubs: organizational level of 4-H programs where members work on a variety of projects with caring adults or older teens (National 4-H Council, 2023)

4-H SPIN (special interest) club: a specifically designed educational opportunity where all members work on the same project in partnership with caring adults or older teens (National 4-H Council, 2023)

AspireIT: a program designed to teach programming fundamentals and computational thinking to girls in grades K-12 in fun, creative, and hands-on environments (National Center for Women & Technology, 2023)

Computer science: the study of processes that interact with data and are represented as programs (Brooks, 2020)

Computer programming: the process of designing and building programs for a computer to complete a task (Gordon, 2019)

Experiential learning: a process of learning through direct engagement

NCWIT: National Center for Women and Information Technology, a non-profit organization of change leaders striving to advance innovation by correcting underrepresentation in computing (National Center for Women & Technology, 2023)

Program assistant: 4-H teen member who assisted the program leader in teaching the program, specializing in helping youth problem solve while working through activities

Program leader: Female high school or college student who taught the 4-H Girls Tech Challenge through the facilitation of activities, also applied for the grant with the program partner

Program partner: Organization leader who recruited youth, handled logistics, trained and supported program leaders as they taught the program

Semi-structured interviews: the interviewer prepares a list of questions, but the interview is conducted in a conversational manner so participants can explore the issues they feel are important (Longhurst, 2003).

Procedures

A qualitative research design was utilized to determine how the 4-H Girls Tech Challenge affected the girls' attitudes toward computer programming and potentially pursuing computer science careers in the future. The data was collected from the responses of semi-structured interviews to explore the impact of the 4-H Girls Tech Challenge on their attitudes toward computer programming and future careers. The data was used in answering the research questions by obtaining a more in-depth look at their experiences in the program. Participants were informed that their identity and personal information would remain confidential, so it was assumed that the girls answered the interview questions honestly.

Limitations

The girls who participated in the 4-H Girls Tech Challenge program were a sample representation of the female members of the statewide 4-H program. The

program was set up as a 4-H SPIN (Special Interest) club that met for at least 28 hours rather than a community club, which meets throughout the year. The program leaders for the 4-H Girls Tech Challenge changed each year as the teens left for college or had other plans for the following summer. However, the program partners remained the same throughout the years. As one of the facilitators of the program serving as the interviewer, it has been acknowledged that there could be some bias in their responses. The girls shared their thoughts and lived experiences. As explained by Cresswell (2018), individuals possess personal filters and could have an incorrect recollection of the experience or be influenced by personal bias.

Delimitations

The research was limited to one 4-H program that served female adolescents ages 9-16 in an informal setting. All of the female youth volunteered to participate in the 4-H Girls Tech Challenge program to learn more about computer programming. The program leaders were recognized through the AspireIT program for their strong leadership skills and experience with technology. Program assistants were 4-H members who had previous experience as participants of the 4-H Girls Tech Challenge program.

Organization

This dissertation and its findings are organized into five chapters. An introduction and an overview of the study is found in Chapter 1. Chapter 2 includes the literature review of the topics associated with the research, including girls in STEM, computer programming, collaborative learning, problem solving,

creativity, and Keller's ARCS Model of Motivation. The methodology, including the research methods, participants, and the program setting, is detailed in Chapter 3. A detailed summary of the qualitative data from the interviews can be found in Chapter 4. In conclusion, Chapter 5 contains the interpretation of the data and a discussion about further research opportunities.

Chapter 2

Literature Review

According to research, girls begin to lose interest in STEM (science, technology, engineering and math) around the age of 12 (American Association of University Women, 2000). To counteract that trend, additional research may help to learn more about the most effective strategies to keep girls engaged in STEM. If educators continue to utilize best practices and girls sustain interest in STEM fields, it may increase the number of women working in the STEM workforce (Martinez & Christnacht, 2021).

Literature Search

A comprehensive search using Google Scholar, the University of Missouri Library, and JSTOR was conducted for a literature review. Keywords for the search included but were not limited to the following: *girls in STEM*, *women in STEM, women in computer science, computer programming for middle school girls, problem solving, collaboration, creativity, role models*, and *informal education*. The literature was reviewed and sorted into seven main themes: Underrepresentation of Girls and Women in STEM, Collaborative Learning, Problem-Solving, Encouraging Creativity, Pair Programming, Role Models, and Informal Education.

Theoretical Framework

Keller's ARCS Model of Motivation

Developed in 1979 by American educational psychologist John Keller, Keller's ARCS (Attention, Relevance, Confidence, and Satisfaction) Model of

Motivation described the strategies for stimulating and sustaining motivation from students that include attention, relevance, confidence, and satisfaction (Kurt, 2021). This framework describes the components that should be present to encourage and sustain learners' motivation in the learning process. At the time of its development, there were no macro theories or models that described how to create instruction that motivated audiences to learn (Keller, 1987a). Keller explained the ARCS Model as "a system for improving the motivational appeal of instructional materials, of instructor behavior, and of the way in which lessons (or modules) and courses are designed. It provides strategies that a course designer or teacher can use to make instruction responsive to the interest and needs of the learners" (Keller, 1987b, p. 1).

Keller derived the ARCS model from Vroom's expectancy-value theory that defines the relationship between a student's expectation for success at an achievement or task in relation to the value of goal attainment or task completion (Vroom, 1964). For example, youth are more likely to complete a task if they expect to be successful and find value in the task. Vroom's expectancy-value theory differentiates task value into four components, including *attainment value* (importance of doing well), *intrinsic value* (personal enjoyment), *utility value* (perceived usefulness for future goals), and *cost* (competition with other goals) (Leaper, 2011).

John Keller suggested that attention consists of perceptual arousal, inquiry arousal, and variability (Keller, 1987a). "In the case of perceptual arousal, the learners' attention would be gained by surprise, doubt, or disbelief. For inquiry

arousal, the learners' curiosity would be stimulated by challenging problems that needed to be solved" (Pappas, 2015, para. 2). Educators utilize several methods, including active participation, using humor, creating conflict with statements that are contrary to what the learners believe, using a variety of media, and using real-world examples, to gain the attention of youth (Pappas, 2015). Learners are more likely to be engaged if they find the new skills or knowledge meaningful and relevant to their interests or needs. Keller recommends achieving relevance by drawing upon previous experience, showing the worth of the new knowledge or skills, modeling success, and giving learners a choice of their own instructional strategy (Pappas, 2015).

The component of confidence includes striving to boost and increase learners' confidence in their own abilities to perform the skills or obtain new knowledge. Confidence can be built by facilitating self-growth, communicating clear goals and objectives to the learners, providing constructive feedback, and giving learners some control over their learning process (Pappas, 2015). Additionally, learners will be more motivated to learn if they are satisfied with the outcome (Kurt, 2021). Finally, the ARCS model presents a strong relationship between satisfaction and the level of motivation. Keller suggests using praise or rewards to motivate learners and encouraging them to utilize their knowledge or skills to solve real-world problems (Pappas, 2015). Guiding questions to help address the essential elements of the corresponding components of the ARCS Model of Motivation are shown in Table 2.1.

Table 2.1

Guiding Questions to Address the ARCS Model of Motivation

ARCS Category and Essential Elements	Guiding Questions to Help Address Essential Element
Attention	
Perceptual arousal	What can I do to capture their interest?
Inquiry arousal	How can I stimulate an attitude of inquiry?
Variability	How can I maintain their attention?
Relevance	
Goal orientation	How can I best meet my learner's needs? (Do I know their needs?)
Motive matching	How and when can I provide my learners with appropriate choices, responsibilities, and influences?
Familiarity	How can I tie the instruction to the learner's experiences?
Confidence	
Learning requirements	How can I assist in building a positive expectation for success?
Success opportunities	How will the learning experience support or enhance the student's belief in their competence?
Personal control	How will the learners clearly know their success is based on their efforts and abilities?
Satisfaction	
Natural consequences	How can I provide meaningful opportunities for learners to use their newly acquired knowledge/skill?
Positive consequences	What will provide reinforcement to the learner's successes?
Equity	How can I assist the student in anchoring a positive feeling about their accomplishments?

Note: The three essential elements of each motivational category of the ARCS Model (Keller, J. M., 1987c, p. 2).

When interviewed by Simsek (2014) about studying the aspects of the ARCS model, John Keller shared that the original formation of the ARCS model was studied extensively to confirm its theoretical and practical validity. Whereas Keller's ARCS Model of Motivation has been applied to a variety of settings and learners of all age groups (Pappas, 2015), there are still many opportunities to study the model in relation to different delivery systems, cultural settings, and learner populations.

Keller's framework is connected to the goal of sustained interest among middle school girls related to STEM (Liao & Wang, 2008). When the activities or content can catch students' attention and connect to their previous knowledge or experience, they feel secure and confident in mastering the subject, which leads to satisfaction with the instruction and learning experience. When these components are met, it creates an optimal learning environment for students to feel comfortable and motivated to learn (Liao & Wang, 2008). With the 4-H Girls Tech Challenge, the activities offered needed to meet the components of Keller's ARCS Model of Motivation. The program did not assign grades or extrinsic rewards; therefore, it relied on the intrinsic motivation of the participants to sustain their interest in the computer programming activities.

Instructional designers are advised to consider students' prior experience and relevant interests to develop their confidence, hold their attention, and achieve satisfaction from the instruction (Pappas, 2015). Students come from diverse educational, socioeconomic, and ethical backgrounds, which presents a challenge for designers to overcome. A continuous ARCS cycle should be

implemented to provide feedback from students about the instruction to the instructors and designers (Liao & Wang, 2008).

The four elements of Attention, Relevance, Confidence and Satisfaction are key components in sustaining the motivation of the learners. Learners need to be engaged in content that is relevant to them to keep their attention. They need to realize the value in the content and feel confident that it will benefit them and feel satisfied in what they have learned or gained from the experience. Effective educators use a variety of methods to gain their audience's attention and meet the components of the ARCS Model of Motivation while working through a continuous cycle to sustain the motivation. The components are instrumental in the challenge to engage middle school girls in computer programming activities to sustain their interest in the computer science field. While the model was developed in 1979, Keller shared that there are still opportunities to conduct research in different settings (Pappas, 2015).

Underrepresentation of Girls and Women in STEM

"Attracting and retaining more women in the STEM workforce will maximize innovation, creativity, and competitiveness. Scientists and engineers are working to solve some of the most vexing challenges of our time" (Hill et al., 2010, p. 3). Some of those challenges include finding cures for cancer, developing renewable energy sources, and feeding a growing world population. New technology that will be used daily is being developed. Without more female STEM professionals, the innovation is happening without the input of women to meet their needs and desires (Hill et al., 2010). Therefore, it is important to

determine the best practices that should be used to keep girls interested in STEM throughout middle school and beyond (Meadows, 2016).

A study by Reinking & Martin (2018) focused on the cultural stereotypes about STEM careers, including the type of people, work involved, and values of the field. Information technology, computer science, and other STEM professionals seem more male-oriented and socially isolated (Reinking & Martin, 2018). Females may be more interested in careers related to STEM if the stereotypes about the culture of STEM professions are changed to reflect their characteristics and values, such as socialization. Reinking & Martin (2018) found that the gender gap may close more quickly if women develop a mindset of confidence and combat the stereotypes associated with their gender. More research also indicated an increase in girls' perceptions of STEM professions when images and portrayals of women in STEM fields were present. "Popular media have played a crucial role in the construction, representation, reproduction, and transmission of stereotypes of STEM professionals" (Steinke, 2017, p. 716).

Research (De La Paz, 2012; Milgram, 2011a; Mosatche et al., 2013) has led to some of the following recommendations for educators, parents, and supportive adults who work with girls: encourage girls to ask questions about the world, problem solve, and use creativity; foster girls' confidence, self-esteem, initiative, and work ethic; recognize that many girls prefer working in groups and collaborating with others to solve problems; and show girls that they can get what they want out of their careers through the STEM workforce. These strategies will

help to keep the girls engaged according to Keller's ARCS Model of Motivation model. The recommendations will help to capture the girls' attention and provide feelings of satisfaction with the opportunity to work with their peers and to help others.

With an overall goal to increase the number of women in the STEM workforce, there is a need to address the issues that are driving women away from STEM. Many women are not viewing the STEM workforce as a place where they can thrive and achieve their goals. Cultural stereotypes about the STEM environment are discouraging to women who enjoy social interaction. Educators need to think about how they are framing the STEM workforce and the way they are delivering activities to make it more engaging for girls. Opportunities to ask questions, work collaboratively, solve problems, and be creative will help to engage girls in STEM. Female STEM professionals can also share a more accurate picture of the current STEM workforce to help girls see that they can reach their goals and be successful in STEM (González-Pérez et al., 2020).

Collaborative Learning

Collaborative instruction involves all participants of a group actively contributing to the accomplishment of a shared goal (Laal & Ghodsi, 2012). The students should take turns to fulfill different roles to promote shared responsibility and joint problem-solving. As the students work together, they will experience the social and collaborative nature of learning and development. Through collaborative learning, students will solve problems and complete tasks that they would not have been able to do as an individual (Eun, 2010).

