Increasing Female Enrollment in High School Computer Science Education

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by

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Abstract

"Women have played a vital role in the field of computer science and information technology (IT), developing some of the most essential components of modern IT" (Purdue University Global, 2018). Despite their prominence and achievements in these career fields, computer science has experienced a noticeable decline in the representation of females in industry and in programs of study. This is not a phenomenon reserved for the college classroom and/or the world of work, but is a situation present across schools in the P-12 arena, to include ZBF High School. As such, the purpose of this work was to examine the problem of practice on how to increase the number of females enrolling in computer science education at ZBF High School.

Two research questions emerged and were instrumental in guiding the direction of this study: (1) Why are female students underrepresented in computer science education at ZBF High School? and (2) What are the influencing factors on females' decisions regarding computer science? A mixed-methods research protocol was selected to conduct the investigation, which sought to discover why females were underrepresented, as well as to determine the influencing factors. Based on a survey of 24 ninth grade female students, combined with focus group input from six of the survey participants, the data revealed that females at ZBF High School are generally not interested in computer science. Self-efficacy in math and related courses/activities were deemed to be the driving force behind the lack of interest. To rectify this situation, it was determined that a concerted effort on the part of all stakeholders, to include students, would need to be undertaken to fashion a solution that could engender change.

The need to increase the number of females in the area of computer science education was an issue that had characteristic implications of an instructional and/or a systemic nature and,

therefore, warranted an investigation that began with the impacted group, female students. Based on literature and results of this study, the computer science curriculum could better serve its intended purpose if it were to be revamped and vertically articulated so that "recruitment" actually begins at the elementary level. This revised and realigned curriculum should incorporate activities and/or courses that would engage female students in creative design and resourceful problem solving projects that would allow them to see how human computer interaction is utilized to help people and society. As documented in research, activities of this nature would capture the attention of female students in a manner that would lead them to select computer science as a course of study at the high school level. Successful execution of this recommended restructuring would have the propensity to reverse the problem of underrepresentation of females in computer science education at ZBF High School, thus increasing the available pool of females who are prepared to enter positions in current and emerging technical career fields.

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First and foremost, I thank God for the strength and courage He bestowed upon me to commence and complete this research study. Without His sustaining power, I would not have been successful in this endeavor. Next, I thank the University of Arkansas for having granted me the opportunity to be a part of this renowned, academically rich program of study. I attribute my achievements and accomplishments to my dissertation committee: Dr. Ed Bengtson, Director, Dr. Kara Lasater, and Dr. Michael Daugherty. I am particularly grateful to Dr. Bengtson for his guidance and patience as he worked diligently to steer me through this process. Dr. Lasater's keen eye for detail and Dr. Daugherty's content area expertise worked in harmony to assist Dr. Bengston's efforts. Together, they made sure that the final product met the standards of excellence required by the University, the College of Education and Health Professions, and the Department of Curriculum and Instruction. Their guidance during this all-encompassing investigation contributed to a personal and professional experience that will be difficult to duplicate.

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strip when I prepared to land. Kathy, you are still the best college roommate a girl could have. Each of you served as a source of motivation and strength for me, as the successful completion of my dissertation would not have been possible had you not been there. I love you!

Dedication

I dedicate this dissertation to my husband, James, to my son, Akheem, and to my father, Jeff Brown. My emotions run especially deep as I express my gratitude to my dad, affectionately known as Papa, who has been there for every great moment in my life. Papa, you taught me how to soar with eagles. James, you entertained my every educational endeavor and served as the wind beneath my wings when I was too tired to fly. Finally, to My Akheem: Thank you for teaching me how to laugh through the struggle. I love you all dearly, and I thank you for your never-ending love and support and for being the greatest "cheering squad" a person could have.

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CHAPTER ONE—INTRODUCTION

Introduction

The purpose of this study was to examine the problem of practice on how to increase the number of females enrolling in computer science education (CS) at ZBF High School (ZBFHS). The focus of the problem was on capturing the interests of female middle/junior high school students so they elect to enroll in CS courses once they enter high school. This undertaking was significant because of its direct relationship to a nationwide problem—the disparity in the number of females employed in the field of information technology, particularly in the area of computer science. According to Goode (2008), "computer science holds the unfortunate distinction as a highly segregated profession—in terms of both gender and race" (p. 362). She further stated, "The underrepresentation of females and people of color occurs at the professional level, university level, and in K-12 education" (p. 362).

As such, this quandary was investigated from two perspectives: (a) examination of barriers to female interest in computer science education in the district, school, and community in question; and (b) exploration of strategies that others used to stimulate the interest of females in computer science education. The desired outcome was to frame a solution in the school of service that would result in increased enrollment of females in high school computer science education that would prepare them for current and emerging technology careers.

Problem Statement

As printed in the Occupational Outlook Handbook, "employment of computer and information technology occupations is projected to grow 12 percent from 2014 to 2024, faster than the average for all occupations" (U.S. Department of Labor, 2015, para. 1). However, in keeping with current statistics, the majority of these jobs will be pursued and occupied by men.

This statement, in and of itself, nurtured a concern regarding the disproportionate number of females represented in the field of computer science.

Recognizing that the absence of females does not begin at the industry level, I intended to investigate the K-12 educational implications related to this dilemma. Inquiry commenced with a literature review in anticipation that it would lead to a proposal of endorsed methodologies/strategies that could serve to awaken and promote female students' interest in computer science education at the secondary level. However, based on conversations with colleagues, building/district administrators, and state consultants, interest has to be created before students enter high school. This signified that additional efforts would have to be exercised to get the attention of female middle/junior high school student, thus, narrowing the central focus of the problem of practice to one of how can we capture the interests of female middle/junior high school students so they enroll in CS programs once they enter high school**.** It was anticipated that a solution to this problem would stimulate increased female enrollment in courses that would prepare them for entry into current and emerging technology career fields. Further explanation has been conveyed through the five dimensions of a problem of practice.

Focuses on Instructional and/or Systemic Issues

The need to increase the number of females in the area of computer science education was an issue that had characteristic implications of an instructional and/or systemic nature. As such, failure to increase course enrollment and/or course completion of this subgroup would continue to find districts/schools out of compliance with federal regulations, namely the Carl D. Perkins Career and Technical Education Act of 2006 (Perkins IV). As recorded on its Web site, the Office of Career, Technical, and Adult Education (2016) provided the following explanation of the Act:

> The Carl D. Perkins Career and Technical Education Act of 2006 (Perkins IV) is a principal source of federal funding to states and discretionary grantees for the improvement of secondary and postsecondary career and technical education programs across the nation. The purpose of the Act is to develop more fully the academic, career, and technical skills of secondary and postsecondary students who elect to enroll in career and technical education programs. (para. 1)

Perkins IV measures secondary programs through six established indicators, two of which address nontraditional students (non-trad): Indicator 6S1 (Nontraditional Participation in a Career Education Program) and Indicator 6S2 (Nontraditional Completion of a Career Education Program). To demonstrate the connection between the Act and the problem statement, an explanation of the phrase "nontraditional students" is warranted. As defined by the Perkins Act, nontraditional students are "persons who elect to enter a career or technical education program which prepares them for entry into a career, for which individuals from one gender comprise less than 25% of the individuals employed in such occupation or field of work" (Perkins IV/CTEA–Basic Definitions, 2013, p. 2). Failure, therefore, to meet indicator requirements affects funding for schools, districts, and the state. Though seemingly small, this problem was deemed to be one that would require the interactive involvement of teachers, students, and content, as well as a collaborative effort on the part of leaders, schools, and communities.

Is Directly Observable

At the stage of problem proposal, it was plausible to assume that low enrollment might not be the real issue, but merely a symptom of a more in-depth problem, which was yet to manifest itself. In anticipation of additional revelations regarding female enrollment, a suggested list of possible concerns that could arise included:

a. Females might not be interested in computer science.

b. Family career traditions/expectations preclude CS as a viable option to explore.

c. Females' choices are inhibited by cultural factors such as stereotypes.

d. Educators (teachers, counselors, and administrators) serve as deterrents to females' interest in computer science.

Though not all-inclusive, the proposed list did provide a preview of alternate directions in which this research could travel. After an intense study of the matter, the expectation, therefore, was that additional observable factors would be uncovered.

An initial look, however, at the stated problem of practice was somewhat empirical in nature in that low female enrollment was confirmed through analysis of participation data—current and historical course enrollment and Perkins IV Accountability Indicators Reports. Data reported on the South Carolina Department of Education (SCDOE) Website for school years 2010-2011 through 2014-2015 revealed the following about South Carolina: The state, nor the school district in question, met the established nontraditional participation goals during any of the aforementioned school years. Table 1.1 displays specific details of the state-level report (SCDOE, 2017).

Table 1.1
Perkins IV Accountability Indicators for South Carolina

Perkins Indicator	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
6S1—Nontraditional Participation	Goal: 14.0% Actual Performance: 13.87%	Goal: 14.2% Actual Performance: 13.04%	Goal: 14.4% Actual Performance: 13.10%	Goal: 14.4% Actual Performance: 14.32%	Goal: 14.6% Actual Performance: 14.48%

The numerator = total number of concentrators of the underrepresented gender enrolled in Career and Technical Education (CATE) programs identified as leading to nontraditional training and employment. The denominator = total number of concentrators enrolled in CATE programs identified as leading to nontraditional training and employment.

Further demonstration of the observability of the problem of low female enrollment was found in school-based data. The Career and Technical Education (CATE) Department at ZBFHS presents the following: Over the course of the last 11 years, female versus male enrollment in upper-level computer science classes had been 8 to 165. This was 5% of the total computer programming population at a school with a student population of 3065. Statistics reported by teachers at the district's other high schools were similar.

Is Actionable

This problem was actionable in that its solution would not only apply to improvements at one school, but could serve as the foundation for progress in the District, the Tri-County Region, and even the State. A solution could also have the propensity to affect enrollment of females in computer science education at the post-secondary level, with implications for a forward move in the employment of more women in current and emerging technical fields.

Furthermore, the ability to stimulate change in the problem lay in the need to identify the barriers that currently impeded females' decisions to enroll in computer science and related course offerings. Once identified, these obstacles could be addressed in a manner that would bring about meaningful change in the underrepresentation of females in high school computer science education.

Connects to Broader Strategy of Improvement

The college and career readiness initiative in South Carolina subscribes to the Perkins mandate to meet the participation in and the completion of secondary and postsecondary students in nontraditional programs. Increasing female enrollment/completion in the area of computer science education was in line with the initiative and with the Perkins legislation. Additionally, this problem was linked directly to the District's goal for Curriculum, Instruction, and

Assessment: "to develop, implement, and monitor an innovative curriculum that promotes personalized learning and continuous academic improvement while supporting the 21st Century learner" (Dorchester District Two, 2013, p.6).

Is High-Leverage

Bringing about a solution to this problem of practice would not only make a significant difference for student learning and District goal attainment, but could serve as a catalyst to better equip female students with technical skills required for entry into the world of work in the area of computer science and in other technical career fields. Additionally, a solution to the problem would enable the school and school system to meet current policy demands that focus on gender issues in the area of computer science. Finally, the researcher would benefit from this work by being better prepared to navigate the challenges that come with school improvement efforts/initiatives.

Research Questions

This study, designed to discover why there are not more females in the targeted courses, required an answer to two central research questions: (1) Why are female students underrepresented in computer science education at ZBF High School? and (2) What factors do female students identify as influences on their decisions regarding computer science education? Answers to these questions have the potential to encourage development and implementation of strategies/policies that would eliminate/reduce barriers to female enrollment, thus engendering change in a significant way.

Overview of Methodology

The need to increase access, role models, and experiences in computer science education for females were concerns that were addressed in the assumptions section of this chapter and were ones that the researcher believed contributed to the lack of female interest in the CS field and/or course of study. These issues, coupled with the stereotype of computer science being a male-dominated career field, warranted an investigation into the underrepresentation of females in the industry. Although no laws or statutes had been violated, this problem could have been viewed by some as an unfair disadvantage for girls and women when it came to equal access to CS education. Because of the social injustice implications associated with the problem of practice, a transformative mixed methods design was used. As defined by Creswell (2014):

> Transformative mixed methods is a form of mixed methods design in which the researcher identifies one of the qualitative theoretical frameworks (e.g., indigenous populations, females, racial and ethnic groups, disabled individuals, and so forth) and uses the framework through the mixed methods study, such as to establish the research problem, the questions, the data collection and analysis, interpretation, and the call for action. It is used in conjunction with explanatory, exploratory, and embedded designs. (p. 249)

For this study, data collection methods entailed the use of surveys and focus group interviews to collect quantitative and qualitative data that was transcribed and coded for analysis and interpretation. Additionally, it was anticipated that a cursory look at student enrollment and course enrollment data might have been necessary to validate some of the demographic information but proved to be unnecessary. Invitations were extended to 120 ninth-grade females; however, slim return of parent consent forms permitted data collected from only 24 first-year female freshmen at ZBFHS, some of whom were invited to participate in a focus group after initial analysis of data.

As the study progressed, it was anticipated that it might become necessary to assess the attitudes, perceptions, and interests of school/district personnel and community stakeholders as they [attitudes] related to gender diversity in the area of computer science and information technology. Again, this measure proved to be unnecessary. According to Sanders and Sullins

(2006), “Regardless of the specific data collection methods that you use, to collect adequate amounts of accurate data you will need sufficient buy-in from the participating stakeholders” (p. 39, para. 3).

Positionality

As defined by Ravitch and Carl (2016), “Positionality refers to the researcher’s role and social location/identity in relationship to the context and setting of the research” (p. 6). As such, this section of the proposal will share information about the author’s role and any assumptions and biases brought into this study as both a researcher and a practitioner.

The Researcher

For the past 17 years, I have been employed as a computer science and information technology instructor at ZBF High School. The last 11 years were spent teaching computer science-related courses—exploring computer science, computer programming (Java, Python, Visual Basic, Scratch, and Snap!), database design with SQL programming, and Web design with HTML and JavaScript. Job responsibilities also required serving as the coach to teams of programming students who participated in the annual Tri-County QUEST Academic Competition and most recently, collaborated with core-course instructors on techniques for infusing computational thinking into their content areas. All of this has been great; however, getting to this point in my career was not easy. What’s more, the makeup of students enrolled in computer science education has remained much the same as 11 years ago—predominantly male.

Since the “early” days of computer programming and data processing (Fall of 1979), a general interest in the two areas eventually developed into a love for both fields, but not without obstacles along the way. As an African-American female on a predominantly white university campus enrolled in a course of study dominated by Caucasian males, expectations for success were mostly nonexistent. An unsuccessful attempt in CSCI 110, PL1/PLC programming, did little to improve the outlooks of major course professors and served to shake my confidence in my abilities to succeed academically. This experience, coupled with the lack of support from an all-male computer science faculty, led to a change in major.

Although unsuccessful in that first course attempt, interest in the field of computer science never waned. Moving to the school of business did not eliminate the need to take programming and data processing courses but ushered in a different approach to teaching methodology. Accompanying this was a better system of student support from professors who recognized that deficiencies did not mean students could not experience success.

Biases on my part included memories of the “computer science mishap” from my undergraduate days. Instead of hindering my academic pursuits, those experiences nurtured my desire to continue developing my knowledge of computer science and fortified my obligation to assist other non-trad females in male-dominated career fields/courses of study. Hence, instead of being the negative agents that they could be, the biases, instead, propelled the search for answers to rectifying the underrepresentation of females in computer science education at ZBFHS. To prevent researcher biases from damaging the credibility of the study, procedural precautions were implemented. These safeguards, as outlined by Maxwell (2013), included triangulation of data sources and methods, respondent validation, and searching for discrepant evidence and negative cases. (pp. 125-129)

Assumptions

Assumptions for this work were based on background, experiences, and employment as a computer science and information technology instructor. As discussed in the previous section, the tendency to interject personal biases into the process was conceivable; however, recognized strategies were executed to curtail any negative impact on results.

The proposed problem of practice brought with it the following researcher assumptions: First, school and community leaders are not as supportive of computer science as they are of other course areas, thus creating barriers to enrollment for female students. Second, students are susceptible to the wishes/influences of peers whose encouragement/discouragement oftentimes guide them away from courses that might not align with peers' thinking/interests. Third, based on experience, most female students do not know any same-gender computer scientists with whom they can identify. Fourth, female students lack academic confidence and think that they do not possess the skills and abilities to be successful in computer science education and/or careers. Fifth, math is one of the foundational requirements for computer science, yet teacher expectations for female students are often different from the expectations of male students enrolled in the same math and/or other STEM-related prerequisite classes. Finally, the school did not have specific recruiting/marketing strategies to encourage females to enroll in computer science education courses.

Definition of Key Terms

This section provides a list of key terms and their definitions. Inclusion of this piece clarifies specific vocabulary that might not be easily decoded in the reader's context. Terms include:

1. Academic Self-Efficacy: student confidence in ability to perform well academically (Chemers, Hu, and Garcia, 2001, pp. 58-59).
2. Computational Thinking: a problem solving process that uses pattern recognition, abstraction, decomposition, and algorithm design (Google, 2015).

3. Computer Science: using the power of computers to solve problems (CODE.org, 2016).
4. Nontraditional Student (non-trad): persons who elect to enter a career or technical education program which prepares them for entry into a career, for which individuals from one gender comprise less than 25% of the individuals employed in such occupation or field of work (Perkins IV/CTEA–Basic Definitions, 2013, p. 2)
5. Student Perception: a personal interpretation of information from our (the student's) own perspective (The National Research Center for the Gifted and Talented, 2002, p.2).
6. Perkins IV: a principal source of federal funding to states and discretionary grantees for the improvement of secondary and postsecondary career and technical education programs across the nation (Office of Career, Technical, and Adult Education, 2016).
7. Stratified Random Sample: a sampling method that allows the researcher to build in *levels or categories* to ensure each of the crucial components of a population is taken into account (Abbott, 2011, p. 155).

Organization of the Dissertation

This dissertation has been organized into chapters, sections, and sub-sections to provide a structured layout for the reader and to serve as an agenda that will apprise him/her of expectations to be encountered in later chapters. To foster an air of anticipation, an introduction to each chapter, along with a synopsis, is provided so the reader will know what to expect when he/she peruses each chapter.

Chapter 1 discusses the problem of practice, with explanations of its different components. It sets the stage for the direction of the literature review and the inquiry methods to be used. Chapter 2 presents a summarized discourse of literature that is related to the problem of practice and explains its foundational support of the primary research question and its associated sub question. It also presents the conceptual framework upon which this study is established. Chapter 3 details the inquiry portion of the study, to include participants, procedure, research methodology, data analysis, and results. Chapter 4 presents the analysis of both quantitative and qualitative data collection, which includes outcomes of statistical tests run on data. Multiple tables and figures have been included to helps the reader better visualize the data and subsequent results. Finally, Chapter 5 discusses the findings and their implication. Recommendations have been given, as well as suggestions for future studies.

CHAPTER TWO—LITERATURE REVIEW

Introduction

The purpose of this study was to examine the problem of practice on how to increase the number of females enrolling in computer science education (CS) at ZBF High School (ZBFHS). The focus of the problem was on capturing the interests of female middle/junior high school students so they elect to enroll in CS courses once they enter high school. This undertaking was significant because of its direct relationship to a nationwide problem—the disparity in the number of females employed in the field of information technology, particularly in the area of computer science.

As such, this quandary was investigated from two perspectives: (a) examination of barriers to female interest in computer science education in the district, school, and community in question and; (b) exploration of strategies that others used to stimulate the interest of females in computer science education. The desired outcome was to frame a solution in the school of service that would result in increased enrollment of females in high school computer science education that would prepare them for current and emerging technology careers.

In preparation for review of the literature, periodicals/information were accessed from several sources. These included databases, research networking sites, academic search engines, professional websites, government sites, and scholarly books. Databases/search engines/networking sites included ProQuest, ERIC, Google Scholar, the University of Arkansas Library, Research Gate, and Semantic Scholar. Review continued to be active throughout the data collection and analysis phases to insure that the most up-to-date information was included in this study. Table 2.1 lists the reviewed source documents.

Table 2.1
Types and Number of Sources Reviewed

Type of Source	Number Reviewed
Peer Reviewed Articles	29
Scholarly Books	6
Scholarly Websites	2
Professional Websites/Publications	20
Government Reports/Websites	8
Research Networking Site	5

Review of the Literature

"Women have played a vital role in the field of computer science and information technology (IT), developing some of the most essential components of modern IT" (Purdue University Global, 2018, para. 1). Some of the most noted contributors to the field include Ada Lovelace, the first computer programmer; Grace Hopper, computer programmer and inventor of the compiler; Katherine Johnson, NASA mathematician; and Megan Smith, the first female chief technology officer of the United States. A visit to The Ada Project (TAP), a website dedicated to providing information about women in computing, revealed just how involved women have been in the field, while also informing visitors about the prominent roles females continue to play in CS. With a history so rich where female involvement is concerned, one has to wonder why women are in the computer science minority today.

Using that as a springboard, this examination of the literature sought to analyze, organize, and report the findings of literature relevant to the problem of practice (Bloomberg & Volpe, 2016): increasing female enrollment in computer science education at ZBFHS. As presented in

Chapter 1, the condition of low female enrollment was attributed to existing and perceived barriers that deter females from selecting these courses as part of their high school studies. The chapter also pointed to the need to stimulate their [females] interest in CS long before they enter high school. As such, this literature review communicates the conclusions of others who have engaged in research and offered academic enlightenments associated with the underrepresentation of females in computer science and its related fields.

Issues of Ethics, Economics, and Equity

"Computer science (CS) is the only science, technology, engineering, and math (STEM) major that has experienced a precipitous decline in the representation of women" (Beyer, 2014, p. 153). As reported by the National Science Foundation (2017), only 18.1% of computer science Bachelor's degrees in the United States were conferred on women in 2014. "While women have reached parity with men among S&E degree recipients overall, they constitute disproportionally smaller percentages of employed scientists and engineers than they do of the U.S. population" (National Science Foundation, 2017). These facts independently sound a nationwide alarm as it regards females in computer science.

Why should we continue to be concerned with the underrepresentation of women in CS? What difference, if any, will a change in status make to the United States economy? Why are females not enrolling in CS courses and/or declaring CS as an intended major? Each is a question that requires an answer, yet there seems to be few answers to find. Why, then, should another study be dedicated to the investigation of low enrollment of females in computer science education and/or the CS industry? In reporting the current state of women in CS, Computer Science.org (2018) presents details that confirm the need for additional studies:

> As STEM-related industries on a whole add over 1.7 million jobs in the coming years, there continues to be a notable absence of women in the field. This trend begins well

> before entering the job market: girls account for more than half of all Advanced Placement (AP) test-takers, yet boys outnumber girls 4:1 in computer science exams. In Mississippi, Montana and Wyoming, not a single girl took the AP Computer Science examination in 2014. There is a clear disconnect between the computer science industry and the message girls receive about their ability to succeed in tech organizations. (para. 1)

Beyer (2014), affirmed that women's underrepresentation in CS is an important topic for economic and social justice reasons. She posits that the underrepresentation of women raises ethical questions surrounding fairness and equity related to the lucrativeness of the career and the realization of a smaller gender pay gap than in other areas. "Thus, women's underrepresentation in CS hurts their income potential" (p. 154). With a projected shortage in a field that is growing faster than any other, this presents "an economic consequence for the USA and most other Western countries experiencing a similar problem with female underrepresentation. Thus, the low number of women in CS hurts the ability of businesses to hire qualified employees" (Beyer, 2014, p. 154).

Margolis and Fisher (2002) contributed much to the growing body of knowledge on the underrepresentation of females in computer science. They addressed the predicament of women and girls being "out of the science loop" (p. 1) despite the multitude of technology changes that affect our personal and professional lives. Even though their research was conducted more than 20 years ago, their contributions revealed issues of economics and equity that ring true today:

> At the turn of the century, women are surfing the web in equal proportion to men, and women make up a majority of Internet consumers. Yet few women are learning how to invent, create, and design computer technology. In the nation's research departments of computer science, fewer than 20 percent of the graduates are female. Fewer still enroll in high school programming or advanced computer science classes. Despite the relative youth of the computer industry, much of which has developed since the rise of the women's movement, women have lost ground in the world of computing. As featured in a thirty-year-old children's book titled *I'm Glad I'm a Boy! I'm Glad I'm a Girl!*, the gender distinction "boys invent things and girls use things that boys invent" remains uncomfortably true today. (p. 2)

Addressing issues of ethics, economics, and equity positioned the problem of practice in a global perspective and provided a context that framed the foundation for this work; however, before framing a solution, an inquiry into enrollment barriers—real and perceived—was necessary. Obstacles to be considered were social and cultural in nature and included concerns related to gender, self-efficacy, attitude, ability, interest, computer use, and academic motivation, to name a few.