The Techbridge, Girls Go Techbridge, and Access for Young Women afterschool offered summer programs to more than 3,000 underserved girls ages 5-12 that focused on hands-on projects, career exploration, and career guidance in science and engineering to engage girls in STEM (Mosatche et al., 2013). Through different themed curriculum kits, girls coded Android apps, built circuits, created models of amusement parks, and built toy prototypes. While collaborating with teachers and role models who provided real-life examples of STEM careers and helped break down stereotypes, families helped to encourage the girls to pursue their interests. “The most successful activities in the Techbridge and Access for Young Women programs are those that are hands-on and relevant to girls’ lives” (Mosatche et al., 2013, p. 23). This program demonstrated the components of Keller’s ARCS Model of Motivation in the relevancy to the girls’ lives and the confidence boost in their STEM skills and knowledge.

An evaluation of the Girls Go Techbridge program from 2010-11 included pre- and post-participation matched surveys for 1,234 girls. The results showed statistically significant positive changes for statements, such as “I want to be a scientist or engineer or work in technology when I grow up.” and “It is fun to learn about science, technology, and engineering.” (Mosatche et al., 2013, p. 19). The program helped the girls to view the STEM workforce as a place for them and to see that they can have fun doing STEM activities.

Findings from the focus group composed of the Techbridge program participants, parents, teachers, and volunteers consistently indicated that the

girls preferred working collaboratively to working alone (Mosatche et al., 2013). “While working together, the girls jointly discover that mistakes are part of the scientific process and that errors can lead to more effective problem solving” (Mosatche et al., 2013, p. 23). Through a survey administered to Access for Young Women participants in 2011, 51 percent of the girls were enrolled in advanced STEM courses, such as Advanced Placement and honors chemistry, calculus, and physics. Findings also showed that 45 percent of the girls who attended at least one year had improved their technology skills, such as creating online presentations, editing videos, and researching using the Internet (Mosatche et al., 2013).

A study of the Australian STEAMpunk Girls program examined high school girls’ engagement in design thinking and project-based learning through an all-girl, STEAM focused program. Designed specifically to increase confidence, self-efficacy, and interest in STEM fields of higher education, the program generated increases in confidence and collaboration, along with confidence and enjoyment of real-world problem-solving (Ng & Fergusson, 2020). The mean values of survey responses about students’ perceptions of the STEAMpunk Girls project were higher than the midpoint of the scale (M = 3.00). The mean results for an increased awareness of STEM careers and the women in them were 3.81. “The girls were also positive about their ability in STEM (M = 3.68) with increased motivation to study STEM subjects (M = 3.51) and increased confidence in: Academic abilities (M = 3.49); creative abilities (M = 3.42); and ability to work positively in a team environment (M = 3.55)” (Ng & Fergusson,

2020, p. 290). From qualitative data, students shared that they developed skills in teamwork, collaboration, and creative problem-solving; gained confidence in speaking out; and learned about women in STEM (Ng & Fergusson, 2020).

Another way to engage female students in STEM activities, which will inspire them to think about the STEM workforce, is to appeal to their desire to help others. Executive Director of the National Institute for Women in Trades, Technology and Science (IWITTS), Donna Milgram, has dedicated her work to closing the gender gap in the STEM workforce. Milgram (2011a) has served as Principal Investigator on several National Science Foundation grants and shares her expertise from consulting and conducting hundreds of training sessions on recruiting and retaining women in technology education. “The best way to attract girls to STEM classes is to emphasize how the program helps others, and also focus on teamwork and collaboration, another area that research shows is appealing to women” (Milgram, 2011a, p. 8).

Problem-Solving

Educators can help to change gender stereotypes by providing experiences that are meaningful and relevant to the girls, which aligns with Keller’s ARCS Model of Motivation. Girls should have experiences that involve working with others to build, use trial and error, and figure out problems that relate to the real world (Mosatche et al., 2013). Andrea Guendelman co-founded DevelopHer, a career development platform that strives to overcome the gender gap by providing women in technology with knowledge, skills, and confidence. She stated in an article published by CNN that “A huge part of the reason women

are not entering these fields and a huge part of the solution starts at the very beginning" (Parke, 2014, p. 5). The very beginning involves how girls are introduced to STEM subjects, which need to be engaging for them and not viewed as another mundane experience (Parke, 2014). According to Dasgupta and Stout (2014), middle school girls are more interested than boys in math instruction taught from an applied, hands-on perspective. Therefore, providing these experiences is critical to keeping girls interested in the STEM field. Opportunities to solve problems and sometimes, controlled chaos with a hands-on approach have been shown to engage girls at a higher level.

Hayden et al. (2011) discovered that most seventh and eighth-grade girls expressed that they gained a higher confidence and more positive understanding of STEM topics, such as engineering, after their hands-on iQUEST (investigations for Quality Understanding and Engagement for Students and Teachers) camp. The girls were able to experience, see, feel, fail, solve, and apply their knowledge to applicable hands-on encounters. The Test of Science Related Attitudes (TORSA) survey (Fraser, 1981), related to student attitudes and interest towards science careers, and the Information and Communication Technology Attitude (ICTA) survey to assess student self-perceptions for ICT skills were both administered before and after the summer camp (Hayden et al., 2011). The TORSA scores increased for the students collectively; girls were more certain about their feelings about science based on a smaller standard deviation (Hayden et al., 2011). Hayden et al. (2011) reported increases in the

ICTA survey that corresponded to higher self-competence with ICT skills by the end of the camp.

The miniGEMS summer camp for middle school girls at the University of the Incarnate Word strived to address the gender gap and provide new opportunities for middle school girls to be exposed to the STEM fields through project-based learning (Wang & Frye, 2019). The EV3 robotics activities at the miniGEMS summer camp encouraged the girls to communicate and solve problems together. The girls also learned about different careers in the STEAM field. Through a mixed methods study to determine the program effectiveness and to investigate a possible change in the girls' attitudes in STEM, pre- and post-survey results with 92 students in grades six to eight showed a significant increase in campers' self-perceived attitude in mathematics (Wang & Frye, 2019). The study utilized the Middle/High School Student Attitudes toward STEM (S-STEM) survey from the Friday Institute, which used a Likert scale to measure attitudes toward mathematics, science, engineering, and technology (Knowles et al., 2018).

In order to learn more about their experiences from the miniGEMS summer camp, semi-structured interviews were held with 22 girls. Based on the interview responses, their communication skills improved as they worked together and felt more comfortable talking with their peers (Wang & Frye, 2019). The students also shared that they were able to apply the problem-solving concepts and the knowledge they gained to their school classes, the development of STEM competencies, and future careers (Wang & Frye, 2019).

These examples fulfill two components of Keller's ARCS Model of Motivation with the increased confidence to talk to their peers and the relevance of applying what they learned to other areas of their lives.

Youth learn problem solving skills through three different problem-solving instructional methods: problem-based learning, project-based science, and anchored instruction. These methods foster critical thinking skills and creativity, which are identified as critical 21st-century skills (Cooper & Heaverlo, 2013). Students have the opportunity to explore issues through multiple levels of thinking when using real-world problems, such as inventing new methods to clean up oil spills or reducing the amount of waste gathered at a school (Bush et al., 2020). Students will observe, make inferences, design and evaluate possible solutions throughout the design process. As the students engage with the subject matter, they are building layers of understanding. When the learner can relate the learning back to themselves, retention is increased (Rinne et al., 2011). The use of real-world problems and their potential impact on the learner develops a relationship between the design problems and the self.

Encouraging Creativity

The American Association of University Women (2000) combined the results from eight research studies to create a resource that focuses on the social and environmental factors that draw women away from STEM fields. It serves as a helpful tool based on research for those who are working on program design to advance STEM opportunities for women. The report includes practical ideas for helping girls and women reach their full potential in STEM to serve as

the multiple solutions that are needed to address the underrepresentation of women in STEM (Hill et al., 2010). According to the National Academy of Success, “spatial thinking is at the heart of many great discoveries in science, that it underpins many of the activities of the modern workforce, and that it pervades the everyday activities of modern life” (National Research Council, 2006, p.1).

Psychology researcher David Lubinski and colleagues at Vanderbilt University conducted a study that provided evidence that early spatial ability, the ability to mentally manipulate 2D and 3D objects, predicts the development of new knowledge and innovation in STEM domains (Lubinski, 2013). Lubinski added, “Creativity is the currency of the modern era, especially in STEM disciplines. Having a better understanding of the human attributes that facilitate innovation has clear, practical implications for education, training, business, and talent development” (Lubinski, 2013, p. 1).

Based upon Keller’s ARCS Model of Motivation model, it is imperative for girls to have positive experiences when engaging in STEM-related activities. Therefore, girls need to explore, ask questions, be curious, and be creative. Creative thinking and problem-solving should be used to fuel students’ curiosity to keep girls engaged in STEM (Reinking & Martin, 2018). Build IT, an afterschool and summer program, focused on creating a positive environment for middle school girls to interact with STEM ideas (Koch, 2010). The girls were challenged to design, utilize communication technologies, and interact with information technology professionals to intertwine STEM-related concepts into a

project. Results from a mixed methods study showed that the experimental group had a more positive view of STEM concepts than the control group and expanded their potential career options to STEM professions (Koch et al., 2010). The researchers concluded that experiencing structured, engaging, and positive STEM concepts influenced and expanded girls' future career options to include STEM professions (Koch et al., 2010).

Pair Programming

Pair programming has been a successful teaching strategy for introductory computer programming classes. Two students work collaboratively on the same program with one serving as the driver to write the code and the other as the navigator to provide feedback and catch any mistakes (Celepkolu & Boyer, 2018). The driver and navigator switch roles frequently and different pairs are formed to spread information throughout the group. In a study about pair programming, students composed reflection essays about their Java course that included fourteen labs where students worked with different partners either randomly assigned or selected by students.

The students wrote about their positive and negative thoughts about the method, their partners, and other factors (Celepkolu & Boyer, 2018). The researchers used a standard inter-rater reliability methodology to convert the subjective writings into a 5-point scale from 1 being the most negative to 5 being the most positive. The results showed that 69% of students reported a positive attitude (rated as 4 or 5) towards pair programming, while the rest reported

negative (rated as 1 or 2) and neutral (3) attitudes (Celepkolu & Boyer, 2018). The differences among the responses were significant.

Students found that having a partner helped to bring new perspectives to the problem-solving process. According to one student who achieved an A in the course:

> One of these benefits was getting multiple perspectives on problems. Sometimes I would not know how to approach a problem or I would not know if there was a better way to solve a problem. When this happened, I sure was glad that I had a partner to program with (Celepkolu & Boyer, 2018, p. 773).

There are several benefits to pair programming, including an opportunity to meet new people, develop communication skills, and connect with classmates to form new study groups (Campe et al., 2019). Pair programming has helped to cut the coding time in half and led to higher quality coding, along with happier programmers, improved teamwork, and enhanced learning (Williams & Kessler, 2003). The method is an excellent way for students to learn computer programming with the opportunity to analyze, critique, and reflect upon code written by their partners (Williams & Upchurch, 2001). Students learn more when working with a partner rather than working individually as they produce a higher quality program and feel more satisfied (McDowell et al., 2003). The satisfaction component provided by pair programming also fits in Keller's ARCS Model of Motivation to motivate learners.

There can also be negative aspects of pair programming. It was pointed out that pair programming could slow down the process if one student was doing

all the work and then trying to explain it to the other student who was not motivated to learn anything. Other issues arose for some students who thought the partnership slowed them down from getting the work done (Celepkolu & Boyer, 2018). There can also be issues with pairing students and their abilities to work together well. Braught et al. (2010) found that students benefited from being paired by ability rather than by random pairing. Students with similar abilities are more likely to be compatible, work together more collaboratively, and acquire a deeper understanding of the material (Braught et al., 2010). When students with a lower and higher ability are paired together, the stronger student typically takes over while the weaker student becomes an observer, which does not strengthen the program or allow both students to resolve programming problems (Maguire et al., 2014).

Role Models

Educators are encouraged to display and share information about female role models in STEM-related fields. Research (Reinking & Martin, 2018; Milgram, 2011a; Meadows, 2016) showed that girls were more interested in STEM when they saw positive STEM role models who looked like them. Role models included females working as scientists, chemists, engineers, computer programmers, and others. The research by Reinking & Martin (2018) confirms the importance of utilizing women role models to increase interest and the ability for girls to self-actualize potential careers in STEM fields.

The founder and Executive Director of the National Institute for Women in Trades, Technology and Science (IWITTS), Donna Milgram, has devoted her

career to closing the gender gap for women in STEM careers by providing educators with the tools needed to encourage women to enter careers where they are under-represented (Milgram, 2011b). Milgram (2011a) shared strategies to be successful in recruiting women and girls to STEM, which includes featuring female role models, conveying work-life balance in STEM careers, involving counselors who provide a pipeline for girls to STEM careers, personalizing outreach to appeal to women and their interests, and include opportunities for girls to work together.

Girls feel more confident in their own abilities and future careers if they can picture themselves in those roles. According to Milgram (2011a):

> Women and girls need to see female role models in the workplace that look like them over and over again. They need to receive the message that women can work in STEM careers and be successful and fulfilled in their work life while still having a personal life, and they need to receive this message repeatedly (p. 5).