Barriers to Female Enrollment in CS Courses

Much like its "sister" math-intensive STEM career of engineering, computer science plays a significant role in the economic life of the U.S. and in other world economies and can be observed in many facets of everyday life. However, both continue to fail in their ability to attract more females to select either as a course of study and/or as a worthwhile career field. Madara and Namango (2016) denote this in their study in Kenya on the perceptions of female high school students on engineering. To gain a better understanding of the underrepresentation of females in the CS industry, an examination of literature turned its attention to some commonly known perceptual/real barriers that deter females. These hindrances include gender, self-efficacy and abilities, stereotypes, federal policies, and other incidental barriers—poverty, peer pressure, age related to gender, age and its effect on self-efficacy, and teaching strategies and educator perceptions of gender/ethnic differences among students.

Gender. The matter of gender in the field of computer science and other technical areas is not new, but is a subject that has served as a theme for many research studies (Buzzetto-More, Ukoha, & Rustagi (2010); Kwasnik & Karwowski, 2015; Margolis & Fisher, 2002; Skelton, 2010;). When taken from a universal viewpoint, gender disparities in computer science contribute to missed opportunities for women to participate in a profitable and powerful field, as well as deprive society of the benefits that perspectives of diversity can offer (Cheryan, Plaut, Handron, & Hudson, 2013; Margolis & Fisher, 2002).

Cai, Fan, and Du (2016) report that gender difference in the attitude toward technology use has long been a concern in education. In their meta-analysis of empirical research studies on the matter of gender, they found that males still hold more favorable attitudes toward technology use than females. In fact, when compared to the meta-analysis of two decades prior, there was only a "minimal reduction in the gender attitudinal gap in general" (p. 1). As it relates to high school students when compared to their postsecondary counterparts, Cai, Fan, and Du (2016) presented results that indicated "secondary students showed large gender attitudinal gap with regard to technology use than college students in general" (p. 9). They were careful, however, to point out that future research might want to focus on the issue of age and its relationship to the gender attitudinal gap toward technology use.

When accounting for achievement gains, popular perception would have us believe that the academic success of girls is attributed to their having "taken up the kinds of gender performances in the classroom previously associated with boys" (Skelton, 2010, p. 131). However, studies completed inside classrooms show that even amid the highest achieving groups of student populations, "girls are anxious about doing well and concerned about their relationships with other pupils" (Skelton, 2010, p.131). As expounded by Margolis and Fisher (2002) in their Carnegie Mellon study, "Significant gender differences in attitudes and experiences with computers appear at the earliest ages. These differences are crucial to understanding the roots of the gender gap in undergraduate computer science and for devising effective interventions" (p. 80). It should be noted that prior to entering college, "women have significantly less hands-on experience with computing than most men" (Margolis & Fisher, 2002, p. 80). As for the relationship between age and gender differences in overall computer attitude, Kay (2008) made this observation:

> In elementary school (grades 1-5), females appear to have slightly more positive attitudes about computers, although the number of tests was small (n=9). In middle school, females and males have similar attitudes toward computers, but in high school, males show more positive attitudes, a bias that continues in university. Male and female preservice teachers and graduate students have similar attitudes toward computers, but the general adult population shows a strong male bias. This pattern is consistent with previous reviews of gender and technology. Males and females do not start out with different feelings and thoughts about computers; they emerge over time and seem to be influenced by education level and culture. (pp. 16-17)

Taking a "page" from the *New York Times* bestseller, *Men Are From Mars, Women Are From Venus*, Charles (2017) explored the relationship on "how the gender gap in aspirations for scientific, technical, engineering and mathematical (STEM) work changes with societal affluence" (p. 1). Although her study was specific to the general STEM field, the merits of the work are applicable to computer science and its particular gender matters. "We cannot possibly understand women's underrepresentation in science and technology in the United States and other advanced industrial labor markets without understanding the social underpinnings of gender-differentiated aspirations and affinities" (Charles, 2017, p. 2). Using data that was collected from 32 countries between the years of 2003 and 2011, she investigated the "relationship between societal affluence and eighth-graders' aspirations for mathematically-related jobs." The results revealed that as societal affluence grew, aspirations became more gender differentiated. This, in part, was attributed to this plausible explanation: regular Internet use that increased "students' exposure to Western cultural values and gender stereotypes that are disseminated online and/or by increasing students' experience with information technologies" (p. 2). To aid the understanding of this finding, Charles (2017) provided additional research-supported information as to how gender stereotypes influence aspirations:

> Gender stereotypes influence work aspirations in at least three ways. First, people's assessments of their own (and others') competencies may be biased by gender stereotypes. Second, gender stereotypes may bias people's expectations about what they will enjoy doing. And third, people may aspire to gender-conforming work ("do gender") to affirm their normative masculinity or femininity or to avoid social disapproval by peers, family, or employers. The general implication is that individual aspirations and cultural stereotypes are largely co-constitutive and their relative effects on behavioral outcomes cannot be clearly separated. (p. 2)

Charles (2017) concluded by noting that young people usually do not know what they want to do, so they tend to choose their paths based on stereotypes of what same-gender influencers might do or might be good at. For instance, girls tend to choose work that is more people oriented/emotionally rewarding rather than select fields that have traditionally been stereotyped as requiring more masculine traits and aptitudes. Her recommendation is to diversify the image of STEM occupations and degrees by making significant inroads into reversing the cultural stereotypes about the field. This, however, is something that will not happen overnight.

Yielding to similar circumstances in other technologically advanced nations, gender differences not only manifest themselves in attitude, efficacy, and aspirations, but also exist in CS course selections, especially at the collegiate level. In a study of 89 graduates in the CS and Technology Department at University of Peloponnese, Tripoli, Greece, findings revealed the following: (a) The percentage of female graduates was less than that of male graduates. (b) Girls showed a general indifference toward programming lab-based courses. (c) Although girls and boys equally chose courses from the Computer Technology Division, some of the courses were not selected by any of the girls. (d) More girls than boys chose general education courses. (e) A higher percentage of girls chose humanities and social science related courses. (Kordaki and Berdousis, 2013). To what do they attribute these outcomes:

> The fact that often times boys tend to monopolize instructors' time, leaving the girls to try and figure thing out on their own, can frustrate young girls. Moreover, more boys are positive and more girls are negative towards computers. Women tend to avoid CS

> because of the 'tinkering' aspect of the field, in spite of being attracted to the mathematical and logical aspects of computing. Even though they perform at the same levels, women have less confidence in their abilities and individual accomplishments than men and report feeling 'out of place' in the male-dominated, hacker culture. The most harmful factors causing this low self-confidence are the discrimination both within the classroom and within the family, the limited access to computers both at school and at home and the hostile and uncomfortable environment created by boys when participating in computing activities. (p. 4771)

The authors stated that the results of this study could not be generalized; however, their findings do align with results of other works presented in this study. They also recommended that additional studies be conducted that would go beyond looking at course selections by considering course performance as a characteristic of gender disparities in CS.

Finally, in their pursuit to analyze the "Anatomy of an Enduring Gender Gap," Sax, Lehman, Jacobs, Kanny, Lim, Monje-Paulson and Zimmerman (2016), sought to explain the CS gender inequities by studying nationwide survey data of college students over a period of 4 decades. Results of their study revealed many fluctuations in students' interest in computer science from 1971 to 2011, and is summarized as follows:

> In the early days of computer programming, computer science was not yet defined as a science but was believed to be more clerical in nature. However, as demand for individuals with programming skills increased, computer science also sought legitimacy as a field. . . .In doing so computer science distanced itself from skill sets traditionally thought to be well suited to women and sought to align itself with other science fields, like engineering that had strong masculine connotations. Additionally, in the mid-1980s, the narrative around computing became gendered, such that tech companies and the media portrayed computing as a predominantly male enterprise. . . .Further, media depictions of computing . . . emphasized the male computer nerd/geek stereotype. Hence, computer science increasingly became a field predominantly associated with men at the same time that opportunities for careers in computer programming expanded. Finally, women's declining representation in computing during the dot-com "bubble" of the late 1990s is owed in part to an increase in weed-out courses that, although intended to manage growing enrollments, ultimately discouraged disproportionate numbers of women from computer science. (pp. 23-24)

Despite these findings, they recommend continuing the investigation to seek influences on women's participation in CS, especially since there is a renewed effort to make computing more attractive to female students, particularly those at the K-12 level.

Self-efficacy and abilities. The Theory of Self-Efficacy, an embedded construct in Bandura's Social Cognitive Theory (SCT), shines a spotlight on changes in an individual's behavior and or interests in response to his/her beliefs about achievement abilities. Bandura (2017) highlights the importance of self-efficacy and belief as he suggests:

> Among the mechanisms of human agency, none is more central or pervasive than people's beliefs in their efficacy to influence events that affect their lives. This core belief is the foundation of human inspiration, motivation, performance accomplishment, and emotional well-being" (Bandura, 2017, para.1).

The SCT, as explained by Nabavi (2012), is a learning theory based on the idea that "people learn by watching what others do, and that human thought processes are central to understanding personality" (p. 11). The connective component of the construct to the theory lies in the beliefs of self-efficacy, which are realized "through cognitive, motivational, emotional, and decisional processes" (p. 15). These beliefs are central to the "self-regulation of motivation through goal challenges and outcome expectations" (p. 15), thus affecting "one's ability or capacity to execute a behavior successfully" (p.15-16). To obtain a clear vision of self-efficacy's role in the underrepresentation of females in CS, discussion will turn to the concepts of perceived self-efficacy and academic self-efficacy.

Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that influence other matters of life. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave. Such beliefs produce these diverse effects through previously mentioned processes (Bandura, 1994). It is these processes that stimulate a student's levels of perceived self-efficacy, which are further influenced by the four sources of (a) mastery experiences, (b) vicarious experiences provided by social models, (c) social persuasion, and (d) perceptions of physical and emotional reactions (Bandura, 1994, 1997).

Mastery experiences relate to an individual's successes and failures. "A resilient sense of efficacy requires experience in overcoming obstacles through perseverant effort" (Bandura, 1994, Section 1). It is suffering through the setbacks, frustrations, and tough times that ultimately serve to convince people that they can overcome the obstacles and succeed (Bandura, 1994). As conveyed by Bandura (1997), "Enactive mastery experiences are the most influential sources of efficacy information because they provide the most authentic evidence of whether one can muster whatever it takes to succeed" (p. 80).

As alluded to in the list of self-efficacy sources, "People do not rely on enactive experiences as the sole source of information about their capabilities. Efficacy appraisals are partly influenced by vicarious experiences" (Bandura, 1997, p. 87). Vicarious (secondhand) experiences provided by social models involve "seeing people similar to oneself succeed by sustained effort" (Bandura, 1994, Section 1, para. 3). This permits the observer to believe that he/she, too, has the capabilities to master comparable tasks.

The third technique for reinforcing people's belief in their ability to do well focuses its attention on social persuasion. This component of self-efficacy proposes that people are verbally persuaded to believe that they possess the capabilities to succeed. Igbaria and Iivari (1995) refer to verbal persuasion as "perceived encouragement and support from others" (p. 588). We are, however, to use caution in relying solely on persuasion, as it could have the reverse effect if some have already convinced people that they lack capabilities. People would then develop a tendency to "avoid challenging activities that cultivate potentialities and give up quickly in the face of difficulties" (Bandura, 1994, Section 1, para. 6).

Lastly, we address the source known as perceptions of physical and emotional reactions. This self-belief modification scheme uses strategies that "reduce people's stress reactions and alter their negative emotional proclivities and misinterpretations of their physical states" (Bandura, 1994, Section 1, para. 8). These modifications are designed to regulate and strengthen perceived coping self-efficacy, which when strong, encourages a person to take on more demanding and intimidating activities (Bandura, 1993).

In describing academic self-efficacy, Chemers, Hu, and Garcia (2001) state, "Academic self-efficacy is related to students' confidence in mastering academic subjects" (p. 56). They continue their discourse by declaring, "Efficacy beliefs influence the particular courses of action a person chooses to pursue, the amount of effort that will be expended, perseverance in the face of challenges and failures, resilience, and the ability to cope with the demands associated with the chosen course" (p. 55). It is beliefs like these to which one has to subscribe if he/she is to succeed in a course of study like computer science. However, self-efficacy related to CS, engineering, math, and science is all too often a quality that is either missing in the female arsenal or is much lower than that of her male counterparts (Felder, Felder, Mauney, Hamrin, & Dietz, 1995). This, in turn, can inhibit expectations of success and/or deter females from pursuing certain courses of studies/career fields. On average, when compared to boys, girls present with lower computer self-efficacy, higher levels of computer anxiety, and negative attitudes toward computers (Kwasnik & Karwowski, 2015).

As cited in a work by Fan and Williams (2010), Bong, along with Schunk and Zimmerman, conclude that self-efficacy consistently predicts academic achievement due to its effects on effort and persistence, because students who demonstrate greater senses of self-efficacy are more likely to put forth the necessary effort and persist longer when facing academic challenges. Furthermore, parents play a major role in their children's levels of academic confidence, a statement supported by theories and research studies which "argue the existence of a relationship between parental involvement and self-efficacy" (Fan & Williams, 2010, p. 56).

In her study to determine why women are underrepresented in computer science, Beyer (2014) notes that "expectancies of success (i.e. self-efficacy) are critical in educational and occupational choices" (p.156). She continues by revealing that women are more inclined to have "low self-efficacy and believe they have little natural ability in male-dominated domains, including mathematics, chemistry, engineering, Management Information Systems (MIS), and CS. In a study on computer self-efficacy and attitudes towards computers, Berkant (2016) found that feelings of low self-efficacy can be gradually improved if students spend more time on a computer each day. They not only gain self-efficacy toward computer use but also gain self-efficacy in their daily lives and in education.

Stereotypes and computer science. "Computer science and engineering are stereotyped in modern American culture as male-oriented fields that involve social isolation, an intense focus on machinery, and inborn brilliance" (Cheryan, Master, & Meltzoff, 2015, p. 1). They also contend that women's choices are constrained by societal factors, particularly their stereotypes about the kind of people, the work involved, and the values of these fields. It is this vision that could be an "early in the pipeline" (p. 2) contributor to steering females and other minorities away from the fields.

In their studies on the campuses of Stanford University and the University of Washington, Cheryan, Plaut, Handron, and Hudson (2013) focused on the potential of various stereotypes to alienate women who might be interested in the field of computer science. They looked at specific characteristics that are often ascribed to computer scientists: technology-oriented, singularly focused on computers, lacking interpersonal skills, intelligent, physical features, and masculine. Their findings "suggest that negative effects of the stereotypes will be more pronounced among females than males" (p. 61); and the more pronounced the negative effects, the less similarity women feel to computer scientists (Cheryan & Plaut, 2010). If, however, the stereotypes were to be reduced and/or eliminated, females might change their minds about choosing computer science as a major and/or career choice (Cheryan & Plaut, 2010); Cheryan, Plaut, Handron, & Hudson, 2013; Cheryan, Master, & Meltzoff, 2015, Margolis & Fisher, 2002).

Despite common beliefs, stereotypes about CS do not suddenly manifest themselves during the teen years but appear as early as second grade, when "girls already hold stereotypes associating boys with math" (Cheryan, Master, & Meltzoff, 2015, p. 2). Labels like this tend to be societal in nature, given that "computer science and engineering stereotypes are perceived as incompatible with qualities that are valued in women, such as being feminine, people-oriented, and modest about one's abilities" (Cheryan et al, 2013, p. 4). Sadly, when it comes to conventional thoughts like this, "Often times, one stereotypical image communicates to everyone what kinds of people are supposedly successful and esteemed by others in the field" (Cheryan & Plaut, 2010, p. 485).

In keeping with this line of discussion, stereotypes are a perceived negative idea in many instances, and when left unchecked, the potential effects could eventually escalate into a concept known as stereotype threat. What is stereotype threat? As defined by Huang, Cotten, and Ball (2015), stereotype threat "is a 'situation-induced threat' that applies other's stereotypes to oneself, which will later have a negative impact on one's performance related to the aforementioned stereotype" (p. 2). In simpler terms, stereotype threat is "a theory that certain people may be at risk for internalizing the negative stereotypes. . ." (p. 1). Even though the research is inconclusive, "several negative effects have been linked to stereotype threat, including higher anxiety, lower performance expectations, and lower self-efficacy" (p. 2).

In his study on detecting stereotype threat on harder topics in introductory computer science, Kumar (2012) contends that "in computer science, stereotype threat is listed as one of the factors that could be contributing to problems with recruitment and retention of female and minority students" (p. 273). Results of the research by Huang, Cotton, and Ball (2015) support this view by suggesting, "Gender was a consistent determinant of STEM attitude and technology efficacy. Furthermore, race was found to be a predictor of technology anxiety." As such, these stereotypes had the inclination to "hinder entrance or interest in STEM related careers" and could eventually "have an impact on STEM related performance via the concept of stereotype threat" (p. 1).

Structural elements, pedagogy, curriculum, and career choice. When considering the pool of potential barriers to female enrollment in computer sciences courses, one has to contemplate what and/or who the key influencers are on girls' career choices. According to Adya and Kaiser (2005), there are three early determinants: social influences, structural variables, and individual differences. Having previously addressed some of the social influences, this section will lend itself to a discussion of structural factors, which include teachers/counselors, school and personal technology resources, and same-sex education versus co-educational schools. In addition to this list of items, curriculum and pedagogy have also been identified as variables that have a tendency to not only inspire career choices, but to also encourage girls' interest and participation in math, science, and technology (MST) courses (Baker, 2013; Goode, Peterson & Chapman, 2019).

When addressing structural factors, Adya and Kaiser (2005) spelled out their role and influence on career choice. In their words:

> Structural factors represent the institutional support available to women in pursuit of their careers. The role of teachers and counselors in exposing students to technology, access to computer technology both at home as well as in schools, and the nature of the school environment—same-sex or co-educational—are structural factors that can influence the genderization or neutralization of IT careers. (p. 10)

They also alluded to findings that "lean toward the negative regarding the role of teachers and counselors on MST career choices" and boldly introduced the notion that "Women in IT are mostly discouraged by teachers, guidance counselors, and male professors" (Adya & Kaiser, 2005, p. 10).

To stimulate females' interest enough for them to consider computer science as a viable career field, specific strategies to address achievement in gatekeeper courses such as science, math, and physics, have to be designed and implemented. Although her work was specific to science, strategies identified by Baker (2013) are also applicable to the field of computer science. She identified instructional strategies, curricula, and organizational structures as successful measures for encouraging girls' participation and achievement in science.

Baker (2013) begins her discourse by asserting that standards-based thematic units, if "framed around a few primary concepts that address real-world experiences of interest to girls, . . . can make a real difference in achievement when these activities are writing intensive, involve hands-on work, and require genuine inquiry" (p. 15). She continues with an enlightening communication that addresses a change in how teachers teach as a way of improving achievement:

> Instructional strategies that focus on the student, rather than the teacher, have been successful in narrowing the achievement gap between boys and girls, especially in the physical sciences in high school. The strategies include real-world experiences of interest to girls, student presentations to classmates, student participation in the development of rubrics to assess their own learning, and classroom interactions that value the student's point of view. (p. 15)

Examples of instructional strategies promoted by Baker (2013) included increasing hands-on laboratory experiences, actively involving girls during instruction, and utilizing design-based learning. As it relates to these strategies, she cautions:

> However, for these strategies to be successful, the teacher must provide sufficient materials so that everyone can participate. Having enough material to go around prevents some girls from being passive observers and prevents some boys from dominating the use of materials. Furthermore, the teacher must allocate enough time to complete hands-on inquiry activities, including time for revision and discussion. (p. 15)

Additional strategies that received a brief mention were out-of-school academic activities, homework, reading material with instructions on how to use reading strategies to focus attention, and grouping strategies.

As for curriculum, it, along with gender segregation of extracurricular activities, has been connected to the influence of the high school context on the gender gap and is believed to impact the STEM career choices of females (Legewie & DiPrete, 2014). They continue by suggesting that "a strong high school curriculum in math and science provides more opportunities for concrete experiences of interest and competence and thus provides a partial antidote to gender stereotyping and the discouragement of girls' interest in STEM fields" (p. 5). As a final point regarding the computer science component of a STEM curriculum, the "availability of teacher preparation that requires classroom teachers to grow their knowledge of CS content as well as the pedagogical practices that enhance inclusive learning opportunities for historically underrepresented students" is a prerequisite for implementation of curriculum that embraces gender-inclusive instructional design strategies (Good, Peterson, & Chapman, p. 394).

Incidental factors and federal policy. Numerous influences have been offered on the subject of the underrepresentation of women in computer science, the most proclaimed of which have been discussed. Nevertheless, additional factors were mentioned within the various cited studies; but the individual bodies of research on those elements as they relate to females were limited, thus justifying their exclusion in the literature review for this work. A few of the additional influences included poverty, peer pressure, age related to gender, age and its effect on self-efficacy, and teaching strategies and educator perceptions of gender/ethnic differences among students. Further [future] research on these stimuli is warranted, as data on said topics could shed additional light on the high school females' assessment of computer science.

Within this section, there is an interesting notion related to policy that is worth mentioning here. High schools are adding more STEM courses to provide opportunities for students to concentrate in technical areas that prepare them for entry into the "STEM pipeline" (Sawchuk, 2018, p. 4). "For more than a decade, politicians have raised concerns that not enough U.S students are specializing in these subjects, leaving the country reliant on talent from overseas to fill engineering and tech jobs" (p. 1).

Historically, federal education policies and computer science education at the P-12 level have had little connection, if any. In fact, it was not until recently that federal conversation geared itself toward the recognized need to expose every child to computer science. This movement began when the nation heard these words: "In the coming years, we should build on that progress, by … offering every student the hands-on computer science and math classes that make them job-ready on day one" (Obama, 2016, para. 21). This statement was made during President Obama's State of the Union address where he introduced his "CS for All" initiative, a programmatic policy that earmarked funds for various efforts to further the CS cause. Though a main component of the initiative was teacher training and expanded access to instructional material, it also included an element to draw the active support of CS industry partners.

President Trump (2017) seemingly kept the momentum going by requesting the Education Department to "establish promotion of high-quality STEM education, with a particular focus on Computer Science. . ." (sec. 2) by directing $200 million to this area of study. The intention of the funding policy was to provide an opportunity to all, but none more than disenfranchised groups—minorities, students in rural communities, impoverished groups, and females. This was evident when he stated:

> Today, too many of our Nation's K-12 and post-secondary students lack access to high-quality STEM education, and thus are at risk of being shut out from some of the most attractive job options in the growing United States economy. . . Minorities and students in rural communities often have even less access to Computer Science education. . . Furthermore, even where classes are offered, there is a serious gender gap: less than a quarter of the students who took the AP-CS A exam nationally in 2016 were girls. (sec. 1, para. 2)

The infusion of funds looks good on paper; however, the proposed 2018 Trump budget removed the line item for federal grants that schools could use for these programs. So how, then, is that going to further the cause of getting students, especially females, involved in computer science education?

Sawchuk (2018) reported on a new body of research being conducted by the National Center for Analysis of Longitudinal Data in Education Research (CALDER). This research, contradictory to new federal policy, suggests that adding more courses at the high school level "may be no panacea for producing more college students who take STEM classes or major in STEM fields" (p. 4). In answer to raised questions about just what changes are needed to improve outcomes in the field, Sawchuk (2018) cautioned the reader to beware that this new research is not without its own problems. One concern is the difficulty in determining the drive behind the findings, and secondly, the research does not account for the fact that students just might not be as interested in STEM as adults would like them to be.

Barriers: A System of Interdependent Events

As presented in this review, each barrier has been discussed as an independent entity, with each seeming to have equal influence on females' decisions about computer science. This, however, is not the case, as has been reported on the ComputerScience.org website (2019). It was their contention that it is "hard to pinpoint a single reason for the lack of female computer science majors" (section 2, para. 2). In keeping with their interpretation, this section expanded on the concept by presenting barriers as a system of related events, which operate as a unified force to influence females' decisions concerning computer science. Relationships that were considered included (a) the influence of cultural stereotypes on sense of self-efficacy, (b) policy impact on decisions and access, (c) the influence of same-gender role models on sense of self-efficacy, (d) the influence of self-efficacy on career and/or course of study decisions, and (e) the influence of community and/or environment on decisions—peer pressure/family support/exposure.

Social Cognitive Career Theory's Justification of Career Choices. Whenever you have multiple factors contributing to a problem, it is reasonable to accept that isolating one element will not bring about a solution, but viewing them as a system of events will move one closer to solving a problem(s). For instance, Social Cognitive Career Theory (SCCT), a construct with deeply rooted connections to Bandura's Social Cognitive Theory, provides an explanation of reasons for career choices. SCCT, a model attributed to Lent, Brown, and Hackett (1994), is "aimed at explaining three interrelated aspects of career development: (1) how basic academic and career interests develop; (2) how educational and career choices are made; and (3) how academic and career success is obtained" (p. 750). SCCT's foundational principles are linked to the variables of self-efficacy, beliefs, outcome expectations, and goals:

> SCCT assumes that people are likely to become interested in, choose to pursue, and perform better at activities at which they have strong self-efficacy beliefs, as long as they also have necessary skills and environmental supports to pursue these activities. (p. 750)

When taken together, the three elements of Social Cognitive Career Theory explain how career-related interests and choices develop over time. The authors illustrated this by using an example of the types and variety of activities to which children and adolescents are exposed. In their words:

> Exposure is partly a function of the context and culture in which they grow up. Depending on cultural norms, for example, girls are typically exposed to and reinforced for engaging in different types of activities than are boys. . . .As people develop interest in an activity, they are likely to develop goals for sustaining or increasing their involvement in it. (p. 751)

As indicated earlier in the literature review, interests have a tendency to change until children reach adolescence, the period in life when interests usually begin to stabilize; however, changes could possibly extend beyond this time. SCCT suggests that when and if changes do occur, it is a result of changes in self-efficacy beliefs and/or outcome expectations related to "exposure to potent new learning experiences (e.g., parenting, technological advances, job training or restructuring) that enable people to alter their sense of self-efficacy and outcome expectations in new occupational and avocational directions" (pp. 751-752). In summary, the development of self-efficacy, outcome expectation, interests, and goals related to career selection and/or courses of study were linked to environmental exposure.

Policy impact analysis. In its *Breaking through Barriers for Women and Girls* report on "Career and Technical Education for Women and Girls," The American Association of

University Women (AAUW) (2013) makes the following observation about the federal investments in career and technical education:

> The Carl D. Perkins Vocational and Technical Education Act funds vocational education programs at secondary and postsecondary institutions across the country. AAUW believes that the investment that the federal government makes in high quality career and technical education is essential to meeting the needs of the nation's evolving high-tech workplaces. The gender equity provision in the law sent the message that career and technical training is critical to ensuring that women have opportunities throughout their lifetimes to develop the skills needed to be competitive in the global economy. (p. 2, para. 2)

Additionally, AAUW (2013) "believes it is important that states be held accountable in both the participation and completion of women and girls in CTE programs" (p. 4, para. 4). Their position supports the belief that the Carl D. Perkins Career and Technical Education Act of 2006 (Perkins IV) could definitely be instrumental in encouraging school leaders to develop strategies that would eliminate/reduce barriers to female enrollment in computer science education courses.

Based on a 2015 survey, "More than nine out of ten parents want CS taught at their child's school." This desire was [and is] based on the recognition that today's students are "tomorrow's engineers, entrepreneurs and leaders who must be equipped with strong computational thinking skills and the ability to solve complex problems" (White House Press Secretary, 2016, para. 8). The press release goes on to present a challenge to the CS for All initiative:

> Access to CS education is limited and wide disparities exist even for those who do have access to these courses. For example, in the fewer than 15 percent of all high schools that offered any Advanced Placement (AP) CS courses in 2015, only 22 percent of those who took the exam were girls, and only 13 percent were African-American or Latino students. Media portrayals and widely-held stereotypes exacerbate this dynamic, with far more men than women depicted in technology roles in film and television roles. As highlighted in the first-ever White House Demo Day, these disparities in who gets included, and who feels included, are one reason why women compose less than one-third of the technical employees, and African-Americans less than three percent, at some of America's largest and most innovative technology companies. (sec. 2, para. 3)

Looking at the aforementioned policy reflection would lead one to believe that environmental impact of guidelines is a new dilemma; however, this is not the case. Policies related to computer technology, dating back to the early 1980s, have had a tendency to drive curriculum, access, use, implementation, and marketing/recruiting efforts of education programs in schools. It was during this era in education that the movement to incorporate microcomputers in the classroom had its beginning. These devices were to be used as assistive agents to help teachers with classroom instruction and to "broaden student's intellectual experiences" (McPhail, 1985, p. 3). This movement, however, was met with inequities in access, much like issues of access in today's school settings.

Although this report dealt more with computer literacy and use, the findings are applicable to current issues surrounding computer science. In referencing a study by the Minnesota Research and Evaluation Center, McPhail (1985) summarized their findings on computer inequity, "unequal access to computer learning as a consequence of social and economic status" (p. 4). He reported five areas of disparity: (1) inequity and wealth; (2) inequity and community size; (3) inequity and region; (4) inequity and gender; and (5) inequity and race. The area with the greatest bearing on this study was inequity and gender, which stated, "Females are less likely to take computer programming classes than are males" (p. 5). In his final analysis on computer inequities, McPhail (1985), made it known that:

> Some measure of the observed difference between males and females in interest and involvement with computers results from cultural socialization. However, there may be structural factors in the schools that serve to inhibit female participation in computer opportunities. . . .Unless conscious effort is made, particularly in high school classes, girls will continue to hang back while boys take over the computers. (p. 13)

He completes his conclusions by suggesting, "If computers are introduced into elementary classrooms, it is likely that boys and girls will use the computer, and conventional sex-role stereotyping will not have time to develop" (p. 13). This conclusion aligned with the 1974 Women's Educational Equity Act Program, whose purpose was:

> to promote educational equity for girls and women, including those who suffer multiple discrimination based on gender and on race, ethnicity, national origin, disability, or age, and to provide funds to help education agencies and institutions meet the requirements of Title IX of the Education Amendments of 1972" (U. S. Department of Education, 1994, sect. 1).

Although there are no federal, state, or local policies that specifically address enrollment of females in computer science and technology education courses, there are numerous regulations that have the proclivity to "leverage change" in the problem of practice. It should be clarified that individual school personnel cannot change policies, but with a little ingenuity in implementation design, school leaders could find suitable ways to work within the boundaries of what may be a rigid policy to effect the desired modification. In recognition of the power of "politics" in and on instructional decisions and/or program implementation plans, Figure 2.1 has been included to illustrate the gamut of policies that were believed to affect, directly and/or indirectly, the problem of practice.

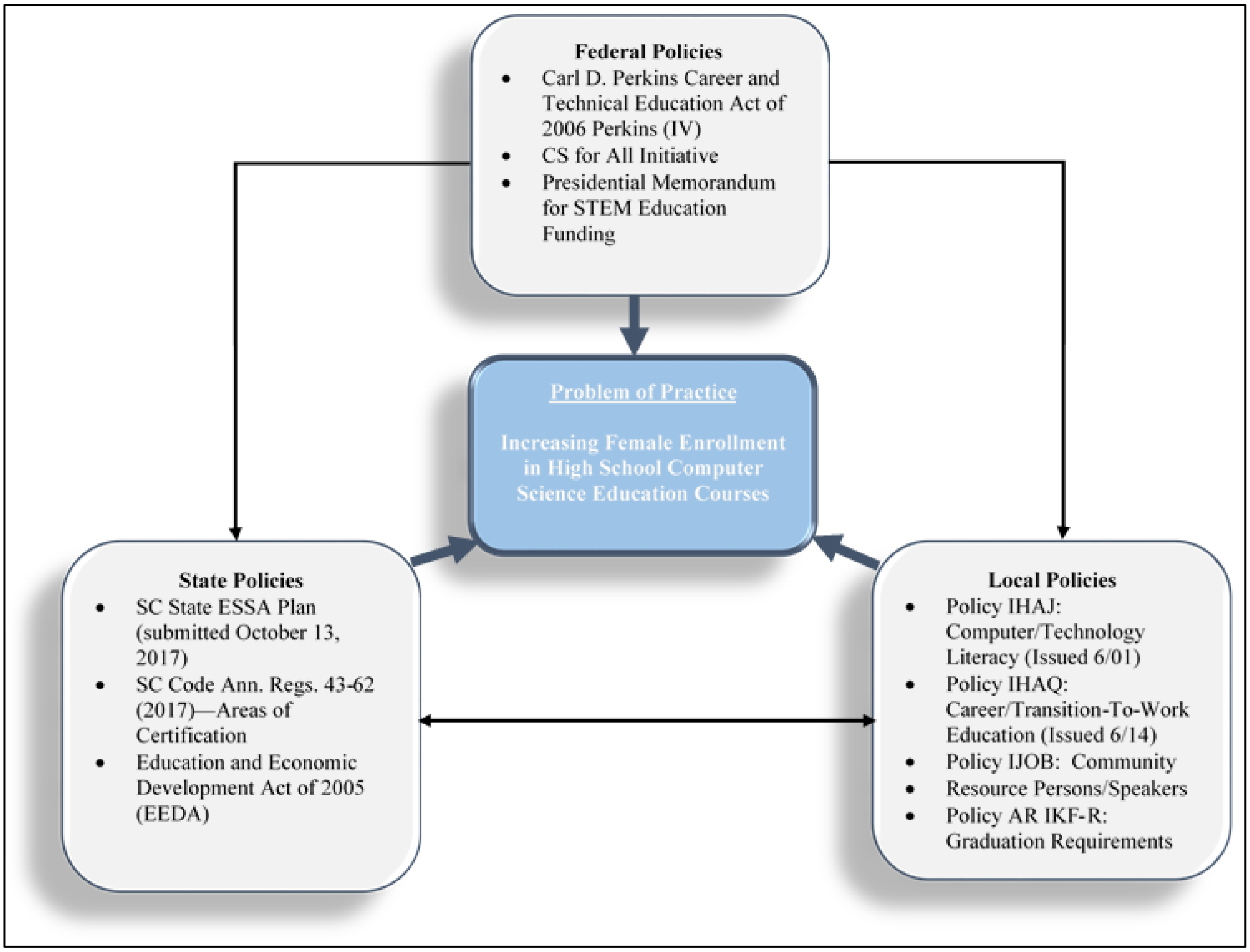

Figure 2.1 Selected local, state and federal policies that could directly and/or indirectly impact the problem of practice

Conclusion

Numerous scholars have endeavored to uncover reasons for female underrepresentation in computer science and other STEM areas; however, despite their efforts, many questions remain, especially where middle and high school females are concerned (Kim, Sinatra, & Seyranian, 2018). It is these critical years where female students require "STEM" nurturing and guidance in a direction that will stimulate their desire to consider CS and related STEM fields as college majors and/or careers. "Often, the moment to select a STEM major field of study has passed for many students if they do not enter college with this pursuit in mind" (Kim, Sinatra, & Seyranian, 2018, p. 590). This means that education personnel will need to be intentional in their efforts to encourage high school females to enroll in the required college-prerequisite math and science courses, as well as select CS course offerings that will prepare them for the rigor of the field.

As stated in Chapter 1, the need to increase the number of females in the area of computer science education is an issue that has characteristic implications of an instructional and/or systemic nature. Though seemingly small, this problem is one that will require the interactive involvement of teachers, students, and content, as well as a unified effort on the part of leaders, schools, parents, employers, and communities. Whether real or perceived, barriers to enrollment in CS courses and/or selection of CS as a course of study/career choice need to be reduced and/or eliminated where possible. Doing so will provide more equitable opportunities for females to enter the field. Moreover, if the system is to improve so that females view CS and related areas as viable career choices, universal program modifications are in order.

Although written to address conditions on post-secondary campuses, Margolis and Fisher (2002) recommended programmatic changes within computer science departments that could benefit the high school environment with implementation efforts to attract and retain female students in CS. As listed in their concluding remarks, recommendations for “unlocking the clubhouse” included:

- Take differences in experience into account. Admit inexperienced students who show promise, and provide them with appropriate curriculum tailored to their levels of experiences.
- Take differences in motivation into account. Revise assignments, courses, and curricula to ensure that they serve the interests and orientations of students who are

studying computing because of what it can do, as well as those studying computing just because they like it.

- Remember that everything bad that happens is even worse for "outsiders." Weed-out courses in which many students receive low grades or fail are virtually guaranteed to drive out differentially female and minority students, regardless of their talent. Indifferent teaching, untrained TAs, and carelessly administered labs will have similar effects.
- Measure. Know who is applying, who is coming, who is staying, and who is leaving. Find out why, and measure the results of programmatic changes.
- Persist. Lasting systematic change happens slowly, through the accumulation of many small changes. (p. 83)

Even though confident in their recommendations, they cautioned against making general changes without first considering the local problems and conditions to which interventions should be tailored.

Conceptual Framework

Author Intent

In aligning myself with the pragmatic worldview to research and the desire to build a personal knowledge base related to the underrepresentation of females in computer science, this problem of practice dissertation was approached from a position that directed the undertaking of a qualitative research study that was informed by a quantitative component. The pragmatic lens through which I viewed the state of females and CS supported this methodology, as it was "not committed to any one system of philosophy and reality" (Creswell, 2014, p. 11). Rather, the researcher applies him/herself to utilizing a combination of available approaches to understand the problem (Creswell, 2014).

While the literature review provided improved insight into the problem, it also gave rise to questions for which answers may not be known even after data have been collected. Yet, it was anticipated that the path I traveled to gain current and historical knowledge would be broadened through interactions with those who were protectors of information that could bring about a solution to the proposed problem of practice. It was these intended consequences that I subscribed to in making a decision about what to research and how best to carry out the process.

Literature Perspective

According to a report released by the National Center for Women & Information Technology (NCWIT Scorecard, 2014, p.1), gender diversity is important in computing because it [diversity] expands the qualified applicant pool, improves the bottom line, enhances innovation, promotes equality, and reflects the customer base. If this is indeed the case, then one has to wonder why female enrollment in high school computer science education is less than that of male enrollment. Nagel (2007) contributes this situation of indifference, in large part, “to a lack of awareness, combined with misconceptions about the field” (para.4), a state of affairs confirmed by statistics in the NCWIT Scorecard (2014, p.10-23). Yes, indifference may be a contributing factor to the circumstance of low female enrollment, but it is certainly not the only one to consider.

In direct opposition to Nagel’s thinking, Sawchuk (2017) reported in a blog that “Girls’ participation in AP Computer Science tests boomed last year—largely thanks to a brand-new, broader course offering with less of an emphasis on programming.” Based on his reported number of 111,000 who sat for the test, 29,700 of them were girls. This meant that females represented 27% of the total who took the test—an increase over the 18% reported a decade ago (para. 1). In keeping with this thought pattern, Ravipati (2017) stated, "In recent years, computer science has become a pillar of K-12 education, helping students to build problem-solving and computational thinking skills, as well as transferable workforce skills" (section 3, para. 4).

Contextual History

Teacher Perspective. As a teacher of computer science education at the high school level and based on the reality of the contextual setting, it was difficult to subscribe fully to the aforementioned positions for several reasons. First, the increase of female participation in testing was to be commended; however, one had to ask how many achieved a passing score, as well as how many continued to the next level? Second, if computer science has become a "pillar" of K-12 education, then why are South Carolina and other states still struggling to develop and implement computer science initiatives for K-12? Finally, over the course of the last 11 years at ZBF High School, females made up only 5% of the programming population (173) at a school whose total student enrollment is 3065.

Influences on the Problem. To further probe the stated problem of practice, dialogue commenced with colleagues and other educators and was followed by a review of related literature. Based on the conversations and the readings, unanswered questions and additional influences on the problem presented themselves. These supplementary stimuli included: teacher/student perceptions, academic self-efficacy, administrative focus on competing programs of study, culture and values of school/district and community in promoting gender diversity in certain program areas, and feeder schools' handling of computer science education.

Additional influences were availability of female mentors, adequate training of/for teachers, perceived male dominance in classes and related activities, peer pressure, female confidence in abilities to be successful in computer science, and female-specific marketing. This, by no means, was an exhaustive list of obstacles to low female enrollment/participation, but was a thematic offering that served as a springboard toward seeking a solution to the problem at hand—increasing female enrollment in computer science education at ZBFHS. Figure 2.2 depicts a simplistic, categorized list of stimuli and/or influences.

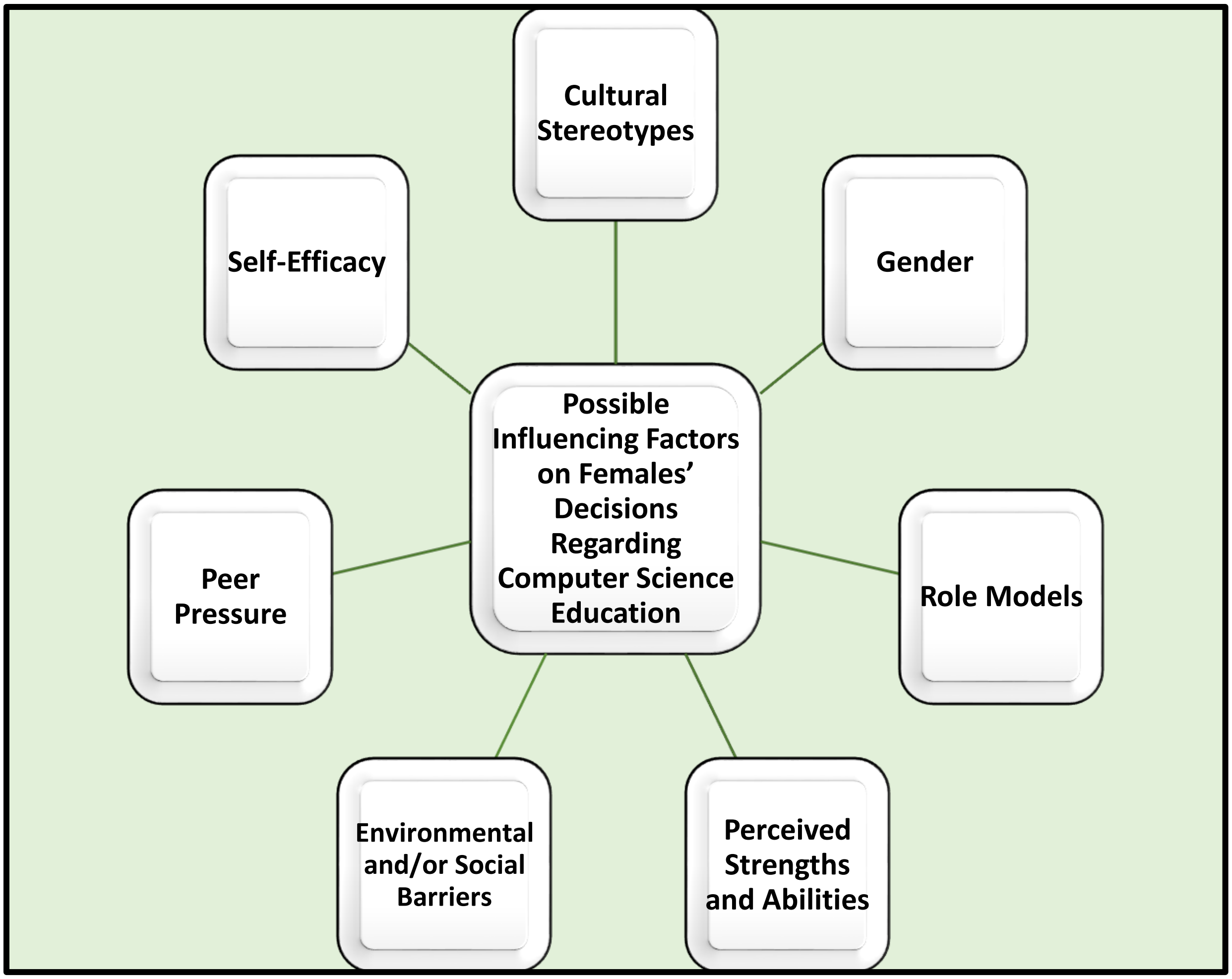

Figure 2.2 depicts a simplistic categorized view of barriers that could influence females' decisions about enrolling in computer science education.

If, however, the problem were to be effectively addressed, the proposed barriers to female decisions regarding computer science had to be considered as a group of individual components working in tandem to influence an outcome. Consideration had to be accorded to the various influence(s) that each barrier might possibly have on the others; so rather than treating them as autonomous entities, the obstacles were regarded as an interdependent system of events. Figure 2.3 illustrates the configuration of events that have a tendency to sway females' CS decisions.

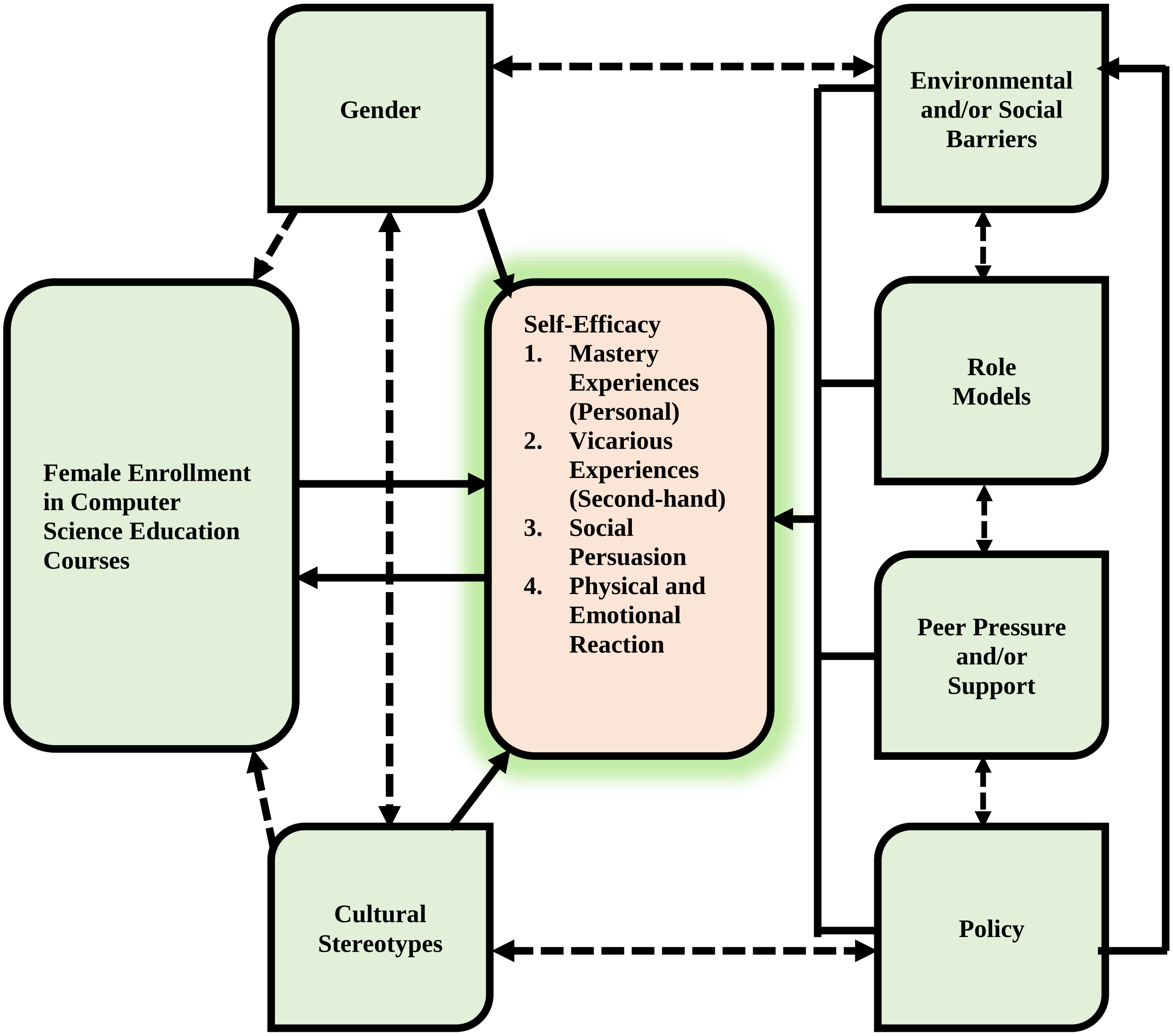

Figure 2.3 displays a systematic view of how proposed barriers could work to affect female enrollment in computer science education. Broken lines indicate indirect relationships, while solid lines point to those that are direct. Close observation of the diagram reveals that all barriers converge on self-efficacy, which is a primary influencer of female course and career selections.

Central Focus of the Study. In an effort to develop techniques for increasing female enrollment in high school computer science education, the focus was on barriers to female enrollment and methods for reducing and/or eliminating said obstacles. In response to the study's focus and to promote a viable research methodology, the proposed central research question was, "Why are female students underrepresented in computer science education at ZBF High School?" An accompanying question was, "What are the influencing factors on females' decisions regarding computer science?"

When considering ways to reduce/eliminate barriers to female enrollment in computer science, it was noted that the role of the teacher was critical. Implementing an effective CS education program is hampered by many things, but none more than educators' and policy makers' narrow understanding of computer science education. This lack of complete understanding impedes recognition of the special attention it takes to ensure that local schools do their part to recruit and train the underrepresented gender for careers and/or undergraduate majors in the field of computer science and other emerging technical career fields.