This lack of girls in STEM has sparked the development of girl-centered after school programming utilizing the arts as a conduit for creativity and collaboration. Girls in STEAM, a program developed for middle school girls in Church Falls, Virginia, utilized topics in robotics, forensics, and makerspace. Students were exposed to female leaders in STEM fields, positively impacting the girls' previous ideas about women's roles in STEM. This program fostered interest and built confidence, both elements instrumental in developing motivation and persistence in STEM fields (Wu-Rorrer, 2019). Mentorships and

career awareness were also foundational in the program development. The community partnerships built awareness of STEM careers and created a tangible framework for long-term interest in the STEM fields.

During the middle school years, some young people tend to gravitate to trusted mentors as they cultivate their identity and sense of self. Girls were able to build connections with adult mentors and fortify their developing interest in STEM by creating connections with adults in STEM (Wu-Rorrer, 2019). The program aligned with Keller's ARCS Model of Motivation to sustain the interest of the girls and build their confidence in skills that will benefit them in the STEM field. This program has offered new opportunities for the girls at Mary Ellen Henderson Middle School and sustained long-term groups of activities, which met the objectives of increasing creative thinking, problem solving, and real-world engineering simulations through community collaborations. The outcomes of the program were measured with surveys and interviews with the participants about their interest in STEM, knowledge about STEM careers, and mentor relationships (Wu-Rorrer, 2019).

Informal Education

Informal education includes what goes on outside of the classroom and is commonly referred to as out-of-school time (Greenfield, 2009). Many after school activities, such as math clubs, 4-H, and science fairs, have provided girls with experiential learning that incorporates problem-solving, creativity, and design skills as part of informal education opportunities. The activities during informal education have played an important role in sparking interest in STEM areas and

careers (Cooper & Heaverlo, 2013). Effective out-of-school time programs have been shown to promote girls' achievement in STEM and increase their confidence in their science ability (Afterschool Alliance, 2011). These programs have increased the STEM knowledge and skills, improved attitudes towards STEM careers, and changed perceptions about who can be successful in science (Clewell et al., 2000; Afterschool Alliance, 2011).

Enrichment programs and camps offered during out-of-school time can offer girls a chance to explore and experiment with STEM concepts outside the boundaries of the classroom. Out-of-school time settings show promise as places for all youth to increase their confidence and interest in STEM careers (National Research Council, 2009). Embedding learning through situations and experiences deepens connections and allows students to actively engage with their own learning. Additionally, girls can explore without the fear of giving the wrong answer and take risks that lead to scientific discoveries (Koch, 2014).

Koch described the stories of girls and young women who pursued STEM majors despite cultural challenges with support from family, school, peers and mentors in an effort to contribute to the ongoing advocacy for girls in STEM. Koch (2014) also discussed the wide range of interventions that are being done to support the efforts in and out of school at all grade levels to inspire girls to engage in STEM fields. Those interventions included alternative assessments to help alter girls' attitudes towards science in school; out of school time programs that offer hands-on, inquiry-based curricula; and pre-college robotics programs that have inspired girls to pursue the engineering field (Koch, 2014).

Learners in an informal educational setting are intrinsically motivated as they determine the path of their path to acquire the abilities, knowledge, or skills (Csikszentmihalyi & Hermanson, 1995). There are typically other forms of recognition or outcomes that can serve as ways to motivate learners since grades are not given. For example, 4-H has awards, contests or competitions, and trips that motivate youth to continue building their 4-H resume and advancing the skill levels through various 4-H project areas (National 4-H Council, 2023).

Informal education provides the setting for learners to work both independently and collaboratively to develop skills and build foundational knowledge about the topics that interest them. These opportunities have been found to heighten students' curiosities, apply school science to the real world, and encourage students to take ownership of their learning (Wang & Frye, 2019). There is a deficiency in the research on the impact of informal education. The study about the 4-H Girls Tech Challenge contributed to the field by determining the ways that the components of collaborative learning, female role models, problem solving, and creativity could potentially increase girls' interest in computer programming in an informal setting.

Summary and Implications of Literature Review

In order to determine if certain learning and instructional approaches can more likely engage female students in computer science, there is a need to know about what research has been done to support the efforts to engage more girls in computer science and STEM programs. Many of these studies have incorporated the components of Keller's ARCS Model of Motivation model to include

opportunities to collaborate to creatively solve problems while working with female role models. It is helpful to study other programs that have used these components, collaboration, problem solving, and creativity, to engage girls in STEM areas in order to determine the strategies that are sustaining middle school girls' interest in computer programming specifically.

The research helps to fill the gap in the literature about the role that informal education can play in engaging middle school girls in STEM. The integration of collaboration, problem solving, and creativity into a computer programming program targeted at female youth provides data about an innovative approach to engage middle school girls in computing. The program strived to fulfill the components of the ARCS model, Attention, Relevance, Confidence, and Satisfaction.

Chapter 3

Methodology

Introduction

This study investigated the extent to which opportunities to collaborate and solve complex problems through informal educational settings impacted middle school girls' attitudes toward computer programming. A qualitative study employing semi-structured interviews with previous 4-H Girls Tech Challenge participants was utilized. The participants were asked about their unique opportunities to work together to identify community issues and utilize creative problem-solving to bring awareness or find possible solutions. The participants were able to interact with female role models in a variety of ways. Female high school and college students facilitated the activities, and female professionals in computer science and technology fields shared about their careers through panels and field trips.

There is currently a trend where girls tend to become less interested in STEM (science, technology, engineering, and math) topics and classes around the age of 12 (Ofori-Boadu, 2018). Educators will benefit by learning more about best practices for sustaining the interest of girls in STEM education and helping girls to see that STEM careers can be an option for them. As more research is conducted and educators utilize strategies to engage girls in STEM, it will likely increase and sustain girls' interest in STEM and hopefully lead to an increase in the number of women in the STEM workforce.

The following research questions guided this qualitative study:

1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity and female role models, affect the attitudes of middle school girls towards computer programming?

2) In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?

Chapter 3 describes the methodology utilized, along with the selected research design. The participant selection process, demographics of the participants, and the setting of the program are also included. A detailed description of the data collection and analysis procedures, along with the rationale behind the data collection instrument, is given. The chapter concludes with the ethical considerations that shaped this research design.

Research Design

A qualitative study determined the ways that the 4-H Girls Tech Challenge affected the girls' interest and attitudes towards computer programming and their attitudes towards potentially pursuing careers in the computer science and technology fields. The interview responses described how their experiences with the program impacted their attitudes toward computer programming and potential future careers in computer science and technology. Qualitative research was utilized since the intent was to understand the girls' experiences, and interviews

are used to “understand how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences” (Yin, 2016, p. 5).

The qualitative lens allowed for more exploration into participant experiences than what would be gathered by using a quantitative approach. Merriam believes “that research focused on discovery, insight, and understanding from the perspectives of those being studied offers the greatest promise of making a difference in people’s lives” (Merriam, 2009, p. 1). Since the purpose was to investigate the potential difference the 4-H Girls Tech Challenge made on the participants’ lives, the qualitative approach lent itself to exploring the research questions. As an organization that values youth voice, the youth perspective about their experiences provides the highest research value (National 4-H Council, 2023). Semi-structured interviews were utilized to collect data about the youth’s experiences directly. Their experiences were considered too complex to capture through a quantitative survey (Gray, 2004).

Setting and Participants

The 4-H Girls Tech Challenge program was started in 2017 as a collaboration between two county 4-H programs. There was a need for providing new opportunities for girls to learn about computer programming, and the grant from the National Center for Women & Information Technology (NCWIT) provided the funding and a connection to high school and college students who could lead the activities. Each county 4-H program recruited girls ages 9-16 from local 4-H clubs to learn about computer programming. The program was also

advertised to the public in both counties for girls outside of 4-H to sign up for the program.

Interested youth participants were asked to register for the program and answer a few questions about their previous experience with computer programming. All girls who registered for the 4-H Girls Tech Challenge program were invited to participate in the program. A unique aspect of the program is the combination of urban and rural youth with the intention for them to be able to learn about different cultures and backgrounds. The program was held during the summers at the local Extension office in the urban county and a library in the rural county. Participants of the program ranged from age 9-16 years old with a variety of ethnic backgrounds, including Caucasian, African American, Native American, Asian/Pacific Islander, and more than one race, as shown in Table 3.1. The girls also attended different schools, both public and private schools, and others were homeschooled.

Table 3.1

Demographics of 4-H Girls Tech Challenge participants from 2017-2020

Race	**Number of participants**
Caucasian	60
Asian/Pacific Islander	13
African American	16
Native American	11
More than one race	4

The 4-H Girls Tech Challenge activities were facilitated by two AspireIT female program leaders who have been recognized by the National Center for Women & Technology (NCWIT) for their strong leadership skills, along with excellent technology and computing skills. The NCWIT AspireIT program teaches K-12 girls programming fundamentals and computational thinking in fun, creative, and hands-on environments and encourages them to contribute to future innovations (National Center for Women & Technology, 2023). The program leaders expressed interest in helping with community programs for girls and were matched with the 4-H Girls Tech Challenge program. Two female 4-H members served as program assistants who helped the girls solve problems and mentored them as they worked through their computer programming activities and community issue projects. The two program partners from 4-H also helped to facilitate the program by supporting the program leaders and program assistants and helping with the logistics of the program.

The program leaders had previous experience with the computer programming activities that they taught, which incorporated programming languages like C++ programming and Python. They helped to train the program assistants about the activities and potential issues that the girls may encounter when learning computer programming languages. When the program activities included micro:bits, a micro-computer used for computer programming activities, the program partners from 4-H provided training to the program leaders and program assistants. Throughout the 4-H Girls Tech Challenge, the girls learned computing and problem solving skills through various activities, including coding

apps, writing code for websites, working with micro:bits, and building robots. The girls worked in pairs to identify issues within their communities and present ways to address or bring awareness to the issue.

Purposeful sampling was used to select the previous participants of the 4-H Girls Tech Challenge program to participate in the study. The logic behind purposeful sampling involves selecting information-rich participants who can provide greater insight into the issue (Patton, 2002). The first criteria to identify girls for the purposeful sampling process included those who were in middle school during the time they participated in the program. Once that list was identified, random sampling was used to select the participants who were asked to participate in the study. Parents were contacted to ask for consent for their daughters to voluntarily participate in the study with the option to drop out at any time. Interviews were conducted with the girls whose parents gave consent for their participation.

Instrumentation

Semi-structured interviews were used and analyzed through descriptive coding to explore the impact of the 4-H Girls Tech Challenge on their attitudes toward computer programming, as well as their career interests, particularly those in the computer science and technology fields. Qualitative research was selected in order to collect more in-depth information about the participants' experiences than a quantitative approach would yield (Creswell & Creswell, 2018). Semi-structured interviews were chosen to investigate the individual experiences of the participants from the program.

While focus groups would gather a wealth of information, some individuals may be less likely to speak up in that setting. Open-ended research questions were used to encourage participants to provide a descriptive response. The suggested questions were created to answer the research questions from the participants' answers. Semi-structured interviews allowed for paraphrasing and asking additional questions as needed to clarify and accurately understand the responses. The questions were adapted from other qualitative studies and tested for face validity as explained below. The interview questions were associated with the two research questions as shown in Table 3.2.

Table 3.2

Interview Questions Associated with Research Questions

Research Questions	Interview Questions
1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity, and female role models, affect the attitudes of middle school girls towards computer programming?	● Why did you choose to participate in the 4-H Girls Tech Challenge? ● How would you describe your abilities in coding and using technology before the 4-H Girls Tech Challenge and after the challenge? ● What did you enjoy about the 4-H Girls Tech Challenge? ● How did the 4-H Girls Tech Challenge program differ from formal school learning? ● Did the program increase your interest in computer science and technology? If so, how? ● How did collaborating with your partner affect your problem-solving ability while discussing your community issue? ● In what ways did this program change your attitude toward computer programming?
2) In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?	● In what ways did this program prepare you for your future career? ● Are you interested in a career in computer science and technology?

As shared by Creswell & Creswell (2018), establishing face validity of the data collection instruments is important for qualitative research. In order to

establish validity, the interview questions were given to four colleagues, three with doctoral degrees and one with a Master's degree in education. One colleague has extensive experience in the youth development field as a 4-H Youth Development Specialist, and the others are currently university professors with years of experience as educators. Given the purpose, research questions, and interview questions, the colleagues were asked to draw upon their expertise to determine if the interview questions would guide the answers to the research questions.

Responses were received from the colleagues, and interview questions were adjusted based on their feedback. One colleague thought the questions were succinct and did not offer any suggestions for changes. Two colleagues suggested a few word choices to clarify the questions' meanings for the intended audience. It was also suggested to break a couple questions into two in order to help interviewees to answer both parts. The fourth colleague suggested grouping the questions for similar topics and emphasized the benefit of semi-structured interviews to ask clarifying questions as needed to help participants to understand the questions and respond appropriately. The suggestions from the colleagues were pondered and applied to the list of interview questions.

Procedures for Data Collection

Potential participants were selected purposefully based on the criteria described above from the lists of the 4-H Girls Tech Challenge program participants. The goal was to interview at least seven previous participants. Parents were contacted through email to explain the study and ask for their

consent for their daughters to participate. Participation was strictly voluntary, and those who started the process could ask to be excused at any time with no penalty or issue. The purpose of the study and the protocol were outlined to the parents. Participants were asked to complete an interview with the investigator, including questions about their formal/informal experiences and their personal attitudes/interests in computer science. Consent forms from parents, posted in Appendix D, were required for the girls to participate in the interviews. A consent form for adults is included in Appendix E. Assent forms for the youth and adult interview participants are found in Appendices F and G.

All interviews were conducted face-to-face in a private setting with limited distractions or via video conferencing, as agreed upon by the participant and the investigator. The interview engaged students for about 15-20 minutes and involved questions about computer programming and possibly pursuing careers in the computer science and technology fields. All audio from the interviews was recorded to be used during analysis. The identities of those being interviewed were kept confidential, and their names were not used. The recordings were accessible to the interviewer only and stored on a locked hard drive. The responses of the interviews were not shared with anyone; only the coded data with pseudonym names was used throughout the dissertation results.

Interviews were scheduled by email at a date and time agreed upon by the parent and researcher. A script was crafted to share information about the project and how the interview would be conducted. The interviews began by thanking the interviewees for their willingness to participate and reminding them that their

participation is voluntary. They were able to choose to end the interview at any time. Participants were reminded that the interviews will be recorded for transcription and coding, and their identities will be anonymous in the research findings. The interview questions served as a framework for the interview, and paraphrasing was used to ensure the meaning of the responses was accurately portrayed. The script for the interview, including the interview questions for both youth and adult participants, is posted in Appendix A, B, and C.

Measures were put into place to protect the privacy of the participants. Their identities were not used on any publications or presentations of this research. Survey data was coded and individuals were randomly assigned a number rather than using their names. Throughout the recorded interview process, participants were given a pseudonym name. The data collected was stored on a password-protected computer and an external hard-drive that was secured in a locked cabinet.

Data Processing and Analysis

The interviews were recorded, and the audio was transcribed to text through Zoom. The researcher listened to the audio recordings of the interviews and checked the transcriptions for accuracy, editing it as needed to capture the interview conversations. Descriptive coding was used to determine emergent themes among the responses from the semi-structured interviews. The researcher read through the full transcripts to process the interview responses. On the second read through, the researcher highlighted passages that addressed the research questions as potential impacts from the program. The

process was repeated for each interview transcript. Comments were added to the highlighted passages, and codes were developed from the themes that emerged from the interview responses, following the process of descriptive coding (Saldaña, 2021). The code book with codes, descriptions of the codes, frequency of codes and exemplar data was created throughout the data analysis process.

Ethical Considerations

The research was carried out according to the approved university IRB proposal. Since most of the 4-H Girls Tech Challenge participants were minors, parental consent was needed to ask them to participate in semi-structured interviews. Parents were given a form that explained the study as it related to their child's participation and how their responses would be used. Only participants with a signed parental consent form participated in the interviews. Adult participants were expected to provide consent forms for themselves.

Conclusion

Two research questions were investigated:

1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity and female role models, affect the attitudes of middle school girls towards computer programming?

2) In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?

Previous participants of the 4-H Girls Tech Challenge were purposefully

selected and invited to participate in semi-structured interviews, which were recorded and transcribed using Zoom. Through the data analysis, emergent themes were identified that described but did not measure the girls' attitudes about computer programming and careers in computer science and technology after participation in the 4-H Girls Tech Challenge and thereby formed the basis of the results.

Chapter 4

Findings

Introduction

Whereas women make up approximately 48% of the total workforce in the United States, they comprise only 34% of the STEM (science, technology, engineering, and math) workforce (National Girls Collaborative Project, 2023). With fewer women in the STEM workforce, the full potential to include more perspectives and infuse diversity into the field is being diminished. Though some strides were made to increase the number of women in the STEM workforce, the last few decades have seen a decline in the number of women entering the computer science field (Palma, 2001).

The perception of a male-dominated environment that lacks collaboration and a work-family life balance may discourage many women from pursuing the STEM workforce. The decision to pursue other interests over STEM typically occurs at a younger age. Whereas many girls possess the academic ability to succeed in the STEM fields, research has shown that girls are losing interest in STEM topics during middle school (American Association of University Women, 2000). Therefore, there is a need to examine how the computer science field is being introduced and conveyed to women and especially girls in the formative ages when they are deciding potential career paths.

The school environment, including how teachers nurture girls' interest in STEM, the presence of female role models in STEM, and their engagement in their science and math classes, plays a very influential role in how girls view

STEM and whether they want to engage in STEM in the future (Archer et al., 2012). Out-of-school time can fulfill the opportunity to enhance and spark girls' interest in STEM through informal learning experiences. With the pressure taken off to get good grades, girls can feel more comfortable to explore STEM topics and take more risk in making decisions to meet the challenges given to them.

The 4-H Girls Tech Challenge provided opportunities for girls to spark their interest in computer programming and the computer science career field. Since the program started in 2017, 104 participants ages 9-16 have participated in the 4-H Girls Tech Challenge program. The program was held once a year, typically in the summer, at the Extension office of one county and the local library in the other county. Female college and high school students taught computer programming activities to the younger youth, who also worked in pairs to address community issues. Participants interacted with female professionals in the computer science field through career panels and field trips to corporations such as Intelligrated Systems, a robotics company.

To investigate the potential impact of the utilization of problem solving, collaboration and creativity throughout the 4-H Girls Tech Challenge program, a qualitative study was utilized. Qualitative methods were chosen to explore if the girls' experiences throughout the 4-H Girls Tech Challenge had an impact on their interest in computer programming and in future careers in the computer science and technology fields. The research was conducted to address the following questions:

1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity and female role models, affect the attitudes of middle school girls towards computer programming?

2) In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?

Through purposeful sampling, eight previous participants of the 4-H Girls Tech Challenge program participated in semi-structured interviews. The girls were interviewed after their participation in the program, so there was no opportunity to administer pre and post surveys. The recordings from the interviews with the 4-H Girls Tech Challenge participants were transcribed and read through. Descriptive coding was used to make a list of potential codes and to develop a code book table with codes, descriptions and examples for each code (Saldaña, 2021). With the research questions in mind, portions of the interview responses that addressed the impact of the program, the girls' interest in computer programming and their interest computer science and technology careers were highlighted and comments were added. Codes were added to the highlighted portions to describe the comments that addressed impact and interest in computer science. The descriptive codes are shown in Table 4.1.

Table 4.1

Overview of Findings - Descriptive Codes

Research Question #1	Research Question #2
Expanded Knowledge	Increased Interest
Sparking Interest	Combined Career Options
Continued Classes	Changed Perspectives
Female Role Models	Increased Confidence
Sense of Belonging	Breaking Stigmas
Giving Back	Women Empowerment
Collaboration	
Problem Solving	
Creativity	

Data Description and Analysis

Research Question 1: In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration and creativity, affect the attitudes of middle school girls towards computer programming?

The outcomes from the 4-H Girls Tech Challenge were identified from the interview responses. Participants described their computer programming abilities before and after the program, their interest in computer programming, the presence of female role models, and the sense of belonging. The code book,

including the codes, frequency counts, descriptions and examples of participant responses, is located in Appendix H.

Expanded Knowledge. Participants shared that the 4-H Girls Tech Challenge program increased their knowledge about computer programming and the computer science field. Jennifer compared her knowledge before and after the program as:

> Before the program, I did not really know much about coding and the different types, and what I could do with it. I just watched a lot of tutorials, and I had to do them step by step. After learning and taking the courses, I was able to do it more independently. I could do more complex coding and do more with the coding that I learned through the program.

Bailey described a similar experience:

> Before [the program], I was doing block coding, and I kind of had a very, very basic level of going forward and stuff. But then after [the program], I was able to identify different kinds of coding, and I understood more about it.

When Lynn thought about what she had learned, she stated, “I enjoyed seeing the hardware. I didn't know that the motherboard or the microprocessor could actually be that dirty. Being able to actually see what was going on inside was actually really cool.” The program introduced the girls to different programming languages and the terms needed to work with the languages.

Christina showed her increased knowledge of technology by describing the importance of technology:

> Technology runs farm equipment, dispenses medication, grows plants, modifies our food sources to maintain large enough stores to feed our country, drives our cars, runs our homes, and teaches our children. We need to advance our technology; coding will build, advance and run it for generations to come.

Sparking Interest. Participants reflected that the 4-H Girls Tech Challenge sparked their interest in computer programming and the computer science and technology field. Stephanie reflected that:

> This brought my attention to computer science and made my interest in computer science greater. Both have helped me in high school. I've taken computer science courses, and it also helped me to discover careers that are reliant upon computer science.

Bailey said, “I think when you start something and you enjoy the way that you start doing it, then it sparks further interest. I just enjoy doing it so it made me more interested.” The 4-H Girls Tech Challenge made computer programming fun for the girls. Bailey added, “When you have fun, you associate what you're doing when you're having fun. So that was like this, after I was associating things like computer science with fun.”

Continued Computer Programming/Science Classes. As described in her interview, Stephanie shared that she had an increased interest in computer programming after the program. That interest has influenced her to take

computer science classes in high school:

> I'd say that before the challenge I had a pretty narrow understanding of coding. I'd only mainly gotten it through school, and even at school it was not very thorough. It was kind of just a basic understanding of using scratch and stuff in our very basic coding class. I wouldn't say that I got an immense coding knowledge, but I think it helped stimulate my interest in coding more. I became more interested and pursued coding more when I got into high school, where I've taken the AP computer science classes and stuff.

Jennifer agreed about the impact of the program to drive her to take additional coding classes, "This program influenced me to take a lot of computer science classes and coding classes in school, and it really helped me develop an interest for computer science. I got to learn more about how you can make a lot of things using the codes and the curriculum we learned."

As the girls developed an increased interest in computer programming after the 4-H Girls Tech Challenge, it has inspired them to not only take classes in school but also pursue activities to learn computer programming languages outside of school too. Megan added:

> It increased my interest in learning more about computer science outside of school. I learned different coding languages and stuff . . . It's more just having fun on my own doing projects and learning more on my own free time.

Female Role Models. Participants were asked about the inclusion of female high school and college students as the program leaders for the 4-H Girls Tech Challenge. One participant shared about the relationship she built with one of the program leaders. Amber said, “The conversation flowed nicely with her, and she had the same views as me. She really wanted to empower women, which is absolutely amazing. I absolutely loved working with her, too.” Her relationship with the college student even influenced her college decision. Amber shared, “One of the instructors actually was going to WashU (Washington University), and she was from a different state which was crazy to me. I think that's what inspired me to go to WashU.”

As research has shown, representation does matter in terms of youth having role models who look like them to help to visualize themselves being successful in that same role or position (Simpson et al., 2021). When asked about her experiences with the female program leaders, Lynn stated, “I really liked that. Specifically, I like the fact that it was also people that look like me that were also teaching it as well.” The presence of female professionals in the computer science field was also impactful for the girls. Amber stated: “It's having all the different women in STEM who were working with us. They talked about their experiences and I think it made me more happy and excited to have a career in STEM as a woman.”

Sense of Belonging. Several participants spoke about their appreciation for the sense of belonging they experienced from the 4-H Girls Tech Challenge.

When asked about their thoughts about the all-girls environment, Autumn responded:

> It definitely made me feel more comfortable, because usually, I feel like if you went into just a normal computer science class, it would be mostly males because it's a male dominated field. So with just girls, I definitely felt more comfortable.

Jennifer also connected the male-dominated field with the sense of belonging that resonated with her during the 4-H Girls Tech Challenge, stating, “I liked it because it's not something you usually see in a field like computer science. So it feels like I belong there, kind of.”

A couple participants also touched on the impact of being around like-minded people. Stephanie reflected on the difference from her computer programming classes at school, “I'd say that being around like-minded people who are all girls who wanted to learn more about coding and learn more about STEM was a nice change from just being around people who are there for a grade.” As the girls worked together during the 4-H Girls Tech Challenge, they also formed bonds with each other. Lynn shared:

> I’m actually still in contact with a couple of them. We obviously worked together in the other program that we did, and we went to Washington, DC. I think just being able to see different people from different places was very enjoyable.

One participant really emphasized the sense of belonging and compared it to being like a family. One participant, Amber, shared:

> I enjoyed that it was more like a family or more like a group. You know people who wanted to empower each other, and, you know, be in STEM, I guess. That was probably one of my favorite parts. Even though not everybody knew each other, we still bonded. All the teachers were cool, and I still even have some of them on social media.

Giving Back. One participant shared that the 4-H Girls Tech Challenge inspired her to start her own computer coding classes. Christina, a participant from a neighboring rural county, spoke about the impact the program had on her:

> I started this coding project because [my county] is a rural community, and they don't have much experience with technology. With the future being more technology driven, I feel that it is important to the younger generation to learn how to code and use technology.