Computer Science Definition. To assist with the limited familiarity of what computer science is and what it entails, a clear description was necessary. The definition is one that should be accepted and understood by all involved, to include legislators, teacher educators, district recruiters/personnel directors, building supervisors, professional development directors/coordinators, teachers, and students. As recorded in the "Running on Empty" report (Wilson, Sudol, Stephenson, & Stehlik, 2010), the Association for Computing Machinery (ACM) and the Computer Science Teachers Association (CSTA) offer the following definition:

> Computer science refers to the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society; and

> Computer science education includes the following elements: design (both software and hardware), creation of digital artifacts, abstraction, logic, algorithm development and implementation, programming paradigms and languages, theoretical foundations, networks, graphics, databases and information retrieval, information security and privacy, artificial intelligence, the relationship between computing and mathematics, the limits of computation, applications in information technology and information systems, and social impacts of computing. (p. 9)

In addition to chronicling problem of practice particulars, the definition alone leads one to consider a comprehensive examination of computer science and its impact on K-12 education; however, such an undertaking was outside the scope of this work.

Synthesis of Conceptual Framework into Research Questions

Literature documents the need to increase female enrollment in the area of computer science education, some of which has been outlined as part of the literature review and again in the conceptual framework. However, before delving into such a study, there existed a prerequisite to present a thorough explanation of the phrase "computer science." After studying and dissecting the meaning, one can appreciate that not "just anyone" can teach CS subject matter. This observation was supported by literature, which referenced the inability to find certified/qualified teachers of CS education, especially females (Wilson, Sudol, Stephenson, & Stehlik, 2010, p. 30; Goode, 2007, p. 66). The absence of qualified female computer science teachers further affects the problem of practice, in that high school girls have limited access to same-gender computer science/STEM role models who could raise and nurture their interest in the field of computer science.

In an effort to effectively develop techniques for increasing female enrollment in high school computer science courses, consideration was given to elements listed in the conceptual framework that pointed to the need to focus on barriers to female enrollment and to explore methods for reducing and/or eliminating said obstacles. To promote a viable research methodology, the proposed central research question was, “Why are female students underrepresented in computer science education at ZBF High School?” Its companion question was, “What are the influencing factors on females’ decisions regarding computer science?”

Summary

This chapter of the dissertation proposal was dedicated to summarizing literature that was relevant to the problem of practice: increasing female enrollment in computer science education at ZBFHS. Careful attention was given to the writing of this section, since it is the foundation upon which the discussion of data collection results and their interpretation rests. As such, the following statement regarding the totality of this chapter is stipulated: Examination of relevant literature continued throughout the course of this study, with additional information being added as the data dictated. Several elements were examined on the subject of underrepresentation of females in computer science and other STEM areas; yet, additional research dedicated to P-12 females is needed to balance the current pool of information that is available on college-age and adult females in CS.

Recognizing the vast body of research available for review, only those works pertinent to this study were included, with expected updates as previously declared. It was intended that this investigation add to the already existing body of knowledge aimed at providing insights into decreasing the disparity of females in CS. For this reason, the framing of a solution was anticipated so that high school females would have opportunities for employment in current and emerging technology careers.

CHAPTER THREE—INQUIRY METHODS

Introduction

The purpose of this study was to examine the problem of practice on how to increase the number of females enrolling in computer science education (CS) at ZBF High School (ZBFHS). The focus of the problem was on capturing the interests of female middle/junior high school students so they elect to enroll in CS courses once they enter high school. This undertaking was significant because of its direct relationship to a nationwide problem—the disparity in the number of females employed in the field of information technology, particularly in the area of computer science.

As such, this quandary was investigated from two perspectives: (a) examination of barriers to female interest in computer science education in the district, school, and community in question; and (b) exploration of strategies that others used to stimulate the interest of females in computer science education. The desired outcome was to frame a solution in the school of service that would result in increased enrollment of females in high school computer science education that would prepare them for current and emerging technology careers.

Research Approach/Paradigm

Research design serves as a blueprint, or step-by-step description, of the overall strategy that is used to integrate individual components of a study in a coherent and logical way, hence, ensuring the researcher will effectively address the research problem. It is important to note that the design protocol should be dictated by the research question(s), not the other way around (University of Southern California Libraries, 2017, para. 1).

To guide the progression of this transformative mixed-methods study, the Interactive Model of Research Design (Maxwell, 2013) was employed. In this model, the research questions serve as the central focus, from which radiates the remaining four elements—goals, conceptual framework, methods, and validity/trustworthiness—all networking with one another. The research questions and the goals listed in the interactive design model continued to evolve as the study developed. Changes of either required a review of the types of information needed, persons/sources from whom to obtain the data, as well as the protocol(s) that would best serve to collect the data. Figure 3.1 presents the design for this study.

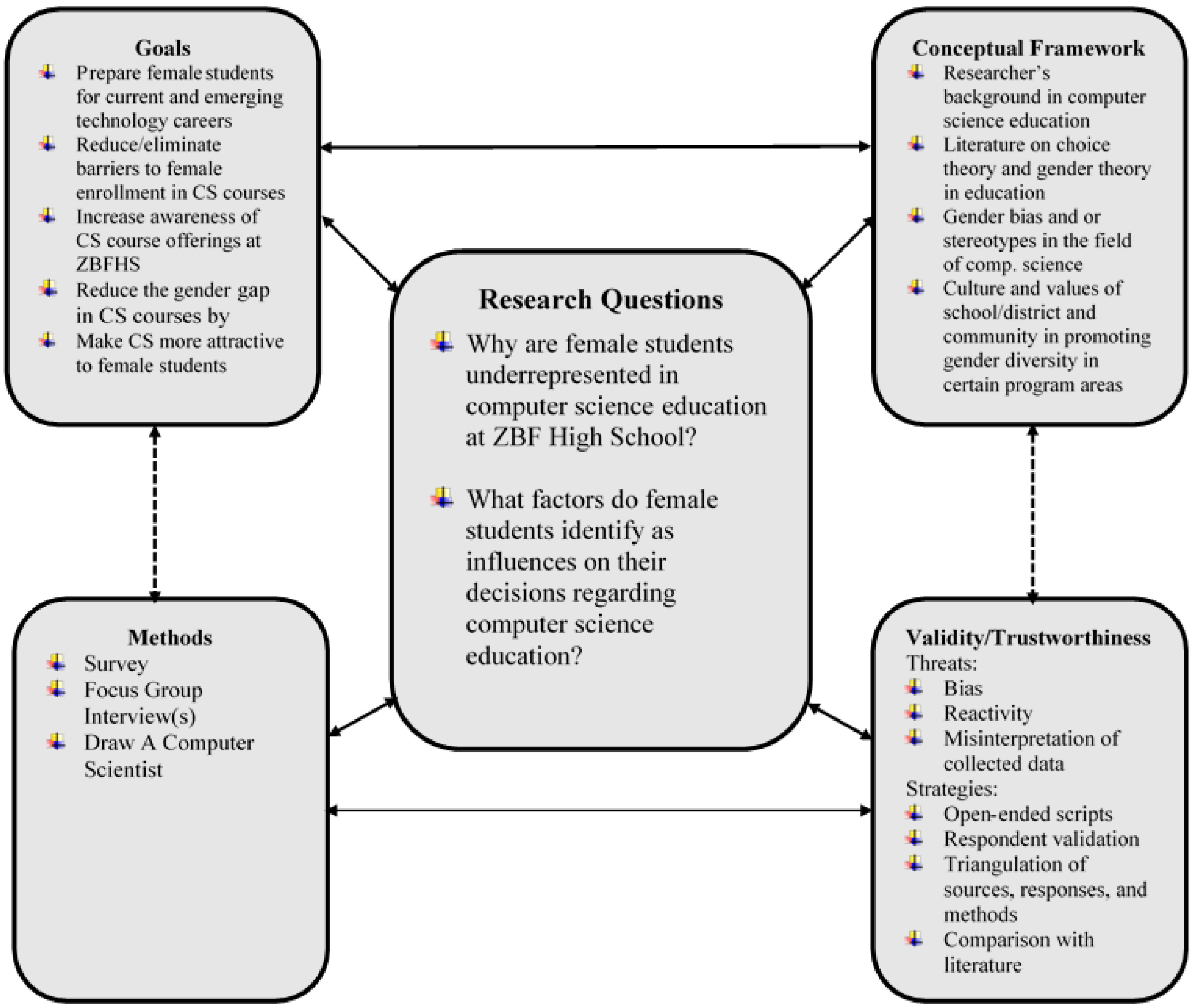

Figure 3.1 is a depiction of the Interactive Model of Research Design for the Problem of Practice. Adapted from Interactive Design Model for Research, by J. A. Maxwell (2013). *Qualitative research design: An interactive approach* (3rd ed.). Thousand Oaks, CA: Sage Publications.

The goals for this study were not just a reflection of the research questions but had a direct impact on the conceptual framework and were also an indirect influence on data collection methods. As such, desired goals are listed in this narrative to add clarity to the design description and to give added support to the rationale for the chosen collection instruments. To frame an appropriate solution to the problem of practice, elements included within the solution would need to be structured in a way that will increase the probability of achieving the following intents:

1. Prepare female students for current and emerging technology careers.
2. Reduce/eliminate barriers to female enrollment in CS courses.
3. Increase awareness of CS course offerings at ZBFHS.
4. Reduce the gender gap in CS courses.
5. Make CS more attractive to female students.

As an added measure of procedural integrity for conducting this investigation, the Interactive Design Model of Research was steadied by Considerations to Ensure Methods Align with Research Questions (Ravitch & Carl, 2016). These considerations established a plan for mapping methods onto research questions in a qualitative research design, thus promoting the achievement of rigor and validity throughout the process. This was a necessary step because of the "interplay between structure and flexibility" (p. 67) associated with qualitative research. The expectation was that alignment of envisioned methods and research questions would lead to realization of goals**.**

Similar in resolve to Maxwell's interactive design, the "Considerations" model accomplishes its job through the deliberate answering of queries about core constructs, study goals, site and participant selection, design and methods, rationale, and instruments. The questions can be answered “in the form of a matrix, in narrative form, or in graphical form” (p. 178). For this study, a representation of the graphical form was chosen. Figure 3.2 reflects the supportive system of design alignment.

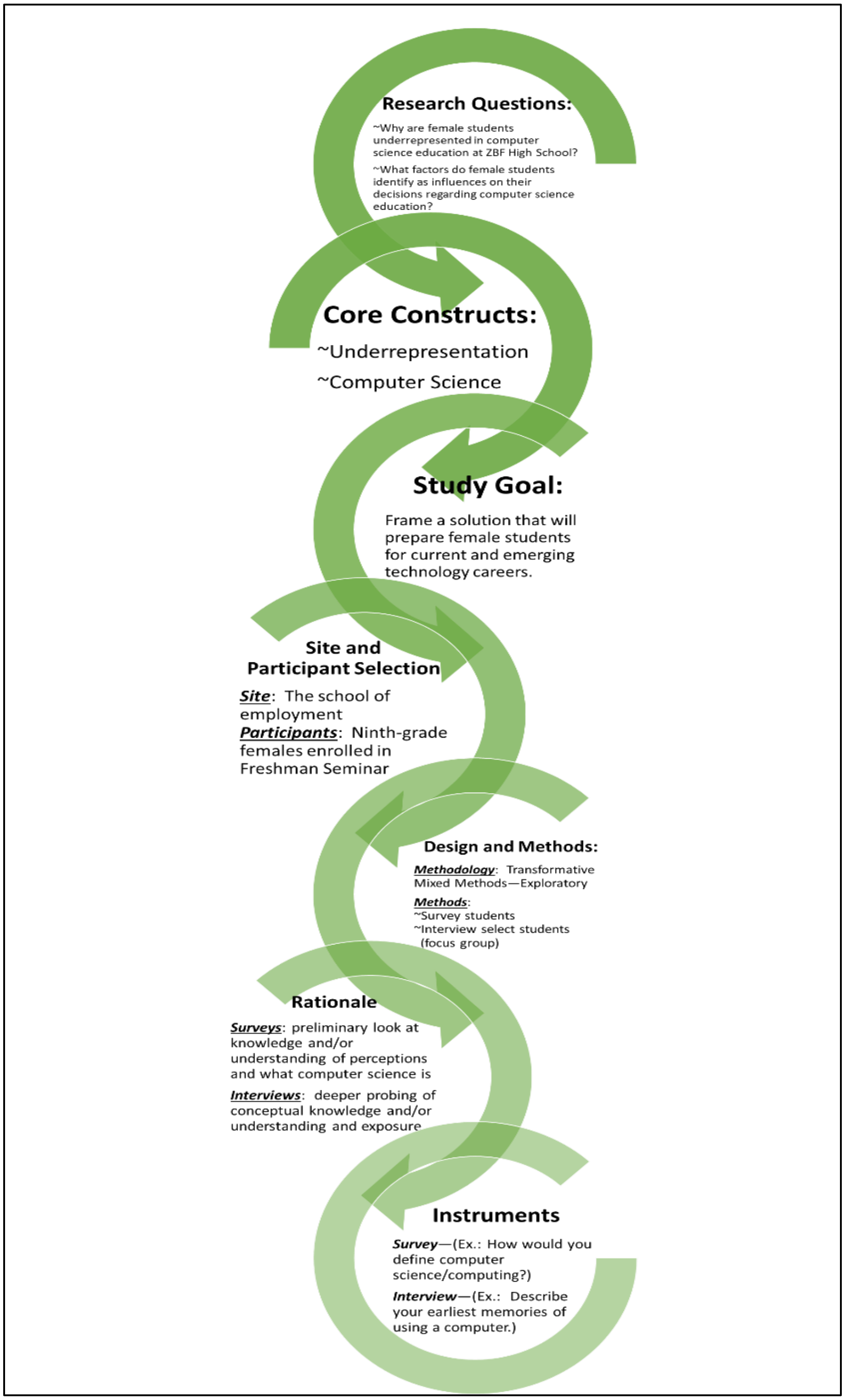

Figure 3.2 Considerations for Problem of Practice Methods Alignment with Research Questions Adapted from: Considerations to Ensure Methods Align with Research Questions, by S. M. Ravitch and N. M. Carl (2016). *Qualitative research: Bridging the conceptual, theoretical, and methodological*. Los Angeles, CA: SAGE Publications.

Transformative mixed-methods design. Because of the social injustice implications associated with the problem—the underrepresentation of females in computer science courses at ZBF High School and in other arenas—a transformative mixed methods design was used. As defined by Creswell (2014):

> Transformative mixed methods is a form of mixed methods design in which the researcher identifies one of the qualitative theoretical frameworks (e.g., indigenous populations, females, racial and ethnic groups, disabled individuals, and so forth) and uses the framework through the mixed methods study, such as to establish the research problem, the questions, the data collection and analysis, interpretation, and the call for action. It is used in conjunction with explanatory, exploratory, and embedded designs. (p. 249)

Methodological approach. The approach to this study followed a transformative design whose theoretical lens is drawn from issues of social justice, one of which is gender. As defined by Mertens (2010), the transformative paradigm is a framework of belief systems that directly engages members of culturally diverse groups with a focus on increased social justice. As discussed in Chapter 2, underrepresentation of females in CS in and of itself is not the social justice issue: it is the ethical questions surrounding fairness and equity that form the link.

Beyer (2014) gave life to the connection in her discourse on women's underrepresentation and its negative effects on their income potential and the economic impact for the USA and other Western countries. She brought awareness to the dilemma of how low numbers of females in CS affect businesses' ability to hire qualified employees and lessened their opportunity to capitalize on female perspectives and innovativeness. Hence, the search for barriers that hinder female students from enrolling in CS courses fits the paradigm in that a solution would allow for the elimination/reduction of obstacles, consequently, directing a change in the status of an underrepresented group—providing females improved access to computer science courses at ZBF High School. Doing so would afford them opportunities to equip themselves with the necessary skills and knowledge required for entry into current and future technology careers.

Research questions. This study, designed to discover why there were not more females in the targeted courses, would require an answer to two central research questions: (1) Why are female students underrepresented in computer science education at ZBF High School? and (2) What factors do female students identify as influences on their decisions regarding computer science education? Answers to the research questions have the potential to encourage development and implementation of strategies/policies that will eliminate/reduce barriers to female enrollment, thus engendering change in a significant way.

Chapter Organization

The inquiry methods section is organized in a manner that will allow the reader to see the logical progression of this mixed-methods exploration. Chapter topics/sections include: (a) introduction; (b) rationale; (c) problem setting/context; (d) research sample and data sources; (e) data collection methods; (f) data analysis methods; (g) trustworthiness; (h) limitations and delimitations; and (i) summary.

Rationale

Using a mixed methods approach involves collecting both quantitative and qualitative data, which provides a "more complete understanding of a research problem than either approach alone" (Maxwell, 2014, p. 4). The combining of the two methods allowed for the exploration of barriers—real and perceived—to enrollment for females in computer science courses. Although it was more time consuming, this method was chosen because of two strengths: (1) The data are more comprehensive, in that different types of details can be used—quantitative, text-based, graphical, etc. (2) The strengths of one method can function to overcome the weakness of and/or improve the other—focus groups providing data that could be used to improve a qualitative instrument such as a questionnaire or a survey.

To clarify, information gleaned from an informal "pre-test" focus group guided the formulation of questions for the survey protocol. This was an important step in that it provided an opportunity to improve the survey design—topic areas to be assessed, level of respondent understanding, assurance of collecting meaningful data, etc.—and added to the collection of knowledge that the researcher already had. The role of the quantitative collection process for this study was two-fold: (1) provide representative data of the population in question and (2) dictate follow-up questions to be used during the formal focus group sessions to collect qualitative data. As stated in the Methodological approach subsection, the transformative worldview was pursued because of the social justice implications regarding limited access of female students to computer science courses at ZBF High School.

Problem Setting/Context

Local Setting

ZBF High School is located in the Lowcountry region of South Carolina. Nestled among the pine trees in a community known as "Flowertown in the Pines," the school serves students in the southeast portion of the county. With a student enrollment of 3,104, ZBF High School is the largest in the Flowertown School District and the fourth largest in South Carolina. Once a high-performing school that was considered the "flagship" of the district, ZBFHS now finds herself as the high school with the highest poverty index and reported student achievement data that places it third among the District's three high schools. Table 3.1 displays population demographics as reported to the South Carolina State Department of Education.

Table 3.1
Demographic Analysis of Student Body (N = 3,104)

Categories	N	%
Grade		
Ninth	930	30
Tenth	768	24.7
Eleventh	672	21.6
Twelfth	734	23.6
Ethnicity		
Caucasian	1,851	59.6
Black	834	26.9
Hispanic	199	6
Asian/Asian Pacific Islander	34	1.1
American Indian	19	.61
Two or more races	167	5.4
Gender		
Female	1,518	48.9
Male	1,586	51.1

Note. 2018-2019 SC State Department of Education 45-Day Pupil Accounting Report

Program Framework

Based on information from N. Miller, Assistant Director of Career and Technical Education, (personal interview, February 28, 2018), computer science education at ZBFHS began during the 2001-2002 school year, when one class of Computer Programming I (CP1) was offered as part of the mathematics program of study, and no females were enrolled. This continued to be the only course offering until the 2004-2005 school year, when two new courses were offered in the Career and Technical Education (CATE) department, Webpage Design and Development and Database Design with SQL Programming. The following school year saw

CP1 moved to CATE, along with the addition of two more courses, Animation and Game Design and Computer Programming II.

During the 2004-2005 school year, I was assigned to teach the two new courses and was again assigned during the 2005-2006 school year to teach both levels of computer programming. The courses experienced incremental increases in enrollment over the next few years; however, the population was predominately male. Efforts to recruit females brought in a few female students, but not enough to warrant meeting established criteria of the Carl Perkins performance indicators for nontraditional student participation and program completion. This information is supported by data in Table 1.1 of Chapter 1 and a recapitulation of local data: Over the course of 11 years from 2004 to 2015, the female versus male enrollment in upper-level computer science classes was 8 to 165. This indicated 5% of the total programming population at a school with a total student population of 3,104. Numbers reported by teachers at the district's other high schools were similar.

The financial status of the district had district officials entertaining the thought of discontinuing the local computer science program and contracting it out to one of the local private community colleges. The lack of district and county funding was understandable, but not the possible elimination of a school-based program area that had the fastest growing career potential, as reported in Chapter 1. According to the U.S. Department of Labor (2018), employment of computer and information technology occupations was projected to grow 13 percent from 2016 to 2026, faster than the average for all occupations. Consequently, limiting CS classes to high school students would have had future implications for the students of ZBFHS.

This change would have also affected the CATE program, and would have further impacted access to CS courses by most students at ZBF High School, to include females and other underrepresented subgroups. The local college required students who enroll in their courses to attend various out-of-school/after-school interactions, and 80% of the student body were bus riders and/or walkers who had no other means of transportation to/from school. Additionally, students from lower-income families would not have had an opportunity to enroll in or to be exposed to such courses because of their reliance on bus transportation to/from school, thus potentially contributing to an underrepresentation of other segments of the population.

Research Sample and Data Sources

Population and Sample

The population considered for this study was the female subgroup of the student body at ZBF High School, with a stratified random sample being drawn from the pool of enrolled first-year female students, ages 14-16. The sample included students in college preparatory (CP), honors level (H), and advanced placement (AP) Freshman Seminar, a companion course to English I-CP, English I-H, and English Language and Composition-AP. Because the seminar is only available to first-year students, a general demographic data collection instrument was not required to determine enrollment status but was incorporated as part of the quantitative data collection instrument. The demographic data was utilized to estimate the size of the different levels in the available pool. This aided the process of a sample selection that was representative of the academic levels within the existing populace.

A stratified random sample "allows the researcher to build in *levels or categories* so that we can ensure each of the crucial components of a population is taken into account." This method is useful when the researcher wants to randomly sample within particular groups to ensure a representative sample group (Abbott, 2011). Because the problem of practice addressed an issue related to female high school students at all recognized secondary levels, the stratified random sample was deemed appropriate for gathering information to address the questions that were posed in this work. One weakness of using this sampling method was that it added more time and expense to the process because of the need to identify group members before randomly selecting participants.

Participants

Participants, as previously stated, were selected from females in the incoming freshman class at ZBFHS. This group was targeted because of their recent middle school experiences and/or possible CS exposure and because of the time remaining in high school to spark an interest that would lead them to register for CS courses. Potential existed for a participant pool of approximately 450 students; however, the adoption of a new scheduling model resulted in a considerably reduced pool size for the semester of data collection. After several due date extensions, 24 students returned signed parental consent forms. One hundred twenty consent forms were distributed, for a return rate of 20%. All students who returned a consent form responded to the survey; however, only ten indicated an interest in taking part in a focus group interview.

For the qualitative segment of the study, the ten students were randomly assigned to one of three focus groups. Because [focus group] assignment was random, this resulted in a mixed sample in each group—some participants with previous exposure to computer science and others who reported no previous exposure.

To ensure participation was limited to "true" ninth-grade females, only those enrolled in Freshman Seminar classes were eligible for inclusion. This course was chosen because it is the one class whose enrollment is restricted to first-year students. Pupils who did not receive credit for their initial attempt of freshman English were not eligible for re-enrollment in Freshman Seminar. Regarding the welfare of research participants, special attention was given to their needs, fears, and concerns related to requirements of the study.

Data Collection Methods

Introduction

The research topic was developed out of concern related to the underrepresentation of females in computer science and information technology career fields. Literature suggested that females were not adequately exposed to courses that would lead to their choosing these areas as college majors and/or career choices. This prompted a superficial review of the computer science program at ZBFHS.

Results of the inspection revealed that there was a disparity in the number of females versus males enrolled in the school's CS courses, hence the formulation of the problem of practice and its parallel research questions. It should also be noted that the Career and Technical Education Department at the school had not collected data to assess the perceptions of female students toward computer science education, nor had it investigated their course selection choices. Additionally, no data existed to address school personnel and/or community stakeholders' attitudes, experiences, and perceptions as they pertained to computer science and gender/gender theory.

Procedures

Institutional review board. Because of the need to involve "human subjects" in the study, a University of Arkansas Institutional Review Board (IRB) application for research was completed and submitted for approval. This process was required to ensure that the design of the research protocol accounted for risks to human subjects. The application provided a description of the procedure for the study and the type of data collection instrument(s) to be used. It also contained an assurance of no stress or physical harm to the subjects, as well as provided a provision for students to opt-out of the study at any point without penalty. A copy of the IRB approval document is included in the appendix.

Permissions and informed consent. Permission to use students as participants in the study was solicited from the principal. As required by the University, a copy of the permission document was included in the IRB application packet. Before any students could participate, a hard copy of the informed consent document was issued to each female in the targeted course. The purpose and details of the study were incorporated in the form's content including time commitment, reason, purpose, anonymity and confidentiality assurances, and an opt-out-at-any-time clause. The form required parent and student signatures, and only those students who returned the form by the due date, which was extended three times, were included in the data collection process. A copy of the consent form has been included in the appendix and was also submitted with the IRB application.