She explained the reasoning behind her drive to teach younger kids about computer programming:

> I started learning about coding and computer science a few years ago and found that I really like it. I also think that other kids should have the opportunity to learn it through 4-H as well. Technology is a large part of our future. To be able to give local kids the opportunity to learn about computers, coding and robotics will hopefully help them to shape their future careers.

Throughout the semi-structured interviews, the girls were also asked about their experiences with three components of the program: collaboration, problem solving, and creativity.

Collaboration. Girls worked in pairs throughout the program to complete computer programming activities, work on their community issue projects, and write the code for the app or website about their project. Participants shared about their experiences with collaboration and how it was helpful to work with others. Megan added, “It was really helpful, because sometimes I would run into issues. My partner would try to help me.” Participants also noticed that having a partner can bring out the strengths of each person to strengthen the efforts of the team. Lynn shared about her partnership:

> I know when I was working with her, I didn't necessarily know how to use PowerPoint. So my weaknesses were balanced with her strength and understanding of what we were supposed to be doing. I was good at the English part, but she was good at the research part of it. Those key points were able to help me to understand.

The program component of collaboration brought in different perspectives for the girls. Bailey said:

> I think it helped me look at it from different angles. I remember, because I think I only thought, “This is the way that I would see to solve this problem,” but having a partner helped me expand my thoughts and see it in a different way.

The participants recognized that the work product can be enhanced with the addition of many perspectives rather than relying on only one individual to create the ideas. Stephanie concurred about the benefits of collaboration:

> I say that having a collaborative group where we all bring our ideas to the table is always better than just doing it by yourself. I'd say because we each bring our own experiences and bring our ideas. While you may think that your idea is the best one, once you share their ideas, you can build it all together and come up with a better one. You may realize that what you thought was for sure getting the best idea turned out to maybe not be, and that it helps when you have a group to bounce things off of each other.

Problem Solving. Another component of the 4-H Girls Tech Challenge was problem solving. As the girls worked on computer programming activities, they were encouraged to work through the coding and figure out the bugs or problems within their program. They tested their coding and made adjustments as needed to achieve the tasks or meet the objectives that they were given for those activities. The program leaders and program assistants were available to help the girls if they were not able to figure out how to solve the issues within their programming codes. When asked about the problem solving component, Jennifer reflected that the program leaders and assistants worked in a collaborative way to help them:

> I really liked how hands-on the instructors were, and how they were able to help solve my problems and help me troubleshoot all these

> different things, and they would sit down, and they would make it like a collaborative experience, instead of just solving it on their own.

Bailey related the problem solving from the program to real life application:

> A lot is like you have to look for problems in the world and figure out a way to solve them. So it's like identifying a problem like that was really nice. And then figuring out how you can solve it. Using coding was very educational, and I think it's a good idea.

Stephanie viewed the problem solving component differently and recognized that she did not fully grasp what working on a community issue meant at the time she participated in the 4-H Girls Tech Challenge. She compared it to her participation in Hackathon, where her team worked on three projects to design an app prototype to address disparity with unconscious bias with grades, enhance virtual learning while promoting peer interactions, and create an app to connect volunteers with local community and service organizations. Stephanie reflected about the two experiences:

> I don't think I had a firm grasp of how much it would matter to work on a community issue. As I'm grown up now, and when we do our hackathon project about a community issue in our school, I can fully realize it now. Back in middle school, I don't think I fully grasped what working on a community issue meant and how much thought it takes to really think about that.

Creativity. As one of the components of the program, participants were encouraged to identify a community issue and think creatively to come up with a way to bring awareness to the issue or think about potential solutions. The girls could show their creativity in the way that they presented their community issues and how they would help to bring awareness or potentially solve the problem. Each year, they worked on designing posters or programming their websites or micro:bits to display the community issues and possible solutions and plans. As an open-ended project, girls were able to think creatively with their designs without any strict guidelines on how they should complete the task. Additionally, they learned the basics of computer programming but could be creative in what they programmed and designed with their coding. Jennifer enjoyed the opportunity to be creative in her programming:

> I enjoyed how independent it was, and you could design how you wanted it. It wasn't following a certain curriculum; you could add a lot of personal touches to the code and create whatever you wanted with what you wanted.

Statement about Research Question 1

The most common thread among the interview responses was the increased interest in computer programming that the girls felt after the program. Several girls shared how the 4-H Girls Tech Challenge introduced them to a broader field of computer programming that has sparked their interest to take computer science courses at school and other locations. The girls also spoke of their experiences with working with the female role models and felt that their

presence inspired them. The participants shared how they appreciated the all-girls environment and specifically, about being around other like-minded girls who also wanted to learn more about computer programming. It was also more comfortable for the girls as they worked through the activities and asked questions. Girls reflected about the sense of belonging they felt during the program as they connected with their peers and worked collaboratively. The experiences of the 4-H Girls Tech Challenge affected the girls' attitudes towards computer programming in terms of increasing their interest, inspiring them to take other computer programming classes, increasing the girls' sense of belonging in the computer programming space, and connecting to female role models.

Research Question 2: In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?

After the 4-H Girls Tech Challenge, all participants participated in more computer science courses at school or in other settings. Six girls responded positively that the 4-H Girls Tech Challenge did increase their interest in potentially pursuing computer science and technology careers. Two girls were considering a career in computer science before they entered the program. Six girls shared that they were not considering a career in computer science before the program, but that changed after the program. Four girls are looking at the computer science field on its own, while two girls are considering adding computer science or technology into their previous career aspirations to combine or mesh their interests together. Two girls are planning to pursue careers in other

fields outside of computer science and technology. Based on the interview responses, the girls felt empowered and more confident that they could also enter and succeed in the field of computer science and technology, along with the STEM workforce in general, from their interactions with the female role models and female STEM professionals who shared about their careers.

Increased Interest. From the interview responses from the participants, the 4-H Girls Tech Challenge increased their interest in computer science and technology careers. For most, the opportunity to expand their knowledge beyond block coding and explore other computer languages led to a wider perspective about the computer science field. Stephanie confirmed:

> I think the program did increase my interest in computer science and like I said, I'm taking AP computer science courses now. I am looking into doing a career and maybe meshing my interests in computer science and medicine. I've done internships and computational drug discovery stuff since then, so I'd say it has definitely increased my interest.

For six girls, the computer science field was not on their radar for careers before the program but that has changed. Bailey shared about the change in her plans before and after the program, "I am hoping if I get into a coding-related job or something like that, I will be able to look back on these experiences. I think it was a good base for what I might do in the future." She also stated:

> Well, before this program, I was really interested in going into the medical field and that was kind of the only thing I thought about.

> And after the challenge, I definitely enjoyed it. So now, I'm definitely thinking about going into computer science.

Combining Career Options. Two girls expressed a desire to combine computer science or a technology aspect into their career aspirations. Stephanie is considering adding computer science into her career path after positive experiences in computer science courses:

> Now that I've taken these computer science courses, they have helped me discover careers that are reliant upon computer science. I'm now trying to find ways to meld computer science to the career I'm going to go into and thinking of ways to continue doing what I'm passionate about.

Likewise, Lynn stated that she was considering adding computer science into her career options:

> Yes, it did [increase my interest in computer science careers]. Next year, I'm taking a graphic design class, and I was thinking about doing a minor in information technology alongside my major in finance. I love having it on the side, so I can make myself look better [on my resume].

While computer science might not be their main career field, it is something that they want to incorporate into their career field. Amber reflected:

> I remember when we went to Intelligrated Systems. That was cool. And then the lady who had been a computer scientist for a very long time was really cool to see too. For a while, that's why I

> wanted to do computer science because of the Girls' Tech Challenge. That's what I was going to go to school for. It changed but it inspired me to go along with the technology side of everything because you can still incorporate that into other things.

Changed Perspectives. The 4-H Girls Tech Challenge participants who were interviewed also shared about a change in perspectives after the experience. After they participated in the computer programming and career exploration activities, the girls had a different perspective about computer science. Jennifer spoke about her change in perspective:

> I would see in movies the hackers and stuff they would all be doing in computer science. They would just be typing for hours and hours, and I thought that's what it was. So I was not really interested in it. It seemed kind of boring, but this program helped get rid of that stigma.

The 4-H Girls Tech Challenge also helped the girls to make a potential career in the computer science field feel attainable to them. Lynn stated:

> I don't see it as difficult or impossible anymore. It looked like a lot, because when you think of coding, you think of zeros and ones, and JavaScript and whatever. But I think after getting a small little detail of it, and then starting to do it later on my own, it made me not fear it like I did before.

Jennifer shared how her perspective about computer science has changed:

> I used to think that computer science was really complicated, and it wasn't something I could do. I thought it would just be boring and just a bunch of numbers and letters on a screen. But through this program, it really helped me see how coding and all these things can help make things more fun. I realized that it wasn't as complex as it seems. I can make a lot of things out of it, which is really interactive and fun.

Increased Confidence. Since computer science tends to be a male-dominated field, women need to have more confidence in their abilities and in their decision to enter the field (Cheryan et al., 2015). It can be intimidating for young women to attend college courses as the only females in the room and work in a career where they will likely be underrepresented. The 4-H Girls Tech Challenge introduced the girls to more aspects of the computer science field and extended their knowledge of computer programming beyond block coding to multiple computer programming languages. The responses from the girls also indicated that the program increased their confidence to enter the computer science workforce. Autumn summed it up:

> It gave me more of a sense that I could do it and could have a future in it. I like what I learned, and that was pretty fun. I like the conversations I had with people. That was probably one of my favorite parts and all the different women in STEM and getting to meet different people. That was really cool.

Lynn also spoke about the program helping her to see herself being successful in the computer science field:

> You could see yourself be [like] them specifically. I know that one girl [specialized] in hardware. I didn't know that you could actually do hardware in that sense when it came to computers. I thought it was just programs, you know. I guess, seeing different aspects [was helpful], and showed that you could actually do that.

Breaking Stigmas. The girls had conceived notions and noted a stigma about the computer science field being made for men since they make up the majority of the workforce. Christina shared that interacting with the female professionals in the computer science and technology fields helped to inspire her:

> I thought it was really nice, because, like I was saying before, in the field of computer science, it's mostly male dominated. It was nice to see more girls and women going into this field, and it made me feel like I could also go into this field because there were others around me who were just like me.

Jennifer stated, “It made me really happy because it released the stigma that only males could do this, and it's a male dominated field. I was happy to see more females talking and sharing experiences.”

Women Empowerment. One participant, Amber, related the increased confidence to the women’s empowerment that she felt throughout the program:

> People wanted to empower each other, and, you know, be in STEM. That was probably one of my favorite parts. It brought a sense of, wow, we could actually do this. I like what I learned, and that was pretty fun. I like the conversations I had with people. That was probably one of my favorite parts and all the different women in STEM and getting to meet different people. That was really cool.

Jennifer shared that seeing other women enter the STEM field inspired her, “It was nice to see more girls and women going into this field, and it made me feel like I could also go into this field because there were others around me who were just like me.”

Statement about Research Question 2

Overall, the 4-H Girls Tech Challenge program increased most girls’ interest in computer programming. All eight girls considered computer science as a potential career path shortly after the program. At the time of the interviews, six girls were planning to pursue a career in computer science and technology as their main focus or as part of their career. The girls are shared the they felt more empowered and confident to enter the computer science field after they interacted with the female program leaders and professionals in the computer science field.

Summary

The 4-H Girls Tech Challenge did have an impact on the participants’ interest in computer programming and their interest in potential careers in computer science and technology. The increased interest in computer

programming was shown by the interview responses and expressed in terms of “before the program” and “after the program.” The girls spoke about how the program sparked an interest in computer programming that led them to take additional courses in computer programming and in different areas of computer science. The girls recalled the impact that was made on them by the female high school and college students who taught them the activities and interacted with them throughout the program, sharing their own experiences in college and their passion for computer programming. The sense of belonging within the program was also highlighted in the interviews as an impact from the 4-H Girls Tech Challenge. The girls felt connected to each other and continue to maintain those friendships today.

Chapter 5

Conclusion

There is an important need to engage more girls in STEM (science, technology, engineering, and math) programs and activities to combat the underrepresentation of women in the STEM workforce. While women make up 48% of the entire workforce in the United States, they fill only 27% of the STEM workforce **(**Martinez & Christnacht, 2021). New technology and decisions about the advancement of the STEM field are being made and developed every day. There is a need for more women in the workforce to provide their perspectives and diversify the composition of the people who are making these critical decisions (Benish, 2018). While the number of women in some STEM fields have increased, computer science is one area where women have not made a dent in their underrepresentation in the workforce **(**Martinez & Christnacht, 2021). The Bureau of Labor Statistics estimates that the gap will only continue to widen. While computer science research jobs will grow by 19% by 2026, women will earn only 18% of computer science bachelor's degrees in the United States (ComputerScience.org, 2021).