There were, however, challenges to the permissions and consent stage that served to limit the participant pool. Anticipated obstacles included language barriers, religious convictions, unintended expectations, absences, lack of interest, and/or simple failure to return the form, just to name a few. Yet none proved to be as serious an impediment as was the unexpected change in the scheduling model used at the high schools. The district transitioned from a hybrid schedule—a combination of 50-minute traditional and A/B block—to one of four 90-minute blocks per semester, commonly known as "4x4." This negatively affected the number of Freshman Seminar offerings during the semester of data collection. Although the freshman class consisted of approximately 450 females, only 120 were enrolled in the target course. This meant that access to eligible participants was reduced to a mere 27% of all who met the qualification for consideration as a first-year freshman.

Collection process. Prior to engaging in data collection from students, a pilot focus group consisting of six female students enrolled in an upper-level computer science course was convened. Members were assessed using a proposed 11-question survey, with prompts to determine the practicality of the questions. Analysis of the pilot group's data was used to improve/adjust the content/length of the survey instrument. Once revised in its final form, teachers of the targeted classes were provided an in-house field trip form for each female student who returned a consent form. These students reported to the designated computer room to complete the electronic survey, a Google Form.

Students who completed the survey were invited to indicate their willingness to participate in the qualitative phase of data collection—the assembling of three separate focus groups. Each focus group was engaged in conversations that provided participants the opportunity to share information on middle school experiences, exposure to computer science education, and their knowledge and perceptions of available computer science courses/activities at ZBFHS. It was emphasized during the survey phase and again when the invitation was extended that inclusion [in a focus group] was not mandatory. The expectation, nevertheless, was that each focus group would remain intact as far as membership was concerned, especially if additional data were needed and/or clarifications were warranted.

The focus group interview protocol was selected based on my experience and professional belief that female students are usually more willing to share information in groups rather than in one-on-one situations, especially when perception is involved. Because the possibility existed for some students to refrain from sharing an opposing perspective, intentional conversational prompts to bring these counter perceptions to the forefront were incorporated, and/or a focused free-writing strategy was employed to give voice to students who felt uncomfortable verbalizing a contrasting view.

One detail to note regarding focus groups: It is important that relationship building with the students be carefully planned and implemented so that solicited data will be "real" and not what they think the group moderator wants to hear. According to Sanders and Sullins (2006), "Regardless of the specific data collection methods that you use, to collect adequate amounts of accurate data you will need sufficient buy-in from the participating stakeholders" (p. 39, para. 3).

Student Created Data. As a culminating activity for the qualitative data collection process, participants were provided an opportunity to draw their perception of what a computer scientist looks like. To encourage students' true perception, no instructions were provided. This type activity, better known as *The Draw-a-Computer-Scientist Test* (DACST), was designed to "gauge how students perceived computer scientists" (Hansen et. al, 2017) and is an extension of the *Draw-A-Scientist Test* (DAST) first used with elementary students. Its objective was to "determine at what age children first develop distinctive images of the scientist" (Chambers, 1983).

The DACST has been used with elementary, middle, and high school age students, as well as college students. "Across all levels of the study, the consistent theme was that computer scientists, computer science majors, and computer users are white, male and associated with geekiness" (Hansen et al, 2017). They also reported the primary goals for such a study, which were to (a) determine how students conceptualize computer scientists; (b) assess students' conceptualization of the work of computer scientists; and (c) determine how computer science curriculum impacts student conceptions of a computer scientist. Images of the drawings from this study have been included and discussed as part of the qualitative analysis phase. Also, a reference has been made as to how closely the illustrations fit with the typical perceived image of a computer scientist.

Instrumentation.

This subsection outlines details of each investigative protocol used in the study. The reader will be able to make an initial determination of how the variables/questions of the research were conceptualized and measured. A copy of each instrument is included in the appendix.

Student survey. The purpose of the survey was to gather general data on perceptions of barriers to female enrollment, criteria for course selection, perceived relevance to future, intrinsic motivation, self-efficacy, community beliefs and values, and strategies that might make CS more attractive to females. According to Ravitch and Carl (2016), a survey approach to research is often used to gather information about individuals' attitudes, beliefs, and behaviors. Additionally, they state, "Questionnaires can be a useful data source within a larger data collection plan for a variety of reasons that relate to triangulation of methods" (p. 172).

The instrument, a copy of which is in Appendix A, included a section of two open-ended questions and two additional sections—(1) directory information and (2) general questions that assessed perception, confidence, attitude, and student interest in computer science. Questions 2-5 of the general questions section were designed along the style of a Likert scale; while Questions 6 and 7 were of the "choose all that apply" style. This electronic survey took students approximately 5 to 10 minutes to complete.

Instrument dependability. The selected instrument was created and published for use with various group sizes ranging from whole school down to the classroom level. To validate that the Likert scale portion of the instrument measured what was intended in this study, Cronbach's Alpha was run on pilot-test data from 25 students enrolled in a business finance course. The purpose of the test was to assess the internal consistency of the full interest scale along with the consistency of each subscale. As defined by Taber (2017), Cronbach's alpha is a statistic commonly quoted by authors to demonstrate that tests and scales that have been constructed or adopted for research projects are fit for purpose. Alpha "reflects the extent to which different subsets of test items would produce similar measures."

For the general interest level of consistency, Cronbach's alpha was .89. Alpha coefficients for the four subscales [relevance to future, intrinsic motivation, self-efficacy, and community beliefs/values] were .84, .93, .67, and .63. "Cronbach's alpha reliability coefficient normally ranges between 0 and 1. However, there is actually no lower limit to the coefficient. The closer Cronbach's alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale" (Gliem & Gliem, 2003). "Although the standards for what makes a "good" α coefficient are entirely arbitrary and depend on your theoretical knowledge of the scale in question, many methodologists recommend a minimum α coefficient between 0.65 and 0.8"

(University of Virginia Libraries, 2015, section 2, para. 2). Because the alpha scores in the domains of self-efficacy and community beliefs/values registered either at the lower end and/or just outside the lower limit of the recommended range, a concerted effort was purposefully launched to scrutinize each question of the focus group protocol, with tweaking where needed. This was done to increase the chances of attaining the anticipated depth of participant responses, with a desired outcome to harvest a "richer" pool of qualitative data.

Interview protocol. This data collection tool was an adaptation of questions/statements from two published instruments that were used to collect qualitative data in semi-structured interview settings. One instrument examined urban high school students' reactions to a . . . (STEM) enrichment/career development program, their resources and barriers, their perspectives on the impact of race and gender on their career development, and their overall views of work and their futures (Blustein, Barnet, Mark, Depot, Lovering, Lee, Hu, Kim, Backus, Dillon-Liberman, & DeBay, 2013). The second instrument assessed sources of middle school students' self-efficacy in mathematics (Usher, 2009). Because computer science is a STEM course of study, which is math intensive in nature, it was supposed that these instruments would serve as a foundational basis upon which to collect data for this study.

This protocol served to stimulate conversation with and among two to four participants during three separate focus group interview sessions. According to Eliot & Associates (2015), "It takes more than one focus group on any one topic to produce valid results—usually three or four." It should be noted that each group was engaged using the same set of questions. The inquiries were designed to gather qualitative data that would help answer the research questions. The sessions, each of which took approximately 35-45 minutes, were intended to have participants provide opinions and clarify answers in greater depth than was possible to obtain with a survey, while also offering participants the opportunity to share information that might not have been solicited. This aided the process for harvesting themes that served to answer the research questions more thoroughly. A copy of the protocol is in Appendix B.

Data Analysis Methods

This section outlines and discusses the processes involved in analyzing the collected data. Examination occurred in two phases: Phase 1 focused on the analysis of quantitative data garnered from an electronic survey, while Phase 2 concentrated on qualitative data gathered during three independent focus group sessions. When deemed necessary, periodic insertion of charts/graphs and tables have been utilized to provide more clarity for the reader.

Quantitative Examination

The process began by downloading non-identifying survey data from the Google Form to an Excel workbook. The systematic quantifying of data, which entailed assigning a numerical code to question choices, followed. Demographic data for the participant group were analyzed with the data analysis feature of Microsoft Excel 2016 to provide descriptive statistics linked to age, ethnicity, and English level of participants. Tables and charts were created to better visualize the relationship of participant responses to the various questions/categories.

Examination of the quantitative data then turned to its attention to creating frequency tables for questions related to computer science courses taken, current CS course enrollment, and previous participation in CS activities. Preview of this data assisted with thematic coding of the open-ended question that asked each participant to explain what computer science meant to her, as well as with the question that asked each participant to share additional information

Likert-style scale data from the survey were evaluated using the data analysis feature of MS Excel 2016. As discussed in Chapters one and two, the possibility for additional questions related to the research might arise. As such, four *t*-tests and two analysis of variance tests (ANOVA) were conducted to determine if there were significant differences in mean values between and/or among certain groups and/or categories within the sample. The results of analyses have been reported in Chapter 4, using narrative form and a display of various charts and graphs where applicable.

Responses from the open-ended questions of the survey were coded and analyzed for emerging themes. Answers were then organized into thematic categories. Finally, the two multiple selection questions were analyzed using frequency tables and Pareto charts for better visualization of the results. Figure 3.3 represents the flow of quantitative data analysis.

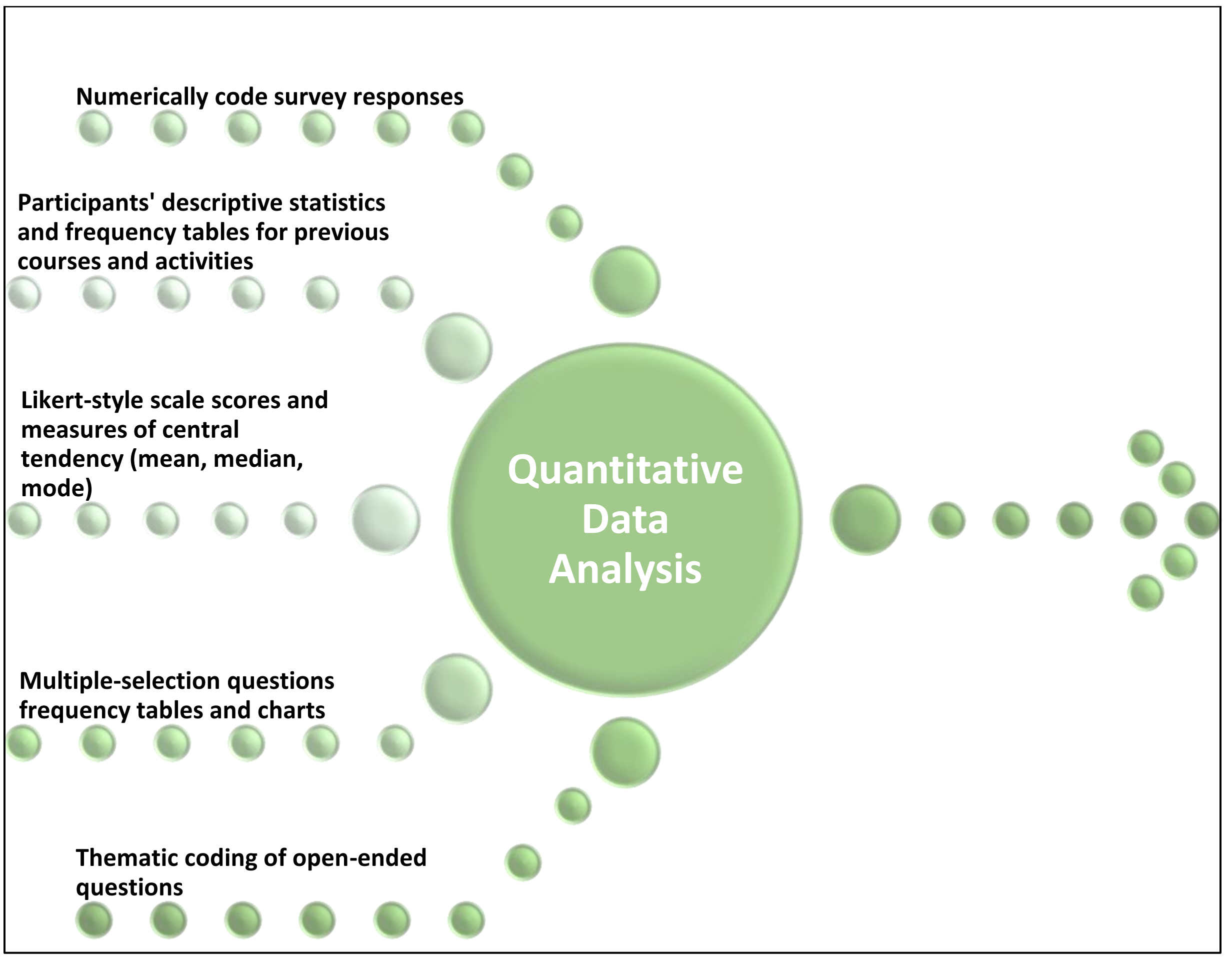

Figure 3.3. Process Flow for Analyzing Quantitative Data.

Qualitative Examination

Analysis of data in this phase was based on verbatim transcripts from three focus groups, as well as researcher field notes captured during each session. The recorded data acquired during the focus group interviews were transcribed and compared to the audio recordings to verify transcription accuracy. Corrections and edits were made where necessary. It should be noted that analysis of focus group data is somewhat different from that of an individual interview. According to Krueger (2006), a focus group is more like a conversation than an interview:

> In a focus group, there is usually not the opportunity for a single person to lay out in detail his or her thinking. Instead, it comes in bits and pieces as he or she responds to a variety of questions. During that time, the participant is interacting, talking to, arguing with, or agreeing with others in the group. Group discussions don't flow smoothly and may not be either linear or sequential. . . .Conversations contain elements such as these, which are not typical of other textual materials:
>
> - silence after someone eloquently expresses a view.
> - not repeating a comment or point because someone else just said it.
> - making changes in how to express a point due to reactions from other participants.
> - avoiding topics that incite others in the group.
> - After a rambling discussion, someone else might succinctly lay out the key points simply because the earlier person was so confusing.
> - Some participants might temper their statements and take a more compromising position after hearing strongly held views. (p. 4)

The next step involved using Microsoft Excel 2016 to create a general response table, after which, "like" responses were grouped and categorized by theme/subtheme. Consideration was given to the use of qualitative analysis software; however, the time needed to become familiar with the software and the additional time needed to code the data prevented execution of this option; subsequently, data was manually analyzed. Responses were subjected to several levels of coding and scrutiny, with the anticipated development of additional themes. As such, emerging topics were compared to those that materialized during analysis of the open-ended questions from the survey. This was necessary because it was probable that qualitative data would fill in gaps that remained after analysis of quantitative data.

Regarding the “computer scientist” drawing requested of each focus group participant, examination proceeded in a fashion similar to that of analyzing words—looking for patterns and themes. Drawings were compared, and items that stood out were noted. Finally, qualitative analysis concluded with the merging of qualitative and quantitative data, along with the matching of thematic domains to the research questions. It was expected that the results from both data collection phases would provide answers to the proposed questions.

Trustworthiness

Ethical Issues/Threats to Validity

“Considering the nature of qualitative studies, the interaction between researchers and participants can be ethically challenging for the former. . . . Therefore, formulation of specific ethical guidelines in this respect seems to be essential” (Sanjari, Bahramnezhad, Fomani, Shoghi, & Cheraghi, 2014). In keeping with this thought, challenges that could have become problematic where participants were concerned included positionality, confidentiality, safety, interpretation, and misrepresentation.

Because of current employment status as a female educator in the selected research setting, positionality was a concern. Job title and gender established the insider role; however, serving as a researcher within the setting shifted the character to that of an outsider. The expectation was that student participants would identify with and accept the gender of the researcher; however, because of quarterly benchmark tests and the numerous other assessments required for accountability purposes, the possibility existed for students to see the teacher position as another attempt to measure their knowledge.

Since personal aspirations are to become an administrator in the district, colleagues might have viewed this as an opportunity or attempt to “climb the ladder.” This had the potential to produce reluctance on the part of some teachers to encourage students' participation in the study. Regardless of the platform from which this was viewed, efforts were made to be as transparent as possible about the processes involved, as was intentional endeavors to share need-to-know information related to the study. Transparency was "active" throughout the data collection and analysis phases and at any time interaction with participants was required, thus securing authentic data to answer the research questions.

Another issue that could have arisen was that of access to minor participants. This required structured communication with administrators, parents, colleagues, and student participants. Since data collection required direct engagement and interaction with participants through interview sessions, special attention was given to location and time of sessions: All were held during the school day, with none held outside of the school environment nor scheduled at times that would have contributed to loss of instruction.

Verbal and written communications that outlined the research protocols were shared with administrators and fellow teachers, and informed written consent was secured from parents/guardians of those students who were targeted for the data collection phases of the study. An opt-out clause was included in the consent document. To avoid the appearance of coercion, students were asked to consent to participating in the study. While researchers will need to be guided by the requirements placed upon them by the local context with regard to accessing children (e.g. any conditions set out by the head teacher of a school), it is of primary importance that, where possible, children themselves have the right to decide about their participation in research (The University of Sheffield, 2012).

Additionally, reminders about student sessions were sent to all "caretakers," and attendance was taken as an added measure of safety and accountability. To ensure confidentiality, all documents that contained student and parent/guardian information was kept in a locked area, and participant information was only shared with those who were legally authorized to have access. For identification of study participants, each was assigned a number and pseudo name for reference purposes or when referring to them in writing. As required by the University, collected data and all records will be kept for three years, after which, all related material and data will be destroyed in a responsible manner.

Establishing Trustworthiness

The pursuance of this study was driven by two factors: a professional responsibility to better serve students and personal identification with the topic. Not only a female, but I am also a member of one of the most underrepresented groups in the field of computer science—African American. To explain further the lens through which the topic was pursued, I initially declared computer science as a major; however, early struggles during the sophomore year of college led to a change in the major field of study. This was in large part due to the lack of support on the part of the professor and the teaching/lab assistants (all male): No one reached out to attempt to make a difference in the outcome of this experience. Despite the change in major, this incident did not destroy interest in the field. Both of the aforementioned admissions set the stage for a primary threat to trustworthiness or validity—researcher bias—that could have contributed to a skewed presentation of the outcome of the study. According to Ravitch and Carl (2016), qualitative researchers should make deliberate methodological choices to acknowledge, account for, and approach researcher bias (p. 13).

To protect validity/trustworthiness of the process and the findings, the issue of bias was controlled by not allowing personal experiences to overshadow the study. This entailed refraining from asking leading questions, abstaining from interjecting a personal voice, and/or avoiding body language that might have reflected displeasure or discomfort with conversations that aligned with the negative situation experienced during college.

To promote a more fertile environment for trustworthiness, interpretation of participant responses were verified through follow-up interviews where necessary. Furthermore, it was important to maintain data integrity. This was accomplished by verifying data sources and by having peer reviewers evaluate the coding of data to detect possible misinterpretations and/or missed themes. Having colleagues and participants review the research findings was yet another option. Finally, the inclusion of peer-reviewed articles in the literature review section was important in validating the quality of the research report.

Although specific to school improvement/program evaluation, the intent wasd to abide by, as much as possible, the following recommendations by Sanders and Sullins (2006): Organizing and analyzing the qualitative information will include the following:

1. Make sure the data is all there.
2. Make copies for safe storage.
3. Organize the data as it comes in.
4. Take stock during data collection and at the end about the findings.
5. Draw conclusions and then back them up with the collected data.
6. Verify and validate the findings by getting reactions from people who were there.

They concluded by stating, “The best analyses of qualitative data use intellectual rigor and documentation to support conclusions” (p.46).

Limitations

One limitation of the study was location: The setting was the high school where the researcher is employed. Even though the population was one of convenience, the sample selection process was conducted along the lines of a stratified random sample. The study was designed to only include female students; therefore, no predictions could be made about male students' knowledge of computer science and/or their perceptions of barriers to female access to courses and careers. To account for this in the future, males could be included, and their collected data compared to that collected from females. Finally, the nature of qualitative research is not conducive to generalizability of outcomes; hence, the results of this undertaking cannot be projected onto other subject areas nor onto other schools in the district, region, or state. This, however, did not affect using the results to devise and implement a framework at ZBF High School to increase the enrollment of females in computer science courses, nor did it preclude use of the results to inform work in other places.

Delimitations

This study was planned within the confines of purposely-selected boundaries. To begin, the transformative mixed-methods design was chosen because of the social justice implications of the investigation and because of the design's intent to "help a marginalized group" (Creswell, 2014, p. 228) improve their situation. In this study, the marginalized group was females, and the issue was their underrepresentation in computer science courses at ZBF High School. It was intended for use of the transformative design to be one of providing a better understanding of the problem.

In keeping with the research design and the affected group, data was only collected from ninth grade female students because of the time that remains in their high school careers. The implication here was that they would not only provide data that could engender change, but they might actually be among those who help initiate the desired change by choosing to enroll in CS courses that would prepare them for current and emerging technology careers. Furthermore, it was my conviction that the female perspective is key to developing a solution that will increase the number of females enrolling in CS classes at ZBF high school. Finally, because of the nature of problem-of-practice focused research, revisions to research inquiries and goals were permissible, in that unexpected data might have been revealed through the interview sessions.

Summary

The Interactive Design Model for Research, as presented by Maxwell (2014), inspired the overall methodological design of the study. This model placed the central focus on the research questions, which directed the other components of the study. To meet the goals of this investigation, the data collection process utilized principles that aligned with those of a transformative mixed-methods design. This strategy was chosen because of its social justice intent to help a marginalized group of people, and this was in keeping with the primary goal of this project—to increase female enrollment in computer science courses at ZBF High School.

This study raised interest because of the significant underrepresentation of females in one of the fastest growing career fields—technology and computer science—along with a desire to increase their presence in computer science courses that will prepare them to enter current and emerging technology and computer science career fields and/or post-secondary programs of study. A stratified random sample was drawn from the pool of enrolled ninth-grade female students, ages 13-15, who completed an electronic survey followed by focus group interviews with selected participants. Collection, coding, and analysis of quantitative and qualitative data will permitted the examiner to seek answers to the proposed research questions. Results of data analysis have been reported in narrative form and in charts and tables where applicable. It should be noted, though, that during the data analysis cycles, the possibility existed for additional questions to evolve that could have guided the study closer to its intended aims.

CHAPTER FOUR—FINDINGS AND ANALYSIS

Introduction

The purpose of this study was to examine the problem of practice on how to increase the number of females enrolling in computer science education (CS) at ZBF High School (ZBFHS). The focus of the problem was on capturing the interests of female middle/junior high school students so they elect to enroll in CS courses once they enter high school. This undertaking was significant because of its direct relationship to a nationwide problem—the disparity in the number of females employed in the field of information technology, particularly in the area of computer science. According to Goode (2008), "computer science holds the unfortunate distinction as a highly segregated profession—in terms of both gender and race" (p. 362). She further stated, "The underrepresentation of females and people of color occurs at the professional level, university level, and in K-12 education" (p. 362).

As such, this quandary was investigated from two perspectives: (a) examination of barriers to female interest in computer science education in the district, school, and community in question; and (b) exploration of strategies that others used to stimulate the interest of females in computer science education. The desired outcome was to frame a solution in the school of service that would result in increased enrollment of females in high school computer science education that would prepare them for current and emerging technology careers.

Chapter Overview and Organization

As stated in the introduction, the conceptual framework for this investigation was based on the proposed problem of practice: how to increase the number of females enrolling in high school computer science courses at ZBFHS. With that in mind, the research mission was carried out using a transformative mixed-methods approach. This chapter was organized into subsections that provide details about the participants, quantitative data analysis, qualitative data analysis, and findings. The progression of the procedures used for data collection and analysis is illustrated in Figure 4.1.

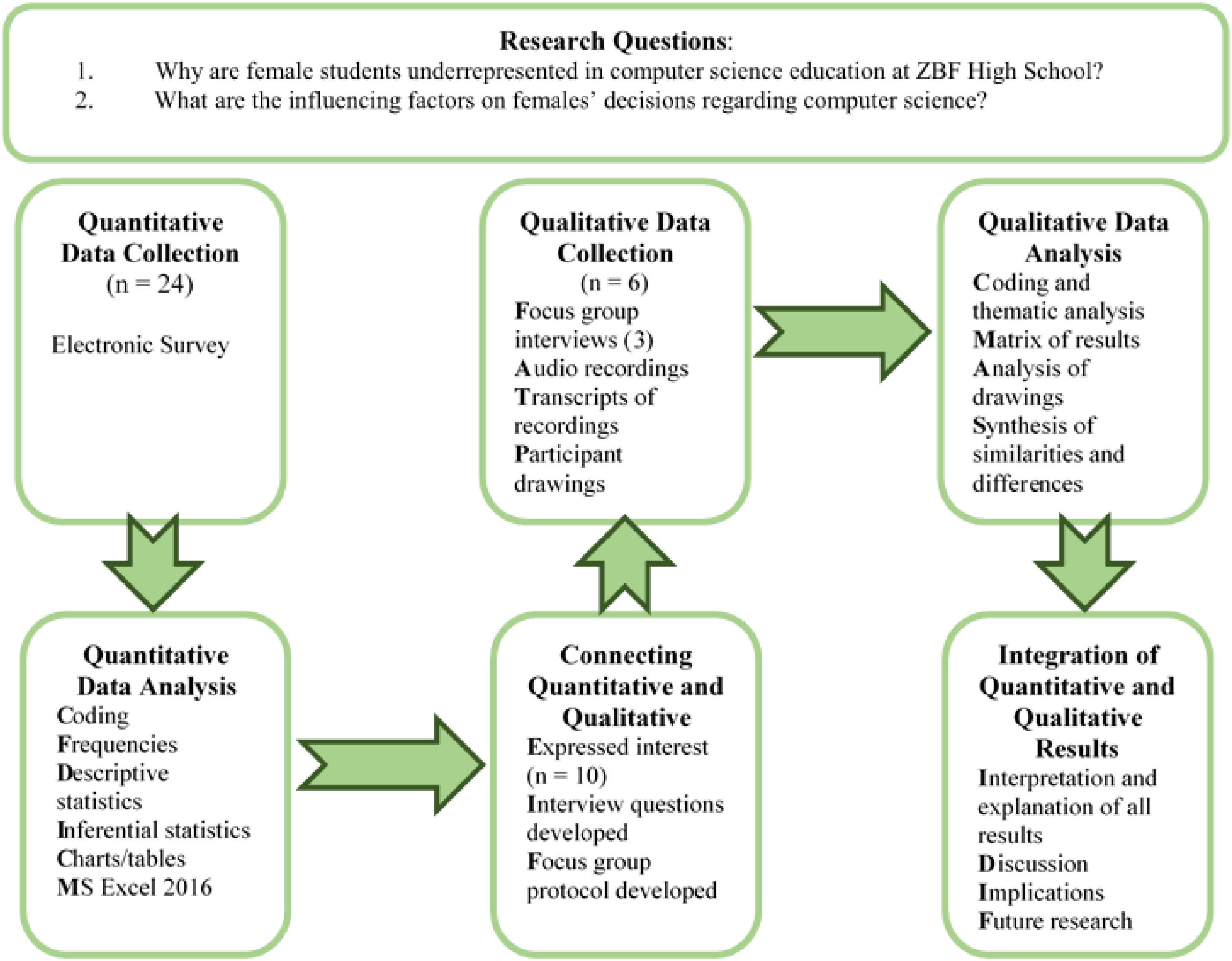

Figure 4.1. Transformative mixed methods progression depicting the methodological sequence of the study. Adapted from: Visual Model for Mixed-Methods—Sequential Explanatory Design Procedure, by N. V. Ivankova, J. W. Cresswell, and S. L. Stick (2006). *Field Methods*. Los Angeles, CA: SAGE Publications.

Phase 1—Quantitative Analysis

Descriptive Statistics

The initial step in the analysis process began by using functions and features of Microsoft Excel 2016 to categorize and chart directory and demographic data as provided by participants. Statistical tests and basic mathematical functions were run to calculate indicators that have been used to define the research participants. Table 4.1 displays demographic and directory details for the sample. A significant item that stood out during analysis was that all participants reported being enrolled in a computer science course during the semester of data collection; therefore, it was not included in the table.

Table 4.1
Participant Characteristics (n = 24)

Categories	n	%
Age at time of survey		
14	17	70.8
15	6	25.0
16	1	4.2
Ethnicity		
Black/African American	7	29.2
Caucasian	10	41.7
Hispanic	3	12.5
Other	4	16.7
English level		
College placement	15	63.0
Honors	8	33.0
Advanced placement	1	4.0
Previous CS course(s) taken		
One or more	17	70.8
None	7	29.2
Previous participation in CS-related activities		
One or more	12	50.0
None	12	50.0

One hundred twenty permission forms were distributed, with 24 having been returned (20% return rate). When compared to the student body demographics presented in Table 3.1, the ethnicity demographic of the sample group closely resembled that of the student population. It was not surprising that the sample contained only one student who was enrolled in AP English, as only 470 students out of 3,104 (15.14%) were enrolled in one or more advanced placement classes. (South Carolina Department of Education State Report Card, 2019). It should also be noted that the age of one participant was outside the expected age range (14-15) of a first-year ninth grade student; however, enrollment in the Freshmen Seminar course confirmed her first-year status. This age discrepancy could be attributed to having been retained at the elementary level or having had a chronic medical condition that prevented her from remaining on track with other students her age. Additionally, the self-reported data regarding previous CS courses taken and/or previous participation in CS-related activities should not be considered an indicator of overall interest in computer science.

To more clearly present course and activities data, frequency tables for the self-reported data were created. Table 4.2 provides data about previous courses. Table 4.3 depicts current course enrollment, and Table 4.4 represents activities in which participants have been involved.

Table 4.2
Previous CS Course Enrollment

Code	Value	Frequency	%
1	Gateway to Tech.	5	21
2	Exploring CS	11	46
3	Principles of Engineering	0	0
4	Intro To Engineering	0	0
5	Comp Programming	0	0
6	Info Tech Found.	1	4
7	None	7	29

The percent of participants who conveyed having previously taken a computer science course was 70.8%, with the majority having selected Exploring Computer Science (45% of the sample and 64.7% of reported enrollees).

Table 4.3
Current CS Course Enrollment

Code	Value	Frequency	%
1	Gateway to Tech.	1	4
2	Exploring CS	20	83
3	Principles of Engineering	0	0
4	Intro To Engineering	0	0
5	Comp Programming	0	0
6	Info Tech Found.	3	13
7	None	0	0

All participants reported enrollment in a computer science course during the semester of data collection, with 83.33% in Exploring Computer Science. Interestingly, four students reported enrollment in courses that are not available at the high school level.

Table 4.4
Previous CS Activity Participation

Code	Value	Frequency	%
1	Robotics	0	0
2	Hour of Code	6	22
3	Code.org	6	22
4	Tech Support	0	0
5	Summer Camp	0	0
6	Girls Who Code	1	4
7	GEMS	2	7
8	None	12	44

One-half (12) of the participants indicated that they had not participated in any previous CS-related activities, while the other one-half reported having engaged in one or more. Hour of Code and Code.org tied for participation. Hour of Code, a special segment of the Code.org network, is a series of targeted online activities often used to encourage student interest in computer science.

Likert Scale Investigation

Following the breakdown of descriptive statistics, analysis was conducted on the 17 questions of the Likert-style scale, which were designed to rate items on a response scale. This scale was based on six points, ranging from strongly disagree to strongly agree. The scale addressed four domains: perceived relevance to own future, intrinsic motivation, self-efficacy, and finally, community beliefs and values—friends and families, thus requiring analysis of the data as a group rather than analysis of individual questions.

The first step entailed assigning a numerical value to each response on the Likert-style scale (Colosi, 2005). For questions 10-26 of the survey instrument—established cataloging in the researcher-created code book—response values were assigned as follows: 1 = strongly disagree; 2 = disagree; 3 = somewhat disagree (SWD); 4 = somewhat agree (SWA); 5 = agree; and 6 = strongly agree. Based on Colosi's (2005) explanation:

> This is important because after you enter the individual scores, you will calculate an average—or mean score for the whole group for each survey question. In the case of assigning higher values to stronger agreement, the higher mean scores for each question will translate into levels of agreement for each item, and thus, lower scores will reflect participants' disagreement with each item asked. (p. 2)

In keeping with this justification, a standard mean scale was developed to determine the level and/or degree of agreement or disagreement with the scale items. The moderate level considered SWD and SWA as a single unit since neither choice was absolute agree and/or absolute disagree. The scale for level/degree of agreement/disagreement was fashioned to reflect the following: 5.1-6.0 = highest degree; 4.1-5.0 = high degree; 3.1-4.0 = moderate degree; 2.1-3.0 = low degree; and 1.0-2.0 = lowest degree. For the group, the mean score levels of agreement/disagreement ranged from 3.25 (moderate degree) to 5.17 (highest degree). Table 4.5 depicts the levels of agreement/disagree with the scale items.

Table 4.5

Compilation of Levels of Agreement/Disagreement with Survey Questions

Domain and Question		Mean	Standard Deviation	Level
Relevance to Future				
Q10	Computer science is useful in the real world.	4.67	1.01	High
Q11	Computer science is important for finding a job in the future.	4.46	1.18	High
Q12	Computer science is important for finding a high paying job in the future.	4.79	1.14	High
Q13	Taking computer science is necessary for me to accomplish what I want to in school.	4.29	1.04	High
Q14	Taking computer science will help me reach my goals for college/career.	4.25	1.33	High
Intrinsic Motivation				
Q15	I find computer science to be very interesting.	4.38	1.28	High
Q16	I enjoy learning about computer science.	4.13	1.57	High
Q17	I want to be good at computer science.	3.83	1.17	Moderate
Q18	Learning about computer science is fun.	4.21	1.64	High
Q19	I think it would be cool to choose a job/career in computer science.	3.63	1.35	Moderate
Self-Efficacy				
Q20	I have the skills and ability to learn computer science.	4.88	1.23	High
Q21	I am better at computer science than most of the other kids at my school.	3.25	1.11	Moderate
Q22	I am very good at computer science.	3.63	1.13	Moderate
Q23	I can figure out how to solve the most difficult computer science tasks if I try.	3.83	1.31	Moderate
Community Beliefs and Values				
Q24	My friends would approve or think it is cool if I chose a job/career in computer science.	4.67	1.13	High
Q25	My family members would approve if I choose a job/career in computer science.	5.17	1.21	Highest
Q26	My family thinks it would be useful for me to take computer science.	4.63	1.21	High

Note: Overall Interest mean = 4.27 (high). Mean score for domains: Relevance = 4.49 (high), Motivation = 4.03 (moderate), Self-Efficacy = 3.90 (moderate), Community = 4.82 (high)

Further analysis of individual participant score totals—indicator of overall interest—revealed a range of 49-92, with a mean score of 72.67 and standard deviation of 12.80, which indicated that the values were spread out over a wider range. When placed on a scale of agreement/disagreement similar to the one used for the individual questions, the resulting levels for overall interest were lowest = 17-33, low = 34-50, moderate = 51-68, high = 69-84, and highest = 85-102. A cursory look at the results indicated that 67% of participants expressed an overall interest in computer science, while 4% had low interest and 29% were neither absolutely interested nor absolutely disinterested. Table 4.6 presents the levels of agreement/disagreement according to total participant scores.

Table 4.6
Participant Summary of Overall Interest Agreement/Disagreement Levels

Total	Response	Level	n	%
17-33	Strongly Disagree	Lowest	0	0
34-50	Disagree	Low	1	4
51-68	Somewhat Disagree/Somewhat Agree	Moderate	7	29
69-84	Agree	High	10	42
85-102	Strongly Agree	Highest	6	25

Note: Total represents participant's total score; possible range = 17-102

The final general examination of the Likert-scale necessitated graphing the data to get a better look at participant responses. Diverging stacked bar charts were used. This chart type "positions the replies horizontally so positive responses are stacked to the right of a vertical baseline and negative responses are stacked to the left of this baseline" (Peltier, 2016, para. 1). Rather than frequency values, "the percentages of respondents who agree with the statements are to the right of the zero line; the percentages who disagree are shown to the left" (Robbins & Heiberger, 2011, p. 1060). This makes it easier to compare the importance placed on survey items. As indicated earlier, this analysis treated somewhat agree and somewhat disagree as a single unit since neither indicated complete agreement or complete disagreement, thus the same color on the charts.

In all but one case in the domain of relevance to future, at least one-half (50% or more) of respondents were in agreement with the statements. Agreement for the statement related to computer science being necessary to accomplish in school was 42%. The opposite, however, was observed in the domains of intrinsic motivation and self-efficacy: More than one-half (50% or more) of responses presented in the moderate (SWA/SWD) to strongly disagree levels. The one area of the self-efficacy domain in which participants expressed a high level of absolute agreement dealt with their having the ability to learn computer science (67%). Figures 4.2-4.5 provide a comparative chart view of the domains.

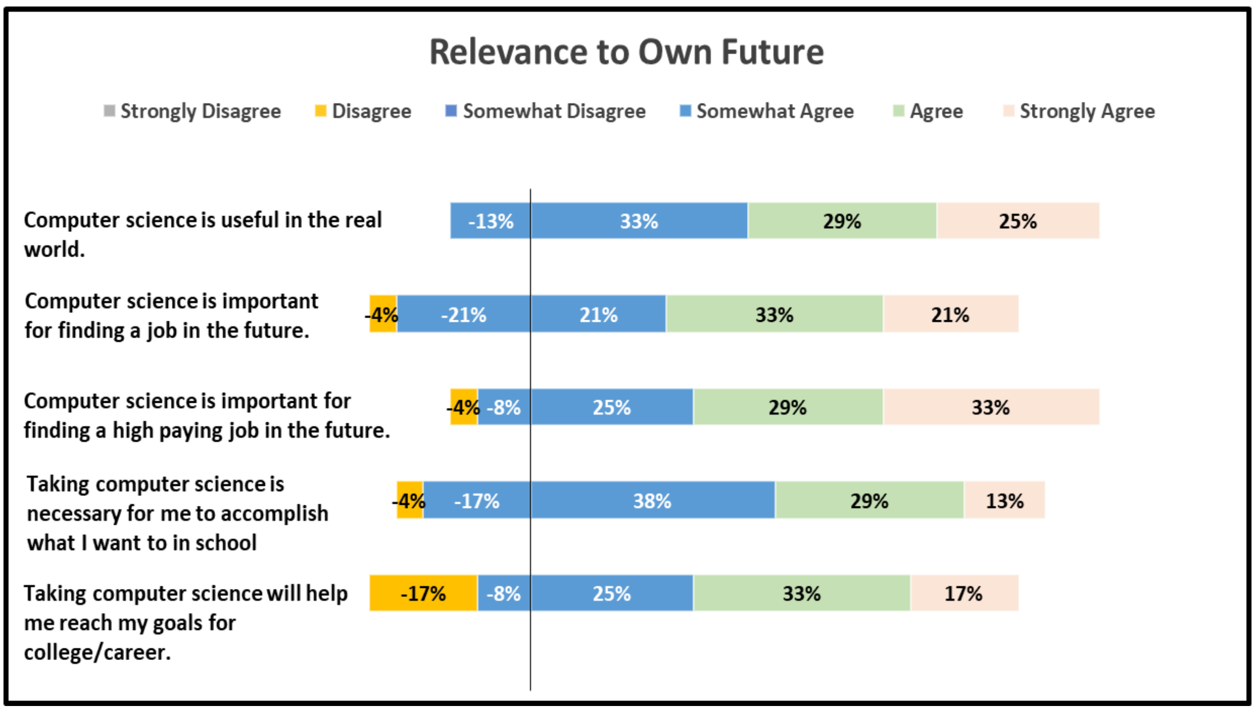

Figure 4.2. This figure reflects how students responded to relevance about their own future. Regarding each statement, the percentage of participants who agreed and/or strongly agreed was

much greater than those who disagreed. No students indicated strong disagreement with any of the statements. As previously explained, SWA and SWD categories were treated as one unit since neither was absolute agreement and/or absolute disagreement; however, more of the "non-committers" registered to the right of the zero line. Furthermore, Sixty-two percent (62%) of respondents perceived that CS is important for finding a high paying job in the future. Lastly, no one absolutely disagreed at any level with the statement related to computer science being useful in the real world.

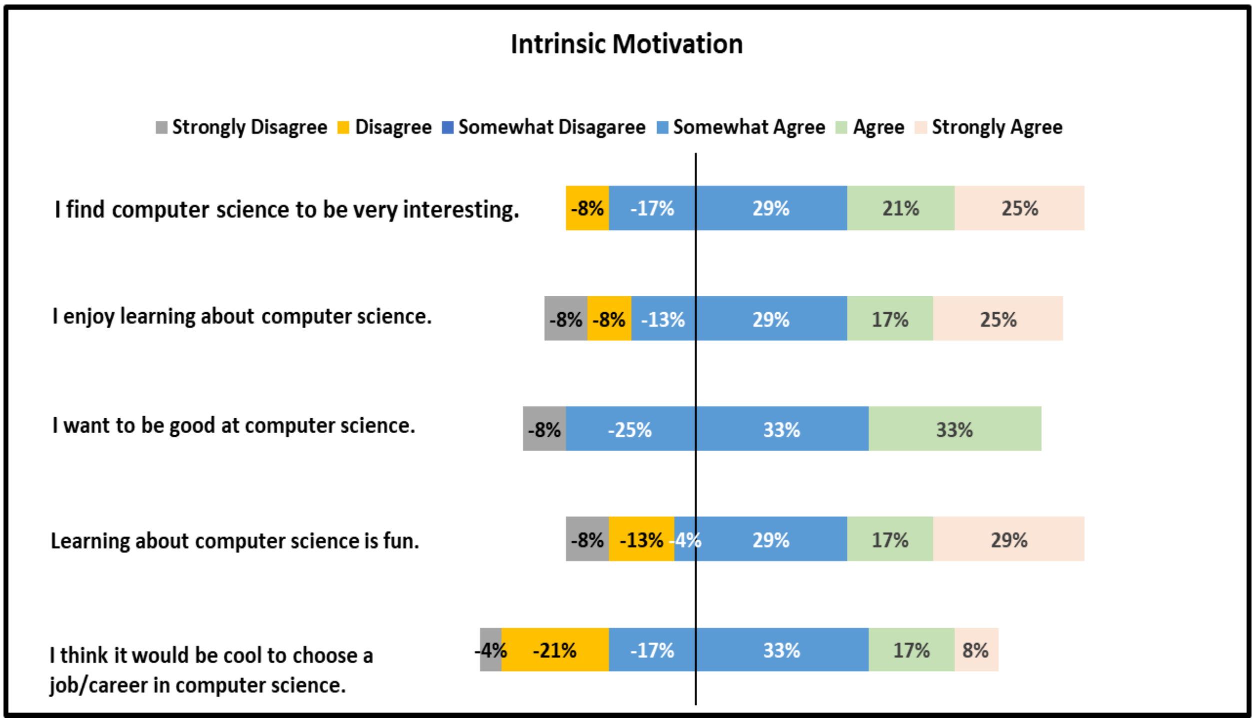

Figure 4.3. This figure reflects how students responded to intrinsic motivation. No participant strongly agreed with wanting to be good at computer science, yet there was strong agreement in the other areas, with thinking it cool to choose CS as a job/career being lowest—a combined overall absolute agreement rate of 25%. This measurement represented 6 of the 24 participants. Several students indicated strong disagreement with all but one of the categories, finding computer science to very interesting.

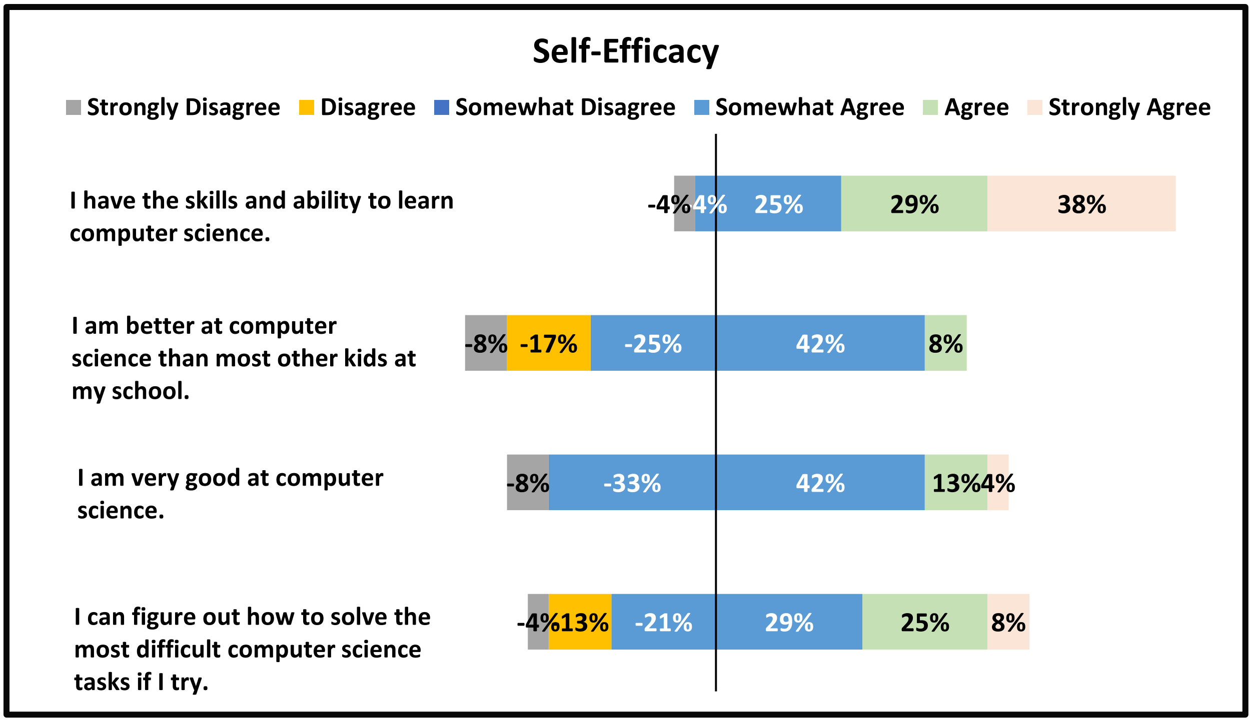

Figure 4.4. This figure reflects how students responded to their perceived self-efficacy. Sixty-seven percent of participants perceived they have the skills and ability to learn computer science. Confidence, however, did not appear to be as strong in the other areas that measured perceived self-efficacy. Compared to the other domains for measuring overall interest, there was more reported disagreement/strong disagreement in this domain.

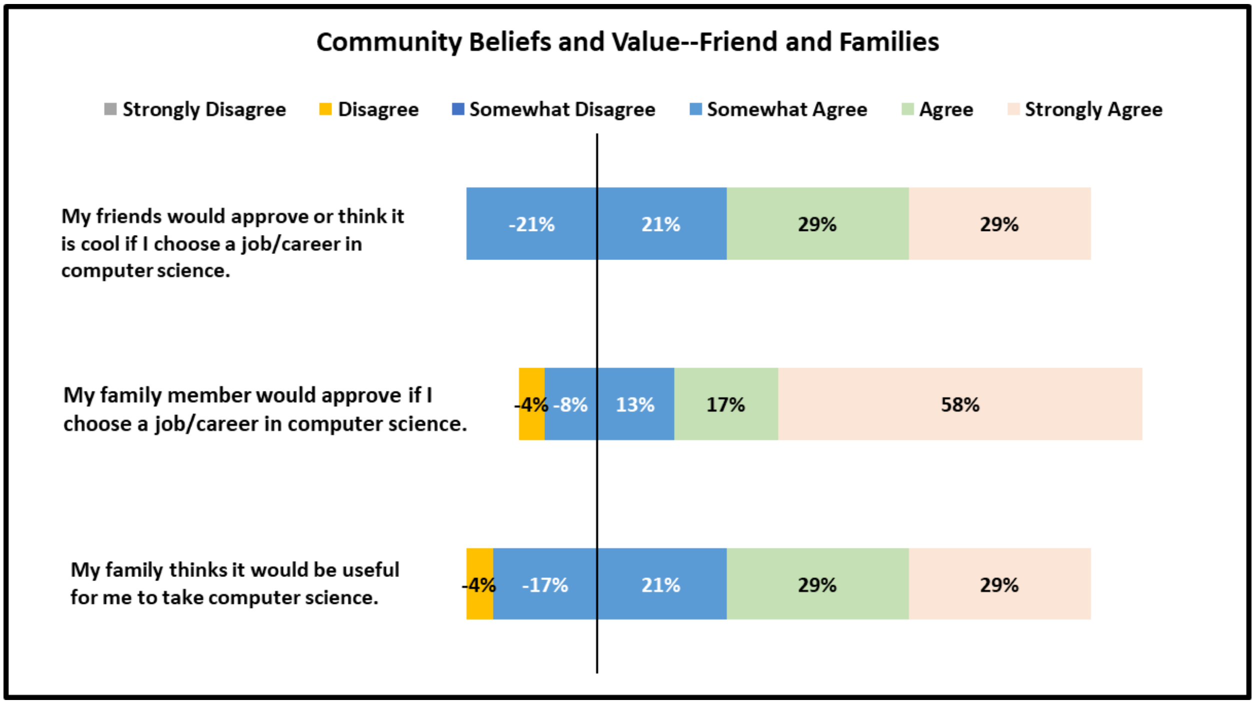

Figure 4.5. This figure reflects how students responded to their view of influence from the beliefs and values of friends and family members. Seventy-five percent (75%) of participants indicated that family member(s) would approve their choice of computer science as a job/career, with 4% disagreeing. None of the students disagreed/strongly disagreed with the statement about friends approving/thinking it cool to choose CS as a job/career. In the two statements that had disagreement, the percentage equated to one student in each instance.