The attempt to combat the gender gap in the STEM workforce involves an examination of the factors that are deterring women from choosing to major in STEM fields and pursuing STEM careers. Hill et al. (2010) suggested that middle school girls are not sustaining an interest in STEM topics, which is deterring them from considering a career in the STEM workforce. The absence of female role models in the STEM workforce can be discouraging for girls. Research has

shown the importance of seeing someone who looks like them to help youth to visualize themselves in that role (Gershenson et al., 2021). When asked to draw a scientist or think about those who work in the computer science field, youth tend to think about white males wearing lab coats and working in isolation on the computer (Hayes et al., 2020). A study conducted by Tan-Wilson and Stamp (2015) showed that female college students tend to value work-life balance and assume that they would have to give up having a family to hold a leadership position in the STEM workforce. These assumptions can steer girls and young women away from pursuing a degree in STEM and therefore, contribute to the underrepresentation of women in the STEM workforce.

While the school environment contributes many of the factors that shape and contour girls' perceptions of the STEM workforce, informal education possesses additional opportunities for girls to explore STEM topics and careers through a hands-on approach. The informal education setting provides opportunities for youth to investigate different topics to find their spark and help to determine potential career fields (Altoum, 2021). With more flexibility in activities and connections to outside resources, youth can participate in a broad array of activities to develop skills that would transfer to multiple career fields.

The 4-H Girls Tech Challenge utilized an opportunity for girls to explore computer programming activities in a low-stakes environment where they were encouraged to be creative, and there were no consequences for taking risks. The girls worked collaboratively to identify community issues and used problem solving skills to think about potential solutions to the issue or ways in which they

could bring more awareness to it. The connection to careers included female STEM professionals who shared about their own experiences as being outnumbered by males in their fields, including how they persevered throughout college and continue to be successful in STEM fields, particularly in computer science and technology. Throughout the program, the girls interacted and were taught by female high school and college students who served as the program leaders and assistants.

The study of the 4-H Girls Tech Challenge was designed to answer the following two research questions:

1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity and female role models, affect the attitudes of middle school girls towards computer programming?

2) In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?

The interview responses from the girls who shared their experiences about the 4-H Girls Tech Challenge and the impact it made on them, in addition to their interests in the computer science and technology field, are discussed. The implications of these findings for current research are explored, and the limitations are included. The chapter comes to a close with an exploration of the implications for educational practice and recommendations for future research.

Summary of Findings

Research Question 1: In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, creativity and female role models, affect the attitudes of middle school girls towards computer programming? Based on the interview responses, the girls were impacted in a number of ways from their participation in the 4-H Girls Tech Challenge. All girls experienced an increase in their knowledge about computer programming and the field of computer science. Before the program, seven girls had little to no computer programming knowledge. While one girl had more computer programming knowledge, it was with a different programming language that was used with her VEX IQ, a competitive robotics team. Three girls started the program with some experience doing block coding. After the program, all girls expanded their abilities and knowledge to other computer programming languages such as HTML and JavaScript. Those who had done block coding previously developed more advanced computer programming skills and learned about the many possibilities for what can be done through coding. The girls also learned how to program micro:bits, which expanded their ability to program on another piece of technology in addition to using a computer or tablet.

The program increased the participants' interest in computer programming based upon their responses. The girls said the activities were fun and showed them that they could be creative in their coding. Two girls specifically mentioned the preconceived thoughts that they had about computer science as "hackers doing a lot of typing" and "boring." Their experiences from the program served as

a spark that influenced them to pursue other computer science courses at school, such as AP Computer Science and Cybersecurity.

One impact that was not expected was the sense of belonging that was brought up multiple times within the interview responses. The girls shared they felt like they had connected and become like family. Most girls also shared how they are still in touch with their partners from the program. Social media has helped to keep them connected with the other girls they met from the 4-H Girls Tech Challenge. It was comfortable for them to be in a setting with all girls and as one participant pointed out, being around like-minded girls who wanted to learn more about coding and STEM was a nice change. The girls felt connected with the program leaders and shared that they were easy to talk to. One participant shared that she is still in touch with one of the program leaders on social media.

The female high school and college students who taught the sessions and the female STEM professionals participating also made a difference to the girls based on their responses about the female role models. As they learned more about the computer science field from the STEM professionals, it helped them to be able to see themselves entering that field as well. As the STEM professionals shared about the benefits and unique opportunities they have had through their professions, the girls learned more about the careers and the opportunities that exist for them.

For one previous participant, her experiences during the program inspired her to reciprocate and give back to her local community by teaching kids computer programming activities. She saw the need for kids to know how to use

technology and to know about the potential career field in computer science and technology. As an organization that values giving back to the community with the motto, “To Make the Best Better,” 4-H instills community service into its program (National 4-H Council, 2023).

The girls were asked about the components used throughout the 4-H Girls Tech Challenge to align with Keller’s ARCS Model of Motivation. Keller (1987c) designed the ARCS framework to describe the components needed to sustain learners’ motivation, which include attention, relevance, confidence, and satisfaction. Girls were paired off with someone they did not know and typically from different geographical areas. They were encouraged to work collaboratively on the computer programming activities and the challenge to address community issues. When asked about the collaboration component, girls spoke about how they worked with their partner to combine their strengths and weaknesses. Participants pointed out that collaborating brought new ideas to the table and helped them to realize that they may not always have the best idea. It was viewed as helpful to combine ideas or look at things from another perspective to arrive at the best solution. According to Dutta and Rangneker (2022), interactive engagement helps youth to build their understanding beyond that as an individual with the complementary knowledge of their teammates.

Three girls brought up collaboration in terms of the program leaders and assistants who answered the girls’ questions. They noticed that the leaders collaborated with them to help solve a problem or troubleshoot any issues rather than the leaders simply telling them the solution. Two girls pointed out that it was

helpful to have a partner while working on computer programming activities. They were able to solve any problems that arose together. The girls felt like the program helped them to develop their problem solving skills. One girl applied those problem solving skills to her involvement in the Student Council at school. STEM educators aim to help students develop cognitive and critical thinking skills through application-based activities that involve solving a problem (Kaplan-Say et al., 2023). There was not as many comments about creativity. Two girls mentioned that they appreciated that the program gave them more flexibility to be creative than the classes they take at school. They liked being able to create projects without having to meet specific requirements to earn a grade.

Research Question 2: In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology? With regards to interest in the workforce, six girls expressed that a career in computer science and technology is now an option for them. While three girls are thinking about majoring in computer science alone, three girls want to expand their current career aspirations to include computer science. The girls expressed a desire to mesh their passions together and see the addition of computer science or technology as a move to make themselves more marketable to potential employers.

The presence of female role models led to another impact that was not as expected. The girls spoke about how nice it was to see women being successful in the STEM field and to be around girls and women who also wanted to learn

more about STEM. The girls felt inspired to see women succeed in STEM and specifically, computer science and technology fields. One girl shared how the experience felt empowering for women to overcome the challenges of having a presence in a male-dominated field.

As the girls explored potential careers in the computer science and technology fields, they felt more confident that they could be successful in the field. The presence of female STEM professionals helped to show them how to pursue a career in the field. The girls learned about the challenges women face in a male-dominated field. The girls mentioned their perspectives changed before and after the program. They were familiar with the fact that computer science and technology fields tend to be male-dominated before the program. Four girls mentioned stigmas or preconceived notions that the computer science careers can be isolating, involve a lot of typing, and are typically only for men. After the program, the girls viewed the computer science and technology fields differently as a potential career field.

Limitations of Findings

The eight girls who participated in the study were a small sample size of the number of total participants of the 4-H Girls Tech Challenge. They also represent a small sample of the female members of the statewide 4-H program. Additionally, the 4-H program was a SPIN (Special Interest) club that met for at least 28 hours rather than a community club, which meets a couple times each month throughout the year. The female high school and college students who served as the program leaders changed most years since the girls went to

college or had other plans for the following summer. The program partners, the 4-H Specialist and the 4-H volunteer, remained consistent throughout the years.

As previously mentioned, the girls reflected upon their own thoughts and lived experiences. People possess personal filters and can recall experiences incorrectly or be influenced by their own personal bias. The girls did not take a pre and post survey to demonstrate the change in attitudes before and after the program. The research was conducted after the participants had finished the program so there was not an opportunity to administer pre and post surveys. Rather, the girls shared their own thoughts about how their attitudes and knowledge changed from before and after the program. The girls reflected about the program and shared what they have been doing since the program as far as their computer programming experiences and classes they have taken.

Researcher Comments

The computer science workforce is an area where women, like other STEM fields, are underrepresented but have also not made the strides that other STEM areas have made in recent years. Women make up only 26 percent of the computer and mathematical sciences workforce (National Girls Collaborative Project, 2023), so there is potential to increase the representation to diversify the perspectives that are contributing to the advancement of technology in the computer science field.

As girls enter middle school, they tend to be less interested in science and math. This can be attributed to a number of factors, including a lack of female role models, how teachers nurture their learning, their learning environment, and

their perceptions of how math and science can be used. Therefore, efforts need to be made to keep girls engaged in the STEM topics in hopes of sparking a desire to enter the STEM workforce.

Informal education has a tremendous opportunity to help to spark the interest of girls in STEM. While working with caring adults, informal education programs like 4-H can offer girls a chance to explore STEM activities and topics with lower stakes. Youth in informal education are not earning a grade and can feel less pressure to take risks and try new things. The 4-H Girls Tech Challenge program was created with the intention to engage girls in computer programming activities and explore computer science and technology careers with the assistance of female professionals in those fields.

The program combined the components of collaboration, problem solving, and creativity into an all-girls environment with female role models in the program leaders, partners, and computer science professionals. The program components intertwined the elements of Keller's ARCS Model of Motivation to motivate the girls. The activities and challenges, which focused on relevant topics and curriculum, grabbed their attention, built their confidence in programming, and ensured their satisfaction by making the program worthwhile and meaningful.

The findings showed that the program increased the girls' interest in computer programming and inspired them to pursue other classes in computer programming to learn more about the field. Additionally, the program increased their interest in potentially pursuing a career in the computer science and technology fields. The results suggest that the 4-H Girls Tech Challenge program

would increase girls' interest in computer programming in other settings. The instructional model of including the components of collaboration, problem solving, and creativity facilitated by female role models could be used by other informal youth organizations to increase girls' interest in STEM topics. Informal educators and practitioners can use the findings from this study to incorporate programs with the components and instructional model of the 4-H Girls Tech Challenge to inspire girls to engage in computer programming and other STEM topics.

Implications for Educational Practice

The findings suggest that the instructional model used in the 4-H Girls Tech Challenge increased the interest of girls in computer programming. After the girls had the opportunity to learn computer programming in an informal, lower stakes environment, they were inspired to take computer programming classes in school and other settings. Based on the findings, practitioners should feature well-thought out and highly developed curriculum plans that will introduce and develop the skills and abilities of the youth.

Practitioners should use the components of Keller's ARCS Model of Motivation when designing activities to increase the learners' motivation to learn. In order to impact the interest of girls in a male-dominated field, the utilization of engaging female instructors and role models is significantly important to achieve the desired results based on the findings. Relevant topics and activities that appeal to the girls' interests are also imperative to motivate learners by meeting the satisfaction component of Keller's model. Learners should feel that the skills

and content they learn is something they view as worthwhile and satisfying (Keller, 1987b).

Activities that encourage the girls to work together and to interact with each other positively will likely help to create a sense of belonging for the girls. As the girls feel comfortable with each other, it will likely build their confidence to take risks and share their thoughts and experiences with each other. The girls will likely find the activities engaging and it will capture their attention, which will increase their motivation to learn according to Keller's ARCS Model of Motivation (1987a). A program that incorporates the components of collaboration, problem solving, and creativity in an informal educational setting can increase the girls' interest in computer programming.

The findings also suggest that opportunities for the girls to explore potential career options for the topics helps to increase their knowledge about that career field. As they learn more about the career field and make the connections between the activities during the program and the advice and knowledge they gather about the careers from the STEM professionals and through field trips. Those experiences are key to increasing their knowledge about the career field and building their confidence to enter that field, which satisfies another component of Keller's model. The youth benefit from receiving a firsthand experience into daily work life and more importantly, seeing someone who looks like them be successful in that field. Additionally, the experience with current professionals in the field brings in the relevance component of Keller's model.

Recommendations for Future Research

The girls who participated in the study of the 4-H Girls Tech Challenge were in middle school when they participated in the program. Currently, most of the previous participants are in high school or recent high school graduates. An opportunity for future research exists to contact the previous 4-H Girls Tech Challenge participants to see what they plan to do after high school or are currently doing. Additional research could be conducted to follow their progress throughout college and career to determine if the 4-H Girls Tech Challenge played a role in their college major and career choices.

Research could be performed to determine how many previous participants pursued a career in the computer science and technology fields. The research could be expanded to include careers in the STEM workforce overall to see if the 4-H Girls Tech Challenge program may have helped to address the overall problem of under-representation of women in the STEM workforce. A longitudinal study could be conducted to determine how long the previous participants maintain their careers in the computer science and technology fields. The study could include a qualitative component to address what the women feel has helped them to persevere and how youth programs should be structured to help girls to stay engaged in computer programming and STEM with the goal of them eventually pursuing careers in the field.

The 4-H Girls Tech Challenge program focused on computer programming and the aspects of the computer science field. The components, which included collaboration, problem solving, and creativity, and the

instructional model of the program to include female instructors and STEM professionals to serve as role models could be replicated. The 4-H Girls Tech Challenge could be replicated in other locations to reach more girls and to conduct further research about the impact of the program and the potential change in their interest in computer science and technology careers. While this study did not focus on the demographics, there is an opportunity to explore the impact of the 4-H Girls Tech Challenge based upon demographics, grade level, and socio-economic status. Other contributing factors such as whether the girls are from urban, rural or suburban areas could also be studied to determine the differences in their experiences and impact of the program.

The 4-H Girls Tech Challenge contained components that aligned with Keller's ARCS Model of Motivation, including attention, relevance, confidence, and satisfaction, that helped to motivate the participants in the program to learn. The model could be applied to other STEM topics, especially those whose careers tend to be male dominated, to study the transferability of the components and instructional model of the 4-H Girls Tech Challenge program to other topics. Replication would involve opportunities for the participants to collaboratively work on activities related to the topic of interest. Participants would be encouraged to think creatively to solve problems and also while working on the activities. Professionals in the career field of the chosen topic should be invited to interact with the participants. An opportunity to visit industries in that field to see the professions in action are important to give participants first-hand experiences about potential careers.

Concluding Remarks

The underrepresentation of women in the STEM workforce, and specifically the computer science field, needs to be addressed. The contributions by more women in the STEM workforce will help the United States to remain globally competitive in the 21st century as emerging technologies such as quantum computing and artificial intelligence are being developed (Athanasia & Cota, 2022). An examination of STEM education to determine when girls are deciding to pursue other fields will help educators and practitioners to reframe STEM content to engage girls and maintain their interest. As determined by the Keller's ARCS Model of Motivation, programs that can hold the attention of the learners while providing relevant content to build their confidence and fulfill their needs will likely help them to feel satisfied with what they learned and their participation.

The findings of this study suggest that a program that implements the components of Keller's ARCS model of motivation will be successful in engaging youth in the content of the program. These components were woven in through several elements, including opportunities for the girls to develop and utilize problem solving and creativity while working collaboratively with their peers and interacting with female role models who facilitated the activities and shared about careers in the computer science and technology fields. The 4-H Girls Tech Challenge provided hands-on activities that sparked an interest in computer programming and connected the girls to female professionals and role models

who helped to build their confidence to enter the computer science and technology fields.

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Appendices

Appendix A - Interview Script

Thank you for taking the time to talk to me today. I am here to speak to you about your experience during the 4-H Girls Tech Challenge program.

I am going to ask you some questions. I want to understand things from your perspective. There are no right or wrong answers to any of the questions.

I would like to ask you to be as honest as possible.

This conversation is strictly confidential. I won't share any details with anyone.

We can talk a lot quicker than I can type, would it be OK with you for us to record this session for my note taking?

Any questions before we begin?
Let's get started!

{RECORD}

Semi-structured Interview Questions

(Interview questions for adult or youth)

Appendix B

Semi-structured Interview Questions for Youth Participants

1. What grade are you in this year?
2. What's your favorite subject in school and why?
3. What experience in computer programming did you have before the 4-H Girls Tech Challenge? Could you share about that experience?
4. Why did you choose to participate in the 4-H Girls Tech Challenge?
5. How would you describe your abilities in coding and using technology before the 4-H Girls Tech Challenge and after the challenge?
6. How did the 4-H Girls Tech Challenge program differ from formal school learning?
7. What did you enjoy about the 4-H Girls Tech Challenge?
8. Did the program increase your interest in computer science and technology? If so, how?
9. How did collaborating with your partner affect your problem solving ability while discussing your community issue?
10. In what ways did this program change your attitude towards computer science?
11. In what ways did this program prepare you for your future career, especially for those related to computer science and technology?
12. Are you interested in a career in computer science and technology?
13. Is there anything else you would like to add about computer science or the 4-H Girls Tech Challenge?

Appendix C

Semi-structured Interview Questions for Adult Participants

1. What experience in computer science did you have before the 4-H Girls Tech Challenge? Could you share about that experience?
2. Why did you choose to participate in the 4-H Girls Tech Challenge?
3. How would you describe your abilities in coding and using technology before the 4-H Girls Tech Challenge and after the challenge?
4. How did the 4-H Girls Tech Challenge program differ from formal school learning?
5. What did you enjoy about the 4-H Girls Tech Challenge?
6. Did the program increase your interest in computer science? If so, how?
7. How did collaborating with your partner affect your problem solving ability while discussing your community issue?
8. In what ways did this program change your attitude towards computer science?
9. In what ways did this program prepare you for your future career, especially for those related to computer science and technology?
10. Are you interested in a career in computer science and technology?
11. Is there anything else you would like to add about computer science or the 4-H Girls Tech Challenge?

Appendix D

Letter of Informed Consent for Youth Participants

College of Education

One University Blvd.
St. Louis, Missouri 63121-4499
Telephone: 314-516-5972
E-mail: meeka@missouri.edu

Informed Consent for Child Participation in Research Activities
The Impact of Collaboration, Problem Solving, and Creativity on Computer Programming Education for Middle School Girls

Participant _____ HSC Approval Number _____

Principal Investigator Amanda Meek PI's Phone Number _____

Summary of the Study

The general purpose is to investigate the impact of the 4-H Girls Tech Challenge on middle school girls' interest in computer programming and possibly pursuing careers in the STEM workforce, particularly computer science. I plan to determine if this instructional method could serve as a model for enhancing interest in science, technology, engineering, and math (STEM) topics and careers, and if it has a differential impact on the engagement of girls in computer programming.

The statistical analyses of confidential interview responses by the researcher measuring student interest in computer programming topics and STEM careers poses a significant risk to the physical, psychological, social, economic, or legal well-being of the participants.

I will take multiple precautionary measures to protect the privacy of participants. As part of this effort, the identity of participants will not be revealed in any publication or presentation that may result from this study. All identifying information will be removed from the interview data so that at no time will the researcher be able to identify a particular student, their responses, or their participation in this study. The confidential interview data will be stored securely for a period of up to three years on a password protected computer that operates behind a firewall and is only accessible by the researcher. Pseudonyms will also be used to lessen the risk of confidentiality being lost.

1. Your child is invited to participate in a research study conducted by Amanda Meek and Dr. Helene Sherman (faculty advisor). The purpose of this research is to measure the girls' interest in computer programming after being given opportunities to collaborate together and explore creative solutions to solve complex problems through the 4-H Girls Tech Challenge program.

2. a) Your child's participation will involve:
   - ❖ Your child will be asked to complete an interview with the investigator including questions about her formal/informal experiences and her personal attitudes/interests in STEM.
   - ❖ All interviews will be conducted face-to-face in a semi-private setting with limited distractions, or via video conferencing, as agreed upon by the participant, parent, and the investigator.
   - ❖ All interviews will be recorded for transcription and qualitative analysis. If necessary, a follow-up interview will be scheduled.
   - ❖ Your daughter's identity and personal information will remain confidential in the report of findings from this research.
   - ❖ Approximately 15 students may be involved in this research. The research will be conducted at the MU Extension - St. Louis County office or at another location as agreed upon by the participant and the investigator.

   b) The amount of time involved in your child's participation will be approximately 20 minutes to complete the interview.

3. There is a loss of confidentiality risk but it will be minimized by using pseudonyms rather than actual names and assigning numbers to the survey data. The data will also be stored on a password-protected computer and an external hard-drive that will be stored in a locked cabinet.

4. There are no direct benefits for your child's participation in this study. However, your child's participation ***may*** contribute to the knowledge about the effectiveness of certain instructional strategies for increasing and sustaining middle school girls' interest in STEM topics.

5. Your child's participation is voluntary, and you may choose not to let your child participate in this research study or to withdraw your consent for your child's participation at any time. Your child may choose not to answer any questions that she does not want to answer. You and your child will NOT be penalized in any way should you choose not to let your child participate or to withdraw your child.

6. I will do everything I can to protect your child's privacy. As part of this effort, your child's identity will not be revealed in any publication or presentation that may result from this study. In rare instances, a researcher's study must undergo an audit or program evaluation by an oversight agency (such as the Office for Human Research

Protection). That agency would be required to maintain the confidentiality of your child's data.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may contact the Investigator Amanda Meek (meeka@missouri.edu) or the Faculty Advisor, Dr. Helene Sherman (shermanhe@umsl.edu). You may also ask questions or state concerns regarding your child's rights as a research participant to the Office of Research Administration, at 314-516-5972.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I consent to my child's participation in the research described above.

Parent's/Guardian's Signature	Date	Parent's/Guardian's Printed Name
Child's Printed Name		
Signature of Investigator or Designee	Date	Investigator/Designee Printed Name

Appendix E

Letter of Informed Consent for Youth Participants

College of Education

One University Blvd.
St. Louis, Missouri 63121-4499
Telephone: 314-516-5972
E-mail: meeka@missouri.edu

Informed Consent for Participation in Research Activities
The Impact of Collaboration, Problem Solving, and Creativity on
Computer Programming Education for Middle School Girls

Participant _____ HSC Approval Number _____

Principal Investigator Amanda Meek PI's Phone Number _____

Summary of the Study

The general purpose is to investigate the impact of the 4-H Girls Tech Challenge on middle school girls' interest in computer programming and possibly pursuing careers in the STEM workforce, particularly computer science. I plan to determine if this instructional method could serve as a model for enhancing interest in science, technology, engineering, and math (STEM) topics and careers, and if it has a differential impact on the engagement of girls in computer programming.

The statistical analyses of confidential interview responses by the researcher measuring student interest in computer programming topics and STEM careers poses a significant risk to the physical, psychological, social, economic, or legal well-being of the participants.

I will take multiple precautionary measures to protect the privacy of participants. As part of this effort, the identity of participants will not be revealed in any publication or presentation that may result from this study. All identifying information will be removed from the interview data so that at no time will the researcher be able to identify a particular student, their responses, or their participation in this study. The confidential interview data will be stored securely for a period of up to three years on a password protected computer that operates behind a firewall and is only accessible by the researcher. Pseudonyms will also be used to lessen the risk of confidentiality being lost.

1. You are invited to participate in a research study conducted by Amanda Meek and Dr. Helene Sherman (faculty advisor). The purpose of this research is to measure

the girls' interest in computer programming after being given opportunities to collaborate together and explore creative solutions to solve complex problems through the 4-H Girls Tech Challenge program.

2. a) Your participation will involve:

- ❖ You will be asked to complete an interview with the investigator including questions about your formal/informal experiences and your personal attitudes/interests in STEM.
- ❖ All interviews will be conducted face-to-face in a semi-private setting with limited distractions, or via video conferencing, as agreed upon by the participant and the investigator.
- ❖ All interviews will be recorded for transcription and qualitative analysis. If necessary, a follow-up interview will be scheduled.
- ❖ Your identity and personal information will remain confidential in the report of findings from this research.
- ❖ Approximately 15 people may be involved in this research. The research will be conducted at the MU Extension - St. Louis County office or at another location as agreed upon by the participant and the investigator.

b) The amount of time involved in your participation will be approximately 20 minutes to complete the interview.

3. There is a loss of confidentiality risk but it will be minimized by using pseudonyms rather than actual names and assigning numbers to the survey data. The data will also be stored on a password-protected computer and an external hard-drive that will be stored in a locked cabinet.

4. There are no direct benefits for your participation in this study. However, your participation ***may*** contribute to the knowledge about the effectiveness of certain instructional strategies for increasing and sustaining middle school girls' interest in STEM topics.

5. Your participation is voluntary, and you may choose not to participate in this research study or to withdraw your consent for your participation at any time. You may choose not to answer any questions that you do not want to answer. You will NOT be penalized in any way should you choose not to participate or to withdraw your consent.

6. I will do everything I can to protect your privacy. As part of this effort, your identity will not be revealed in any publication or presentation that may result from this study. In rare instances, a researcher's study must undergo an audit or program evaluation by an oversight agency (such as the Office for Human Research Protection). That agency would be required to maintain the confidentiality of your data.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may contact the Investigator Amanda Meek (meeka@missouri.edu) or the Faculty Advisor, Dr. Helene Sherman (shermanhe@umsl.edu). You may also ask questions or state concerns regarding your rights as a research participant to the Office of Research Administration, at 314-516-5972.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I consent to my participation in the research described above.

Participant's Signature	Date	Participant's Printed Name	
Signature of Investigator or Designee	Date		

Appendix F

Assent Form for Youth Participants

College of Education

One University Blvd.
St. Louis, Missouri 63121-4499
Telephone: 573-341-4692
E-mail: meeka@missouri.edu

Assent to Participate in Research Activities (Minors)

The Impact of Collaboration, Problem Solving, and Creativity on Computer Programming Education for Middle School Girls

1. My name is Amanda Meek.

2. I am asking you to take part in a research study because I am trying to learn more about how particular components of the 4-H Girls Tech Challenge can increase middle school girls' interest in computer programming and careers in the computer science field.

3. If you agree to be in this study, you will be asked to participate in an interview designed to measure your attitude towards computer programming, post-secondary pathways, and computer science career interests. The survey will take 20 minutes or less, and you will take it one time during an agreed upon time with the researcher.