Statistical Analysis of Likert Scale Data

In response to the previous subsection's results, supplementary questions arose that warranted further investigation. It was believed that answers to these questions would provide a more insightful connection between the various domains and select pieces of directory information, specifically if there were a difference in participant interest and/or in self-efficacy related to whether or not previous CS courses had been taken and/or prior participation in CS activities had occurred. To guide the direction of this portion of the analysis, additional questions included:

1. Is there a statistically significant difference in the overall interest of females who previously took a CS course and females who had not taken a CS course?
2. Is there a statistically significant difference in the overall interest of females who participated in CS activities and females who had not participated in CS activities?
3. Is there a statistically significant difference in self-efficacy of females who previously took a CS course and females who had not taken a CS course?
4. Is there a statistically significant difference in self-efficacy of females who participated in CS activities and females who had not participated in CS activities?
5. Do significant differences exist in self-efficacy for Caucasians, Blacks/African Americans, Hispanics, and other ethnicities?
6. Do significant differences exist in overall interest for Caucasians, Blacks/African Americans, Hispanics, and other ethnicities?

Inquiry at this point required utilizing the total score for each participant on the full interest scale and the score on the self-efficacy domain. Calculated scores were organized into four categories: (a) previous CS courses taken; (b) no previous CS courses taken; (c) participation in previous CS activities; and (d) no previous participation in CS activities. Again, Microsoft Excel 2016 was used to conduct four *t*-tests and two analysis of variance tests (ANOVA) to determine if there were significant differences in mean values between and/or among groups. The outcomes of the research were based on findings from a survey of 24 participants.

The *t*-test was used with the first four questions because it is one of the most commonly used significance tests to assess whether the means of two groups are statistically significantly different from each other (Zhang, 2000, p. 25). Because the last two questions involved more than two groups, the analysis of variance test was chosen. The ANOVA was selected ". . . because the researcher is able to compare several different groups" (Abbott, 2011, p. 257).

Statistical tests. The first *t*-test was run to determine if a significant difference existed in the overall interest of females who previously took a CS course and females who had not taken a CS course. A second *t*-test served to indicate whether or not there was a significant difference in the self-efficacy of females who previously took a CS course and females who had taken a CS course. The third *t*-test was run to assess if there was a difference in overall interest of females who participated in CS activities and females who had not participated in CS activities. The fourth *t*-test was used to determine if a significant difference existed in self-efficacy of females who participated in CS activities and females who had not participated in CS activities. Finally, two ANOVA tests were used (a) to decide if noteworthy differences existed in reported self-efficacy among ethnic groups—Caucasian, Black, Hispanic, and others; and (b) to determine if there were significant differences in overall interest in CS among ethnic groups. To assist with the calculation of test results, the Data Analysis feature of Microsoft Excel 2016 was used.

Test results. A two-sample *t*-test was run to determine if there was a significant difference in overall interest between females who previously took a CS course(s) and females who had not previously taken a CS course(s). Based on a *t-critical two-tail* of 2.07, the results indicated that the mean of calculated overall interest scores for females who took one or more CS courses ($M = 70.47$, $SD = 13.82$) was not significantly different from the mean of calculated overall interest scores for females who had not taken a course ($M = 78.00$, $SD = 8.49$), $t = -1.33$, $p = .197$. These results, therefore, suggested no significant difference in the interest of females who previously took CS courses and females who had not.

A two-sample *t*-test was run to determine if there was a significant difference in self-efficacy between females who previously took a CS course(s) and females who had not taken a CS course(s). Based on a *t-critical two-tail* of 2.07, the results indicated that the mean of calculated self-efficacy scores for females who took one or more CS courses (*M = 15.76*, *SD = 3.65*) was not significantly different from the mean of calculated self-efficacy scores for females who had not taken a course (*M = 15.14*, *SD = 2.91*), t = .04, p = .693. These results, therefore, suggested no significant difference in the self-efficacy of females who previously took CS courses and females who had not.

A two-sample *t*-test was run to determine if there was a significant difference in overall interest between females who had participated in CS activities and females who had not participated in CS activities. Based on a *t-critical two-tail* of 2.07, the results indicated that the mean of calculated overall interest scores for females who had participated in CS activities (*M = 71.92*, *SD = 11.89*) was not significantly different from the mean of calculated overall interest scores for females who had not participated (*M = 73.42, SD = 14.14*), t = -.28, p = .781. These results, therefore, suggested no significant difference in the overall interest of females who had participated in CS activities and females who had not.

A fourth two-sample *t*-test was run to determine if there was a significant difference in self-efficacy between females who previously participated in CS activities and females who had not participated in CS activities. Based on a *t-critical two-tail* of 2.07, the results indicated that the mean of calculated self-efficacy scores for females who had participated in CS activities (*M = 15.50 SD = 3.29* was not significantly different from the mean of calculated self-efficacy scores for females who had not participated in CS activities (*M = 15.67*, *SD = 3.65*), t = -.12, p =

.908. These results, therefore, suggested no significant difference in the self-efficacy of females who had participated in CS activities and females who had not.

For the final comparisons, two one-way analysis of variance tests were conducted to (a) determine whether significant differences existed in calculated self-efficacy scores for Caucasians, Blacks, Hispanics, and other ethnicities, and (b) determine whether significant differences existed in calculated overall interest scores for Caucasians, Blacks, Hispanics, and other ethnicities. In both cases, there were no statistically significant differences between ethnic-group self-efficacy scores nor between ethnic-group overall interest scores, as indicated by the one-way ANOVA. Tables 4.7 and 4.8 present a summary of returned analysis of variance results.

Table 4.7
One-Way Analysis of Variance for Differences in Self-Efficacy for Ethnicity

Source	*df*	*SS*	*MS*	*F*	*P*	η^2
Between-group	3	40.88	13.63	1.21	0.33	3.10
Within-groups	20	224.95	11.25			
Total	23	265.83				

Table 4.8
One-Way Analysis of Variance for Differences in Overall Interest for Ethnicity

Source	*df*	*SS*	*MS*	*F*	*P*	η^2
Between-group	3	44.10	14.70	0.08	0.97	3.10
Within-groups	20	3723.23	186.16			
Total	23	3767.33				

Influence on Enrollment

If presented with the opportunity to take a computer science course at the school, students were asked to select [from a list] the top three reasons that would stimulate their decisions. Items with the highest selection frequency were (1) good for me to learn—16 students (66.7%); (2) help me reach my college and/or career goals—12 students (50%); and (3) interest in computer science—9 students (37.5%). The same type response was solicited about preference for taking a computer science course over a suggested list of courses. Least desired options were manufacturing (15, 62.5%), marching band (14, 58.3), with a tie between early childhood and finance/accounting/entrepreneurship (10, 41.7%). Table 4.9 presents frequency and percent of selection for influencers. Table 4.10 depicts course desirability frequency and percent.

Table 4.9
Frequency Table of Student-Selected Influencers

Response Item	Frequency	%
I think it is good for me to learn.	16	66.7
It would help me reach my college and/or career goals	12	50.0
My interest in computer science	9	37.5
If my friends were taking the course	6	25.0
I will need computer science skills in the future.	5	20.8
If the course fit well in my school schedule	5	20.8
If I liked the teacher	4	16.7
If a teacher encouraged me to take it	3	12.5
If a guidance counselor/adviser encouraged me to take it	3	12.5
If a family member encouraged me to take it	3	12.5
If it were a prerequisite for another course	1	4.2
If other students encouraged me to take it	1	4.2
Only if nothing else fit in my school schedule	1	4.2

Note: Instructed to select top three choices

Table 4.10
Computer Science Preference over Other Courses

Response Item	Frequency	%
Manufacturing	15	63
Marching Band	14	58
Early Childhood	10	42
Finance/Accounting/Entrepreneurship	10	42
Sports Medicine	8	33
Culinary Arts	4	17
Media Arts	3	13

Note: Students instructed to select all that applied

Open-Ended Questions

The final two questions of the survey were open ended and asked students to respond by keying in their answers. Questions 30 asked, "What does computer science mean to you?" and Question 31, "Do you have any other thoughts about computer science that you would like to share?" Replies to both provided a slight hint of the direction that some conversations could take during the qualitative phase of data collection.

First-round coding for these questions required reading through the responses to draft a list of keywords/phrases that originated in the content of the various statements. To confirm the viability of the list, *Textalyser.net*, a free text analysis website, was used to analyze the text of the participant responses. Among the returned results were word count, frequency and top words, word phrase frequency, and unfiltered word count. Comparison of the electronically produced list of top words and the researcher created list revealed that they were similar in content, thus signifying a move to the next step.

Microsoft Excel 2016 was employed to create a spreadsheet on which participant responses were entered as row labels; column labels were based on the top keywords/phrases found in the content of the different responses. A checkmark was then placed in the column(s) which best represented each statement. To quantify the open-response data, each checkmark was replaced with the number one, which aided the calculation [for each column] of the total number of participants who responded and the percent of respondents who answered. Table 4.11 lists the calculated results of Question 30—What does computer science mean to you? Table 4.12 displays response frequencies for Question 31—Do you have any other thoughts about computer science that you would like to share?

Table 4.11
Personal Meaning of Computer Science

Keyword/Phrase	Domain(s)	Frequency	%
Learn/use a computer	Future and Motivation	15	62.5
Learn a skill or other things	Future and Motivation	10	41.7
Problem solving	Self-efficacy	8	33.3
Future employment	Future	6	25.0
Future success	Future	5	20.8
Coding	Motivation/Future/Self-efficacy**	5	20.8
Exploring	Motivation	5	20.8
Challenging	Self-efficacy	4	16.7
Credit [graduation] satisfaction	Motivation	3	12.5
Create/make things	Motivation	3	12.5
Collaboration	Motivation and Self-efficacy	2	8.3
Not much	Motivation and Self-efficacy	2	8.3

Table 4.12
Additional Thoughts about Computer Science

Keyword/Phrase	Domain(s)	Frequency	%
No response	Motivation and Self-efficacy	9	37.5
Interesting/engaging	Motivation	6	25.0
Good class	Future and Motivation	6	25.0
Future employment	Future	5	20.8
Comfort level	Self-efficacy	5	20.8
Future education	Future	4	16.7
Beneficial for students	Future	4	16.7
Ability level	Self-efficacy	4	16.7
Fun	Motivation	4	16.7
Hard/Difficult	Self-efficacy	3	12.5
Encourage females	Self-efficacy and Community beliefs	3	12.5
Learn things	Motivation	3	12.5
Coding	Motivation, Future, and Self-efficacy	2	8.3
Helpful teacher	Self-efficacy and Motivation	1	4.2
Digital citizenship	Future	1	4.2

Key words for both inquiries were classified based on their relationship to the Likert scale domains. One finding worth singling out was that of participant responses to Question 30. When compared to the definition of computer science offered in Chapter 1, scrutiny of responses revealed that the majority did not fully understand the meaning of computer science. To restate in simple phrasing as used with students during instruction, computer science is the study of how to use computers and computing concepts to solve problems and/or design solutions that will impact society.

Phase 2—Qualitative Analysis

This section presents the outcomes from three mini focus groups. An overview of the findings is presented in this section, while inferences and recommendations have been recorded in Chapter 5—Implications, Conclusions, and Recommendations. Participation of ninth-grade female students was necessary (a) to have a pre-high school view of exposure to/preparation for CS to gain insight into present-day perceptions and attitudes toward computer science; and (b) because of their time left in high school to consider enrolling in CS courses, thus possibly increasing female enrollment in computer science courses at ZBFHS. The responses and comments from focus group participants provided awareness of interests, perceptions, and attitudes that were deemed beneficial to laying a foundation for framing a solution to the problem of practice: increasing female enrollment in high school computer science courses.

Collection of quantitative data established a base for the gathering and analysis of qualitative data gleaned from the three mini focus group meetings. The sessions, two participants each, were conversational in nature and were conducted inside a classroom at the school of attendance. Each participant chose a pseudonym to protect her identity when names were to be associated with direct quotes. For this work, students were referred to as Jewell, Kyndall, Michelle, Javaria, Molly, and Bethany. Furthermore, each student was asked to assent to participation in an audio-recorded session. Parental consent to take part in both quantitative and qualitative phases was secured prior to the start of data collection. As a reminder, ten students indicated an interest in the focus group phase; however, one moved out of state and three opted out after notification of session dates. Table 4.13 provides information about focus group participants.

Table 4.13
Participant Demographics

Group	Name	Ethnicity	Age
1	Jewell	African-American	14
1	Kyndall	African-American	14
2	Michelle	Caucasian	14
2	Javaria	African-American	15
3	Bethany	Caucasian	14
3	Molly	Caucasian	14

The length of each session ranged from 35-40 minutes, during which time all responses were audio recorded. Some manual notetaking was deemed necessary to record observed facial expressions and/or body language that occurred as a result of specific questions and/or responses. Recordings were transcribed and verified for accuracy by listening to the conversations while reading the scripts. Once corrections/edits were applied, participant responses to a specific question were grouped for comparison. This provided an opportunity to look for common themes/threads that emerged. Thematic categories were developed based on commonalities among the responses and were compared to threads that materialized during quantitative data analysis. Interestingly, themes from both collection cycles aligned with one or more of the domains measured on the Likert-style scale: relevance to future, intrinsic motivation, self-efficacy, and community beliefs and value. Because of the similar nature of the domains and the question classifications on the qualitative protocol, the decision was made to analyze questions based on their categorical groupings.

Qualitative data functioned as an extension of quantitative data in the pursuit of answers to the research questions: (1) Why are female students underrepresented in computer science education at ZBF High School? (2) What are the influencing factors on females' decisions regarding computer science? Questions in the focus group protocol were used to conduct a more in-depth inspection of the problem and were categorized into topics that included: (1) background/self-description as a student; (2) post-high school plans (future goals/expectations); (3) STEM courses and experiences; and (4) gender, STEM exploration, and social/relational support. A visual perception opportunity was provided to participants in which each drew a picture of a computer scientist as envisioned in her mind.

Analysis Preview

This section presents a synopsis of findings from the focus groups for the following key areas: (1) personal perception as a student; (2) confidence in math and/or courses that require the use of math; and (3) family and peer support. A comprehensive discussion of these and other areas follows this preview.

Personal perception as a student. All of the participants reported doing pretty good to well in school, with self-reported grades ranging from C up to A. Despite a report of "could be doing better," one of a little struggle in science, and another of a great deal of struggle in algebra, each participant equated good grades with getting into college and having a successful future. Two expressed being motivated by grades, one motivated by music, one by future success, and two contributed motivation to parents.

Confidence in math/courses that require math. When asked to rate math ability on a scale of 1 (lowest) to 10 (highest), the participants' scale scores ranged from 1-8 with one student describing her ability as a negative four (-4). Explanations for the ratings included issues such as "hard to understand," "depends on the type of math," "my skills aren't the best," and "I'm good in division and multiplication." Though not much higher than ability ratings, four participants expressed more confidence in courses involving the use of math. Additional details have been presented in the comprehensive analysis discussion.

Family and peer support. In general, participants not only reported parents as motivators, but also described them as supportive in whatever career choice or course of study they would choose to pursue. There was, however, one report of non-parental support for a preferred career path. There were no accounts of being pressured by peers if interests were different or if the decision was made to choose doing well in school over friendship(s). Overall, the students reported ample family and peer support with their school/career-related choices.

Background/Self-Description as a Student

Self-descriptions. Each student was asked to share a little about herself as a student, and all reported doing well in school, with letter grades ranging from A-C. When asked what motivated them, the list included grades, music, parents, success, getting into a good college, and having a good career. Michelle stated, "Grades are an incentive for me. I'm motivated by knowing I'll do good in school and end up getting my goal of having a good career and being able to provide for my family." This [good career and outlook] aligned with items on the lists from the two open-ended survey questions—personal meaning of computer science and additional comments—in which the majority of participants equated grades with future success and/or getting into a good college.

For the two who spoke of parents being their motivation, it was inferred from their phrasing that they desired to please their parents. Kyndall explained that her mom and dad motivated her "because me achieving at this would help them know that I am something, like not gonna go down a bad path like siblings." Javaria, on the other hand, was encouraged by her stepdad each time he asked about her wanting to be independent when she grew up. She stated, "That makes me push harder when he asks that (*short pause*) makes me want to make good grades." Surprisingly, there was no mention of friends during this portion of the conversations.

Despite reports of doing well in school, two unfavorable words stood out in the response comparison for this question, "struggle" and "hard." Two of the participants used the word struggle in relation to courses: Bethany stated, "I struggle a little in science," and Molly said, "I struggle a lot in algebra." As for the word "hard," Kyndall conveyed, "In school, doing pretty good, could be better, but it's hard." When taken together, the two words could have led to an early "diagnosis" of low self-efficacy; however, this determination was delayed until after analysis was complete. At this point, attention turned to the examination of Question 2: What would you say is your best subject in school? Why? Which subject is your least favorite? Why?

Favorite and least favorite courses. Among the list of favorite courses, English/reading weighed in with four responses, while science, art, and history had one vote each. For least favorite, three reported math, two science, and one English/reading. Jewell softly and halfheartedly reported, "I'm not good in anything." but later chose art after listening to the response and explanation from her fellow group member. She was also the one who placed great emphasis on the word "math" when naming her least favorite course: "Math could be quite difficult to understand for me and all the numbers and stuff; I get really confused often about math, so that's probably why I'm doing so bad." Her tone of voice and body language during this revelation gave the impression of low self-esteem as well as pointed toward a lack of self-efficacy in her abilities.

Post-High School Plans (Future Goals/Expectations)

Post-graduation plans. The question "What ideas do you have about what you would like to do upon graduating from high school?" received a variety of responses. The common response was go to college; conversely, career choices included nurse, child protective services worker, immigration lawyer, judge, doctor, and artist. Although two of the career choices were within the STEM area, neither was anything akin to computer science. In fact, all of the career preferences dealt with helping people, which aligned with the position of Charles (2017) whose work was discussed in the literature review. She offered the argument that young people usually do not know what they want to do, so they tend to choose their paths based on stereotypes of what same-gender influencers might do or might be good at. Charles' tendered example was that of girls inclining toward choosing work that is more people oriented and/or emotionally rewarding rather than select fields that have traditionally been stereotyped as requiring more masculine traits and aptitudes.

To bear witness to her [Charles'] position, Molly spoke of becoming an immigration lawyer and expounded further with:

> I feel like immigration policy is something that I feel kind of passionate about, and I feel like if I can help people get there and like if they already have family here and they want to be with their family then I can help them get to their family. I think that would be good.

Bethany was moved by a situation in which her cousin "got put into child services." She added that the cousin was "then placed with my grandma and then got back to her parents who were responsible for her, and I want to help fix that." Finally, Jewell's desire to be an artist had to do with moving people in an alternate direction. She desired to "inspire them in ways and sometimes confuse them but open up their minds a little more to, like seeing different things."

Dream career. When asked about being able to choose any career, regardless of preparation required or talents needed, once again, they selected careers that involved helping and/or providing a service to people: teacher, business owner, doctor, to name a few. Supporting statements included, “help younger people and lead them in the right direction.” “I like the idea of helping people, you know, when they’re sick or like in need or help something.” Lastly, “I just think the idea of owning a business and being able to do something that you love or producing whatever product you’re going to make would be nice.”

Reflection. A concluding thought from dialog created by questions in this section offered assistance toward arriving at an answer to the first research question, “Why are female students underrepresented in computer science education at ZBF High School?” When considered in conjunction with quantitative data, this group of females had little to no interest in the field of computer science; however, neither a generalization nor a definitive conclusion can be offered at this stage of analysis.

STEM Courses and Experiences

Because computer science is a math-intensive area of study, it was considered appropriate that participants be polled about confidence in their math abilities. The first question asked them to share a story that explained something about the type of student they are in math. Question 2 required them to rank their math ability on a scale from one to ten, with one being lowest and ten being highest, whereas Question 3 measured their confidence level in courses involving the use of math. As expected, ratings varied along the continuum.

Math stories. First-person reports ranged from being a good math student on one hand, to not knowing anything on the other. Michelle described herself as being good in math, which dated back to third grade. She attributed this to a teacher who always pushed her “really, really hard." "Every time I have a really hard time or like give up on something, she was always there for me to contact. . . .She'll tell me that I can do it. I just have to focus harder. So I feel I'm a good student because of that in math." Jewell, on the other hand, provided a different experience when she quietly stated, "Probably because I don't know anything, I get really embarrassed when the teacher probably calls on me for like a question and I don' know it. That's probably the most difficult part I think." As for Kyndall, math concepts are difficult for her to grasp. When assistance was requested or questions were asked of her math teacher, she usually received a response of "should have been paying attention" or other similar statements. She concluded by saying, "I just never get the full understanding about it."

These accounts served as examples of the impact teachers and classroom environment have on the development of student confidence levels related to academic abilities and/or achievement. This inference is supported by Rubie-Davies (2010), whose research concluded that class level expectations are important for student learning. Additionally, she stated, "A further implication of teachers' expectations is that when teachers have high expectations for some students and low for others this may lead to a halo effect in which teachers also perceive there to be differences in student characteristics" (p. 122).

Supplementary literature evidence to explain feelings expressed by Jewell and Kyndall emanated from Madara and Cherotich (2016) in their report on challenges faced by female students in engineering education, a "sister" course to computer science. They observed that "female students learning engineering and technology courses receive discouragement and off-putting remarks from their teachers." Because of this type of action and other negative classroom experiences, it is more likely than not that:

> . . . female students pursuing engineering and technology courses develop low self-esteem and low confidence due to the fact that they are perceived as incompetent.

> Consequently, they avoid asking or answering questions, for fear of being put down by their teachers and male students, who dominate classes. (p. 9)

A final reflection in their study linked challenges faced by female students from teachers and classmates to the probability of lowered performance.

Math rating and confidence level. As previously specified, students were asked to assess their ability in math and then consider their level of confidence in courses that use math. Based on stories about themselves as math students, it was not startling that most rated their math ability from extremely low (less than one) to medium-high (seven or eight), with no reported confidence level above an eight. Table 4.14 presents participant ratings of math ability and course confidence, along with paraphrased explanations for the rankings.

Table 4.14
Self-Assessment of Math Ability and Confidence Level in Other Courses

Participant	Math Ability	Explanation	Course Confidence	Explanation
Javaria	5	Not really good with numbers	7	Science uses a lot of math; you just have to pay attention to the steps.
Michelle	7 or 8	Good, but I like to push harder to learn.	6	Hard time with math outside of a math class—not having a teacher to show me the right steps
Bethany	7.5	Skills are not the best but can do a lot of math	6	Understand it but get confused; cited binary code as an example
Molly	4-5.5	I understand and remember basic math.	3 or 4	Not very confident; [I] don't do well on test and quizzes; binary code easy because calculator was used
Kyndall	-4	Hard to understand	4 or 5	No explanation, just a shrug of the shoulders
Jewell	1	Very difficult	4	No explanation; continuous shaking of the head in the negative

Note: Lowest = 1; highest = 10

STEM career exploration. Having studied the self-assessment scores, it was not unexpected to learn that students had limited experiences in the exploration of STEM careers as a whole. Even fewer had probed CS careers, despite the fact that all were enrolled in a computer science and/or computer science-related course. Only two, Bethany and Molly, reported having engaged in class activities geared toward STEM/CS career exploration. Between the two of them, the career fields list included web page design, engineering, game design, medical professions, and computer programming. This, as reported by both, took place in their Exploring Computer Science class. The four remaining students not only failed to present data on the subject of STEM/CS career exploration, but also struggled with and/or did not know the name of the CS course in which they were enrolled. This was an indicator of deficient knowledge of school offerings in the area of CS education, as well as little to no teacher/counselor discussions of course content and/or connection to computer science.

When asked if anything had hindered them from considering computer science further, each responded in the negative. Jewell admitted she just never thought about it and continued her explanation by stating, "Computers are more difficult to learn, but I'm slowly getting there." Kyndall contributed to the conversation by declaring, "I just feel that they are just another technology for us to get something to use." When asked to explain, she stated, "Like games. You do Netflix and all of that; it's easier for us to get sucked into that instead of paying attention to the real world." Her response verified that she understood the concept of digital citizenship but not the content or definition of computer science.