4. Being in this study should not harm you in any way.

5. You will probably not get any direct benefits from being in this study but you might enjoy knowing that your honest answers may help educators design instruction that will better engage middle school girls to sustain an interest in computer programming.

6. Please talk this over with your parents before you decide whether to participate. I will also ask your parents to give their permission for you to take part in this study. Even if your parents say "yes," you still can decide not to do this.

7. If you do not want to be in this study, you do not have to participate. Remember, being in this study is up to you. No one will be upset if you do not want to participate or if you change your mind later.

8. You can ask any questions that you have about the study. If you have a question later, you can contact me at meeka@missouri.edu (Amanda Meek).

9. Signing your name at the bottom means that you agree to be in this study. You will be given a copy of this form after you have signed it.

_____ _____

Participant's Signature Date Participant's Printed Name

_____ _____

Participant's Age Grade in School

Appendix G

Assent Form for Adult Participants

UMSL | Education

One University Blvd.
St. Louis, Missouri 63121-4499
Telephone: 314-516-5972
E-mail: meeka@missouri.edu

Informed Consent for Participation in Research Activities
The Impact of Collaboration, Problem Solving, and Creativity on
Computer Programming Education for Middle School Girls

Participant _____ HSC Approval Number _____

Principal Investigator Amanda Meek PI's Phone Number _____

Summary of the Study

The general purpose is to investigate the impact of the 4-H Girls Tech Challenge on middle school girls' interest in computer programming and possibly pursuing careers in the STEM workforce, particularly computer science. I plan to determine if this instructional method could serve as a model for enhancing interest in science, technology, engineering, and math (STEM) topics and careers, and if it has a differential impact on the engagement of girls in computer programming.

The statistical analyses of confidential interview responses by the researcher measuring student interest in computer programming topics and STEM careers poses a significant risk to the physical, psychological, social, economic, or legal well-being of the participants.

I will take multiple precautionary measures to protect the privacy of participants. As part of this effort, the identity of participants will not be revealed in any publication or presentation that may result from this study. All identifying information will be removed from the interview data so that at no time will the researcher be able to identify a particular student, their responses, or their participation in this study. The confidential interview data will be stored securely for a period of up to three years on a password protected computer that operates behind a firewall and is only accessible by the researcher. Pseudonyms will also be used to lessen the risk of confidentiality being lost.

1. You are invited to participate in a research study conducted by Amanda Meek and Dr. Helene Sherman (faculty advisor). The purpose of this research is to measure the girls' interest in computer programming after being given opportunities to

collaborate together and explore creative solutions to solve complex problems through the 4-H Girls Tech Challenge program.

2. a) Your participation will involve:
   - ❖ You will be asked to complete an interview with the investigator including questions about your formal/informal experiences and your personal attitudes/interests in STEM.
   - ❖ All interviews will be conducted face-to-face in a semi-private setting with limited distractions, or via video conferencing, as agreed upon by the participant and the investigator.
   - ❖ All interviews will be recorded for transcription and qualitative analysis. If necessary, a follow-up interview will be scheduled.
   - ❖ Your identity and personal information will remain confidential in the report of findings from this research.
   - ❖ Approximately 15 people may be involved in this research. The research will be conducted at the MU Extension - St. Louis County office or at another location as agreed upon by the participant and the investigator.

   b) The amount of time involved in your participation will be approximately 20 minutes to complete the interview.

3. There is a loss of confidentiality risk but it will be minimized by using pseudonyms rather than actual names and assigning numbers to the survey data. The data will also be stored on a password-protected computer and an external hard-drive that will be stored in a locked cabinet.

4. There are no direct benefits for your participation in this study. However, your participation ***may*** contribute to the knowledge about the effectiveness of certain instructional strategies for increasing and sustaining middle school girls' interest in STEM topics.

5. Your participation is voluntary, and you may choose not to participate in this research study or to withdraw your consent for your participation at any time. You may choose not to answer any questions that you do not want to answer. You will NOT be penalized in any way should you choose not to participate or to withdraw your consent.

6. I will do everything I can to protect your privacy. As part of this effort, your identity will not be revealed in any publication or presentation that may result from this study. In rare instances, a researcher's study must undergo an audit or program evaluation by an oversight agency (such as the Office for Human Research Protection). That agency would be required to maintain the confidentiality of your data.

7. If you have any questions or concerns regarding this study, or if any problems arise, you may contact the Investigator Amanda Meek (meeka@missouri.edu) or the Faculty Advisor, Dr. Helene Sherman (shermanhe@umsl.edu). You may also ask questions or state concerns regarding your rights as a research participant to the Office of Research Administration, at 314-516-5972.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I consent to my participation in the research described above.

Participant's Signature	Date	Participant's Printed Name	
Signature of Investigator or Designee	Date		

Appendix H

Code Book

Research Questions

1) In what ways did the 4-H Girls Tech Challenge experience, which included components of problem solving, collaboration, and creativity, affect the attitudes of middle school girls towards computer programming?

2) In what ways did the 4-H Girls Tech Challenge experience affect the attitude of middle school girls towards potentially pursuing careers related to computer science and technology?

Code Book

Code	Count	Definition	Exemplar Data
Expanded Knowledge	13	Girls increased their knowledge about the field of computer programming and computer science	"Before the program, I did not really know much about coding and the different types, and what I could do with it. I just watched a lot of tutorials, and I had to do them step by step. After learning and taking the courses, I was able to do it more independently. I could do more complex coding and do more with the coding that I learned through the program." - Jennifer "Technology runs farm equipment, dispenses medication, grows plants, modifies our food sources to maintain large enough stores to feed our country, drives our cars, runs our homes and teaches our children. We need to advance our technology; coding will build, advance and run it for generations to come." - Christina

Sparking Interest (in computer programming)	7	4-H Girls Tech Challenge activities increased the girls' interest in computer programming.	"I think when you start something and you enjoy the way that you start doing it, then it sparks further interest. I just enjoy doing it so it made me more interested." - Bailey "I'd say that after the experience, I wouldn't say that I got an immense coding knowledge, but I think it helped stimulate my interest in coding more so that I became more interested, and would pursue coding more when I got into high school, where I've taken the AP computer science classes and stuff." - Stephanie
Continued computer programming/science classes	4	Girls have been taking computer science classes at school.	"This program has exposed me to a lot of different aspects of computer science, and It's helped me choose the classes I've wanted to take for high school, such as AP Computer science and cyber security and all these different classes. So I feel like this program has helped me and exposed me to different career choices that I could have in the future." - Jennifer "It increased my interest in learning more about computer science outside of school. I learned different coding languages and stuff . . . It'd be more just having fun on my own doing, doing projects, and learning more on my own free time." - Megan
Female Role Models	8	Influence of female high school and college students as the program leaders and role models	"One of the instructors was going to Wash U. and she was from a different state which was crazy to me. I think that's what inspired me to go to Wash U." - Amber

			"I like that because I feel like it was more relatable. It was easier to talk to them." - Bailey "I really like that. Specifically, I like the fact that it was also people that look like me, too, that were also teaching it as well." - Lynn
Sense of Belonging	9	Girls felt that they belonged in the group and in the field of computer science	"I'd say that being around like minded people who are all girls who wanted to learn more about coding and learn more about STEM was a nice change from just being on people who are there for a grade." - Stephanie "It was almost like a family, or it was more like a get together if that makes sense. Even though not everybody knew each other, we still bonded. All the teachers were cool, and I still even have some of them on social media." - Amber
Giving Back	2	Teaching kids about computer coding after participating in the 4-H Girls Tech Challenge	"I started this coding project because [my county] is a rural community, and they don't have much experience with technology. With the future being more technology driven, I feel that it is important to the younger generation to learn how to code and use technology." - Christina "I also started a computer coding project in [my county]. I started learning about coding/ computer science about two years ago and found that I really like it. I also think that other kids should have the opportunity to learn it through 4-H as well. Technology is a large part of our future. To be able to give local kids the opportunity to learn about computers, coding and

			robotics will hopefully help them to shape their future careers." - Christina
Collaboration	6	Girls worked in pairs to learn computer programming and also developed a plan to bring awareness and possible solutions to a chosen community issue.	"I say that having a collaborative group where we all bring our ideas to the table is always better than just doing it by yourself. I'd say because we each bring our own experiences, bring our ideas, and while you may think that your idea is the best one once you share their ideas, you can build it all together and come up with a better one. You may realize that what you thought was for sure getting the best idea turned out to maybe not be, and that it helps when you have a group to help bounce things off of each other." - Stephanie "I think it helped me look at it from different angles. I remember, because I think I only had like this is the way that I would see to solve this problem. But having a partner helped me expand my thoughts and see it in a different way." - Bailey
Problem Solving	6	Solving problems with their partners and instructors	"I really liked how hands-on the instructors were, and how they were able to help solve my problems and help me troubleshoot all these different things, and they would sit down, and they would make it like a collaborative experience, instead of just solving it on their own." - Jennifer "A lot is like you have to look for problems in the world and figure out a way to solve them. So it's like identifying a problem like

			that was really nice. And then figuring out how you can solve it. Using coding was very educational, and I think it's a good idea." - Bailey
Creativity	3	Girls were encouraged to use their imagination with their coding, creating designs, and making community action plans.	"I enjoyed how independent it was, and you could design how you wanted it. It wasn't following a certain curriculum; you could add a lot of personal touches to the code and create whatever you wanted with what you wanted." - Jennifer
Career Exploration	5	The program included components of career exploration in the fields of computer science and technology.	"I thought it was really cool to see all these different machines and all these computers, and see the people like work and make all these new, cool things. Because I've never seen anything like that. So it's a really cool experience." - Jennifer "I think it's what helped me decide what I wanted to do, because I had a problem deciding. I knew what I wanted, but I didn't know what jobs had that." - Lynn
Increased Interest	8	Girls showed increased interest in potential careers within the computer science field.	"I think the program did increase my interest in computer science and like I said, I'm taking AP computer science courses now. I am looking into doing a career and maybe meshing my interest in computer science and medicine. I've done internships and computational drug discovery stuff since then, so I'd say it has definitely increased my interest." - Stephanie "Before this program I was really interested in going into the medical field and that was kind of

			the only thing I thought about. And after the challenge I definitely enjoyed it. So now I'm definitely thinking about also going into computer science." - Autumn "I'm taking graphic design in class and I was thinking about doing a minor in information technology alongside my major in finance. So, it made me want to, at least, even if it's not the main thing that I'm doing. I love having it on the side, so I can make myself look better." - Lynn
Combining Career Options	2	Adding computer science and technology careers into their current career options to combine both fields	"Now that I've taken these computer science courses, they have helped me discover careers that are reliant upon computer science. I'm now trying to find ways to meld computer science to the career I'm going to go into and thinking of ways to continue doing what I'm passionate about." - Stephanie "Yes, it did [increase my interest in computer science careers]. Next year, I'm taking a graphic design class, and I was thinking about doing a minor in information technology alongside my major in finance. I love having it on the side, so I can make myself look better [on my resume]." - Lynn
Changed Perspectives	6	A change in perspective about how the girls thought about computer programming and the field of computer science	"I would see in movies the hackers and stuff they would all be in computer science, and they would just be typing for hours and hours, and I thought that's what it was. So I was not really interested in it. It seemed kind of boring, but like this program, help get rid of

			that stigma.” - Jennifer “I don't see it as difficult or impossible anymore.” - Lynn “It looked like a lot, because when you think of coding, you think of zeros and ones, JavaScript and such. After getting a small little detail of it, and then starting to do it later on my own. It made me not fear it like I did before.” - Lynn
Increased Confidence	7	Girls built confidence to see themselves in the computer science field.	“It made me really happy because it released the stigma that only males could do this, and it's a male dominated field. I was happy to see more females talking and sharing experiences.” - Jennifer “People wanted to empower each other and be in STEM. That was probably one of my favorite parts. It brought a sense of ‘Wow, we could actually do this.’ I like what I learned, and that was pretty fun. I like the conversations I had with people. That was probably one of my favorite parts and all the different women in STEM and getting to meet different people. That was really cool.” - Amber “It gave me more of a sense that I could do it and could have a future in it.” - Autumn
Breaking Stigmas	3	Releasing the stigma that computer science is for males	“It made me really happy because it released the stigma that only males could do this, and it's a male dominated field. I was happy to see more females talking and sharing experiences.” - Autumn “I thought it was really nice, because, like I was saying before,

			in the field of computer science, it's mostly male dominated. It was nice to see more girls and women going into this field, and it made me feel like I could also go into this field because there were others around me who were just like me." - Christina
Women Empowerment	4	Girls feeling empowered to enter the computer science/STEM field after seeing other women succeed in the field	"People wanted to empower each other, and, you know, be in STEM. That was probably one of my favorite parts. It brought a sense of, wow, we could actually do this. I like what I learned, and that was pretty fun. I like the conversations I had with people. That was probably one of my favorite parts and all the different women in STEM and getting to meet different people. That was really cool." - Amber "It was nice to see more girls and women going into this field, and it made me feel like I could also go into this field because there were others around me who were just like me." - Jennifer