Despite dismal accounts about career exploration, Molly enthusiastically communicated her plans to take additional CS courses during her eleventh grade year—no room on proposed tenth-grade schedule. She was especially interested in web page design and proudly shared that she liked it because it was fun, so much so that she practices creating web pages at home. Although she liked the web design area, she would not want it as a career but thought about it "for like a side job." As for computer programming, she did not like that unit. "It used too much thinking. . . . that one confused me a lot." No one else had comments on the topic of programming.

Reflection. Comments extracted from this segment of the conservations yielded results that connected to various quantitative open-ended responses, namely, the declarations about math being hard/difficult. One account from the open-ended data section of the survey instrument that spoke volumes was a recounting of feelings/opinions when asked to share additional thoughts about computer science, a math-intensive course of study. The anonymous participant wrote:

> It is a very hard task to accomplish and I feel students need to be able to have a teacher that will sit down and talk with them one on one and guide them through a sample activity that involves the curriculum in order for them to fully develop and understand how to do the work. Textbooks are too hard for students to learn new material from because they do not give the student the one on one opportunity they need in this category.

The conceptual framework spoke of teacher/student perception and academic self-efficacy as supplemental negative stimuli on the problem, and the previous testimony is a representative example of this. It also addressed the dilemma that not "just anyone" can teach computer science, which was also supported by research conclusions presented in the literature review—the inability to find certified/qualified teachers of CS education, especially females.

Gender, STEM Exploration, and Social/Relational Support

This class of questions was designed to poll students with the intention of gaining more insight into whether or not a perceptual relationship existed between gender and career exploration and/or available options. An additional desire was to assess the level of impact that parents and peers had on participants' career selections and/or courses of study. It is worth mentioning that resulting conversations yielded several opportunities to engage in unscripted inquiries to follow up on vague/interesting responses and/or observed displays of body language. Questions in this section addressed areas that dealt with:

1. their sense of gender [being a female] on career exploration and options;
2. the influence of gender on interests and what they believed they could do in the future;
3. their perception of the role of females in STEM career fields such as computer science;
4. parents' reaction to expressing an interest in computer science classes or in a computer science career;
5. parental guidance in and family expectations of future education and career plans;
6. peer influence on career choice or course of study.

Gender and career options. Regarding sense of gender and its influence on career exploration and options, all responses in one way or another alluded to their not being affected by being female. The conversation during Focus Group 3 was much more energetic than those of Groups 1 and 2. Their [Group 3] contributions to the discussion touched on information referenced in the literature review. One remark dealt with expressions of anger when boys commented in the negative at the mention of a desired career(s). When asked to elaborate on the anger, the passionate reply was:

> . . . For some of the stuff I use to want to be, there would be like guys who would be like 'you can't do that,' and it would just make me angry because yeah, I'm a girl, but I can do stuff like that. Like when I was in elementary school, I wanted to be a mechanic and they were like 'you can't do that cause you're a girl'; and I wanted to prove them wrong so bad."

This was powerful because it exposed an earnest conviction that girls do not have to limit their career choices; however, it should not be interpreted to mean that girls would positively choose computer science or another STEM field as a career option or course of study.

In keeping with this thought, Participant 2 of the group presented a slightly different view. "I feel like being a female for me doesn't really affect it much because I've never wanted to be anything like an engineer, or I never thought about computer science until I was put in it this year." When asked to express thoughts on who goes into computer science and/or engineering, the response was astounding because of its connection to research:

> I think guys usually do it more. I think because boys have more of an interest than girls do, and I think around middle school and high school girls start to lose interest in that stuff and start to focus more on like their friends, social stuff, and guys.

Bethany chimed in with agreement:

> I believe they also start to lose a lot of interest and it's more towards what guys like because it has a lot to do with video games, and they love video games. And it like, it pulls them more than girls.

Gender influence on interests and future accomplishments. Once again, conversations stimulated by the questions in this section were quite enlightening. Four participants (67%) believed that gender did not have a starring role in influencing things that interested them nor did it sway what they believed they could accomplish in the future. Comments ranged from "It doesn't really bother me, because anything a man can do a woman can do." to "Boys don't need this cause mostly girls work as nurses and stuff. . . . It's mostly girls who need this." Based on the conversational context of the preceding statement, the participant was speaking of her specific career choice, as well as referring to the use of computers, commonly known as computing. This thought aligned with the literature discussion that reported on the view of computer science before it found literacy as career field: It was clerical in nature, with women being hired to perform most of the jobs in this area.

One participant in Group 2 asked if there was "a computer class where all girls go there to learn about how to use them." Although she visually presented with self-confidence, the tone of voice when she inquired about the all girls' class was something other than a sound of confidence. When asked if an all girl's class would affect how she viewed/thought about computers, her immediate response was "no;" however, Michelle eagerly interjected with a different opinion:

> I know I would. Because, I mean I feel like I would, like, because boys don't take it as serious and they hinder like our focus and stuff because they sit there and like they goof off so then we don't take it as serious, but like if it was like just girls, then I feel like it would be taken more seriously.

She continued her response by relaying that boys don't really sit down and work the way females do. "You don't see them doing a lot of the inside stuff . . . so I feel like as a female, we do more of the technological stuff inside."

After hearing Michelle's point of view, Javaria altered her response by declaring, "Cause we all want the same thing in life if you offered an all girls' class. Yeah." Although an unanticipated point of view, the "all girls" statements permitted a glimpse into a state of anxiousness and/or apprehension about academic achievement when sharing a technology class with males, a theme common among studies about gender and computer science. Margolis and Fisher (2002), as discussed in Chapter 2, addressed differences in attitudes and experiences with computers and exposed these differences as crucial elements to understanding the roots of the gender gap in computer science and for devising effective interventions.

Female role in computer science. Inquiry continued by asking participants to communicate their beliefs regarding the role(s) females have in STEM career fields, such as computer science, a question that required clarification in each group. After listening to the various conversations that ensued, it was evident that participants did not fully understand STEM nor the concept of computer science; yet, this lack did not lessen the value of the comments. For instance, one respondent presented engineering as a role that a female could have. When asked why engineering, it was explained, “My aunt is an engineer, so that’s what role they take.” Even though she recognized engineering as part of the STEM field, she was unable to provide additional information when further probing asked for a description of what engineers do. No one was able to provide names of specific job titles in the CS field; however, one connection was made to the computer repair area—“Aah, would it be someone who like replaces stuff on computers, like computer fixers?”

This sparked a short discussion on not seeing females in this arena. As stated by Bethany, “Every time I’ve gone to go get a phone screen fixed or a computer fixed, it’s always been a male. I don’t really see girls working there.” She does believe, however, that it is a position that a female could do because “anyone can do anything they put their mind to. So if girls really want to go do stuff like computer fixing, then they can as long as they put their mind to it.” Her groupmate commented:

> I think nowadays, more than whenever computers and all that stuff was new, I think that females have a more important role in everything like that because now, like stuff is getting to be more equal between the two, not quite there yet but getting kind of close.

Lacking full clarity about the questions in this category, compounded with the inability to offer specifics related to the inquiries, group member responses, or lack thereof, proved to be instrumental in steering the pursuit of answers to the research questions. Based on the flow of the conversations, it was reasoned that none of them had been exposed to female computer scientists. Absence of access to female CS role models, as reviewed in Chapter 2, could function as a barrier to preventing girls from considering CS as a career option and/or feasible course of study.

Parental influence and expectations. Conversations in this area were focused on an exchange of ideas about future education and career plans, family expectations about plans, family reaction to expressing an interest in computer science, and family members employed in computer science or other STEM fields. When asked how parents would respond if an interest in computer science were to be expressed, five of the interviewees relayed that their parents would be happy, with various reasons being reported—". . . future jobs are going to involve like the stuff that we need to learn in those classes." "My mom would be very proud because that's something she used to do. She went to study, aah, web paging . . . ." ". . . I think my mom would definitely like it because she's a bookkeeper at two places; so she uses computers a lot, and she actually taught me a lot about computers that I didn't know at first." These three statements were reflective of research that presented evidence of the positive outlook for careers in computer and information technology, two of the fastest growing career fields. Kyndall's report of "happiness" was a bit different. Her parents would just be glad that she had an interest in something else other than sports. She also alluded to her lack of confidence with CS as she stated, "They would be happy, I guess, cause I'm always playing sports, so maybe doing something out of my comfort zone, they would just see me as being happy or, I don't know."

As the lone dissenter of the participants, Jewell seemed surprised that this was even asked. Upon hearing the question, she quickly exclaimed, "On a computer all day!" Her facial expression reflected the surprise in her voice. Not only was she surprised by the question, but she also expressed a belief that her parents might not understand, as she continued with, "Most likely, for me, I'm a very creative person, so they probably wouldn't understand why I would do that. Like, but they'll accept it if I'm doing good and I like doing it."

During the course of describing conversations that had been held with parents or guardians about future education and career plans, some of the accounts were more positive than others were. For instance, Bethany recounted how here parents were supportive and were there to offer guidance regardless of the number of times she chose something different. "I change my mind about what I want to be all the time and so my parents are always like, 'Well, what are you in love with doing now?'. . . They have helped me like decide what I want to do." In keeping with this view, two of the other participants had reports along the same line. Molly stated that her parents "give me like pros and cons for different stuff." Michelle [from Group 2] explained how her parents took time to help her decide what courses she should choose for the next school year:

> My parents, like whenever we do my IGP and stuff, like the couple of weeks before, we sit down and we talk about it. Like what classes I would need to take that would help me like learn more about that career, so I know what I'm getting myself into.

Jewell, on the other hand, described a different conversation experience with her parents. They, especially her father, were not supportive of her career choice to become an artist:

> Aah, well, my parents don't like, like my dad, doesn't like me being an artist, because I use to be a basketball player. Like I said, I don't do sports anymore, and I was really good at basketball. It's like you probably can't get like a career in art; like just go back to basketball. So I'm trying to decide if I want to do that. It's not something I really want to do.

She did add that her mother had explained the process of getting into art school and had helped her sign up for art classes and similar programs. She ended by stating, ". . . It's not their decision of, like of what we want to do."

The next question was "How do you think your family's expectations about your future plans are shaped by the fact that you are a female?" For the most part, participants shared that this was not an issue for their parents. Some of the comments included, ". . . As long as you go to college and get the education to be what you want to be, then we will be there for you 100%." "As long as I have a job that can be stable to me like a boy, girl, or whatever and can support me, I think they're fine with whatever." "They just kind of told me to do what I feel like would make me happy . . . like building a building, which is something like you would normally see a guy do, they'd say go for it." Contrary to these admissions, one account had a thread of female versus male roles entwined within the words of the conversation about a desired after-graduation choice of going into the military. This preference was met with a difference of opinion from the parents:

> My parents, when I said that I want to go to the military, my mom didn't want me to go; but my dad, he doesn't, he cares, but he's like, he wants me to do whatever makes money come to the table for me in the future and be able to be successful for myself in the future. So he's good with it. My mom, she doesn't want me to go. She'd rather me be like a nurse or start my own business like her or something.

The final question in this group inquired about family members who might work in computer science or some other STEM-related career field. There were two reports of having no family members in either field. In one case, it was stated, ". . . the adults in my life, when I was telling them what we were learning about binary code, they didn't seem to know what that was, . . . but no one works with computers." For the remaining four participants, there were reports of having a family member(s) in fields such as engineering, computerized HVAC system design [for new houses], and web page design and development.

Peer influence related to expression of interest in computer science. The first question in this area was, "Think back to a time when your interests were different from those of your friends' interests. How did you maintain that interest and your friendships? It was attention grabbing, and refreshing at the same time, that one response was, "This never happened to me before. I only have one, two, couple of friends, but we're all interested in the same things." This was an unexpected response, since teenagers often have ideas/desires about which they disagree. This was quite different from the input of the other students. Though similar in thought, the phrasing of each expression was unique, as illustrated by the following:

> I kind of just went along with it and did what I felt like I wanted to do to, like make myself happy and to make like, make my future better for myself. And if my friends didn't like it, I would sit down with them and tell them, 'Hey, I needed to do this for me.' And they kind of just said okay. (Michelle)

> Aah, I know like how for clubs, I do debate club and I do FBLA, and my, like best friend, she was not interested in either of those. But on some Tuesdays and some Thursdays, I will have to leave her and go to the club, even if it's not the whole time. Still, for SLT, whenever I have it, like I do right now for algebra and I have to leave her, but we still text. I mean, I just feel like sometimes when you have a friend and they just don't understand that you're interested in something else, then they just don't understand and that's kind of their loss. (Molly)

> I just did what I did, and if they didn't accept that, they wasn't a true friend. I haven't really lost any friends. They will accept me, or I'll accept anything they do because we are good friends to each other. (Kyndall)

> Well, we do have different interests, but I like her interests and her being what she wants and her being comfortable of what her future is, and she's being comfortable with mine. So I think we put up a pretty good friendship if we don't come out, like in a bad future as a person. (Jewell)

The last contribution was Bethany's matchless account, which provided a glimpse into how friends can agree to disagree in a manner that turns out to be beneficial for all. Her explanation included details of how differences have the potential to create opportunities to explore and/or pursue new interests:

> Well last year, me and all my friends wanted to get in the same classes together because we didn't want to go make new friends, so we all put the same things. But I seen that they had intro to culinary, and I was like I really want to do that, and all my friends were like 'No, we are not going to make new friends and stuff.' And I was like, 'I want to do

> that,' so I put that. And even though I didn't get it this year, me and my friends still didn't get any of the same classes together. We only basically had ILT to spend, so, uhm, we ended up making ILT our time to get together and stuff; and we all ended up making new friends, and we just went our separate ways.

In each instance, the discussion of different interests segued into dialog related to conversations with friends about STEM-related issues. Each group was invited to respond to three questions, the first of which was, "If you were to express an interest in computer science classes or a computer science career, how would your friends react?" Responses varied in content and ranged from, "I think my friends would think that it would be good, and they would think I was smart just because I'd want to do that." to "They probably wouldn't have thought I would have done something like that." Javaria gave a thought-provoking comment when she stated:

> They would probably ask me why. What's in computer science for me, and then I would have to break it down to them of why it's for me. Because it's a lot of things you can do inside computer science and you can use computer science for other things. Like teachers use computer science, nurses use it, engineering workers. It's little things that you need computer science for. . . . They would be curious why.

Bethany spoke of her friends being supportive and confirmed her belief by informing the group that one of her "other friends loves computer science. She takes it too, and so they've all been very supportive." Jewell, the most timid of all the participants, shared that her friend would think it was unlike her to be in computer science, and although she has admitted to not being interested in computer science, she would not be opposed to her friend's consideration of CS as an option. This was made known when she stated, "But I think she would like it for herself."

Peer influence that could prove to be negative. How would you respond if your friends told you not to explore the computer science field? How would you react if your friends thought that studying computer science was just not cool? These two questions generated interesting comments in each group, as well as served as a launching pad to a more in-depth discussion in Group 3.

Participants delivered their responses in a way that reflected astonishment. More now than at any other time during conversations, each student appeared to be somewhat agitated at the thought of being discouraged from pursuing an idea or an aspiration. Both verbal and non-verbal expressions demonstrated their ability and/or need to be independent in some areas of their lives. One of Group 2's members stated, "It's to better me, not them. They're not gonna take care of me when I get older, so I have to. So that means I have to do what I have to do to survive later on in the future." Her group associate spoke in agreement and commented, "I would basically just let them know, hey, I have to do this for me. If you don't like it, that's on you." Each of Group 1's participants spoke of being distressed, as verified by the following: "I would be kind of upset, cause, like it's something I would want to do and her not accepting it is not okay." "Yeah, I'd be upset, too, because it's not their decision to make for me"

As previously mentioned, Group 3 had a lengthier conversation, beginning with Bethany's input:

> I would just be like, it's something I'm very interested at so I mean yeah, you are my friend but you don't necessarily get a say in what I choose and choose not to do; so please either stick by my side while I choose to do this or don't."

In answer to the question about friends not thinking CS was cool, Bethany felt that some of her friends would think, "that's kind of lame," while others would think it's cool. Molly, on the other hand, was more expressive with what she believed to be her friends' opinions:

> I think that they don't really know if it's cool or not cool because they have never taken it. They've just heard what I said about it. But I feel if they would just take it, they would, hopefully, think it was pretty cool because, yeah, I did. You never know.

Since both students made known they were enrolled in an exploring computer science class [Fundamentals of Computing], curiosity about their friends' reactions to their enrollment arose. According to Bethany, some friends had questions about the difficulty level of the course, especially since it is required for graduation. She attempted to put them at ease with her reply, "It's not hard. It's actually kind of fun." The word "fun," which also appeared several times in the survey's open-ended responses, stood out and prompted a follow-up question about what made it fun. "As we said earlier, web paging. Web page design was my favorite thing to learn this entire year, and uhm, binary code was kind of fun, but I feel like, uhm, I feel like those things made it really fun." Molly chimed in with:

> Web page design. I actually want to take a picture of this book to look for it afterward. Okay. Since I can't do any web page design class probably until 11th grade cause I already have my schedule for next year, I think that and binary code was fun.

Choosing friends or school. After exhausting the conversation concerning possible negative peer influence, attention turned to choices. The chats were stimulated by having participants describe how they would handle a situation in which they would have to choose between doing well in school and maintaining their friendships. All reported that the choice would be school, even if it meant possibly losing a friend.

Focus Group 1, the most conversationally reserved group, contributed the following to this data collection moment. "I would be doing well in school." Kendall proceeded to explain how she would move away from that friendship. "Probably stop talking to them for a while. I would explain it to them cause people, they take things the wrong way. So school comes first." Jewell's easy-going reply was, "I would want to do well in school. School comes first! It's what makes you get there in life. You know. You have to have an education before you can get in." She did not add anything about how to move away from the friendship.

Michelle took the lead for Group 2. "I would choose doing better in school. I would just tell them, hey, I can't be around you anymore. I need to do better in school and make sure that I keep my education up and be a good student." Javaria agreed with her and provided an example of an actual experience:

> I was in that position before when I used to sit back there, but it was another student. She was, uhm, she was upset because I had to go in myself and had to move my seat to make better decisions, like move my seat away from her. She was mad and upset because she felt like, uhm, I was choosing school over her, and I was because it's my education. And just because she didn't care about school, that doesn't mean I don't.

Both reported having lost a friend because they [the participants] chose something different or did not do something that the friend wanted them to do. "I didn't care." was Javaria's response, with Michelle responding similarly by adding, "I just went on with my day and let it be." Finally, yet importantly, came Group 3's contribution:

> Uhm, well, my mom always told me that grades always come first, because during high school friends are going to come and go. So I would, I always try to put my grades first; but there's that sometimes rare occasion where my friends come first, and I let my grades slip and then it comes close to cutting, and I'm like, I need to get my grades up. So I kind of push everything aside and hammer down at school. (Bethany)

> I think that I should maintain my grades first, and if my friend doesn't understand that my grades need to come first and that they need to come after that, then I don't think they are really worth having around if they don't think things that are important to me should also be important to them. (Molly)

Visual Perception of A Computer Scientist

The final structured opportunity to gather data involved a method that asked each student to create an image to show her visual perception of a computer scientist. Having students draw their idea of what a particular category of workers looks like is not a new idea. David Chambers (1983), a noted social scientist, used this method, which dates back to 1966, when he had elementary students draw a scientist. His research covered a period of 11 years, from 1966-

1977, and his objective for doing this was "to determine at what age children first develop distinctive images of the scientist" (p. 257).

The drawing request for this study was an extension of Chambers' work and is known as the "draw-a-computer-scientist test (DACST)." This assessment was developed to "better understand elementary school students' conceptions of computer scientists and the nature of their work" (Hansen et. al, 2017). The statement to group participants was, "Using the sheet of paper in front of you, please draw a picture of a computer scientist the way you see or visualize it in your mind. Table 4.15 presents a description of each drawing, all of which appear in Figure 4.6.

Table 4.15
Draw-a-Computer-Scientist Test Report

Participant	Portrayal Account
Jewell	Female slumped in a chair in front of a computer workstation; sad look on face; staring at computer monitor; hands appear to be in lap; wrote the statement, "This was fun."
Kyndall	Female at computer workstation; slight smile on face; appears to be typing; not looking at the monitor.
Bethany	Stick figure of a male with glasses on; long outstretched arms that extend a good distance outside shirt sleeves; no computer in picture; legs a good deal longer than bottom of pants; expressionless face.
Molly	Computer monitor in background; image appears to be a male with curly hair and glasses; face somewhat animated with a smile; looks like a teddy bear's face. Arms outstretched from body; pants on; shoes tied; no interaction with computer, just standing in the forefront.
Michelle	Full computer workstation; stick figure of what appears to be a female interacting with the mouse; somber-looking face; no smile; appears to be looking at the monitor
Javaria	Computer workstation in background; female with larger than normal glasses; exceptionally long arms in relation to the proportion of the rest of the body; smile on face; callout which reads, "I'm a computer scientist!!"; no interaction with computer; character looks really "girly."

Figure 4.6 Participant perceptual sketches from the Draw-A-Computer Scientist Test.

The drawings were analyzed using the coding scheme as explained by Hansen, et. al (2017):

> . . . drawings were coded for the following: observable demographic information (e.g., gender), worn accessories (e.g., glasses), emotionality (as depicted in speech or thought bubbles), technologies included, the setting (e.g., classroom, garage), the title (e.g., computer scientists, scientist), actions (e.g., coding, fixing), and the object of the actions (e.g., computer, website). (p. 281)

Although a few elements from each image coordinated with those of the coding scheme, when compared to the reported results of earlier Draw-A-Computer Scientist Tests, the artworks for this study did not completely match the described results of previous works: As reported by Hansen, et. al (2017), "students most often drew male computer scientists working alone, and featured actions that were connected to technology in general (e.g., typing, printing), but not specific to computer science" (p. 279). Only two of the images portrayed what looked to be male figures.

Supplemental Input

As suggested in guidelines for conducting individual and/or focus group interviews, it is good practice to seek additional comments from participants. In keeping with this recommendation, group members were encouraged to share supplemental information that might be helpful to the study. Only three participants elected to give input.

Group 3 members offered feedback about who should "try" CS and why. Bethany began with, "I feel like everyone should give computer science a try, cause at the end, it's really fun to do, fun to learn about, especially web page design." Molly, her group partner, agreed by stating, "I mean, I think the same thing, and I think that everyone should be forced to do it." When asked to elaborate, both had ready responses:

> Because I think that it's good if you know HTML, then there's just a side job you can end up doing, and it would help you later on in life, too; and then you can be really smart whenever it comes to computers. You can know how a computer works. (Molly)

> I also feel that it's very important to know this type of stuff because uhm, yeah, you need this to graduate, but it's also really good to have in the back of your mind because you never know when this stuff is going to pop up in real life. (Bethany)

Javaria, a Group 2 participant, revisited her earlier remarks related to "all girls." Her recommendation was, "Make your own class of web page design for females only." When asked to expound further, she declined.

Summary

Each focus group session concluded with a restatement of the goal of the meeting, after which, a verbal synopsis of the various conversations was given. At the close of the summation, group members were asked to verify its accuracy. As a final point, participants were thanked for their time and input.

Although, the transformational mixed-methods design was more time consuming than either a single quantitative or a lone qualitative study, the process contributed to a heightened level of confidence in the results of data analysis and strengthened the assurance of recommendations that will be offered. This declaration is based on the privilege of having facilitated conversations, which not only provided a thought-provoking listening experience, but also gave a voice to students who might otherwise not have been heard.

Participants presented genuine concerns that were shared with department personnel and with the building leadership team. Because the desired outcome of this study was to increase female enrollment in computer science education courses at ZBFHS, the expectation was that a viable framework that could engender change would soon be forthcoming, thus preparing them [females] for current and emerging technical careers.

CHAPTER FIVE— IMPLICATIONS AND RECOMMENDATIONS

Introduction

The purpose of this study was to examine the problem of practice on how to increase the number of females enrolling in computer science education (CS) at ZBF High School (ZBFHS). The focus of the problem was on capturing the interests of female middle/junior high school students so they elect to enroll in CS courses once they enter high school. This undertaking was significant because of its direct relationship to a nationwide problem—the disparity in the number of females employed in the field of information technology, particularly in the area of computer science.

As such, this quandary was investigated from two perspectives: (a) examination of barriers to female interest in computer science education in the district, school, and community in question; and (b) exploration of strategies that others used to stimulate the interest of females in computer science education. The desired outcome was to frame a solution in the school of service that would result in increased enrollment of females in high school computer science education that would prepare them for current and emerging technology careers.

Significance of Study

Initial thoughts about a viable problem of practice stemmed from a concern regarding the disparity in the number of females, when compared to males, employed in the field of computer science, an area of high-growth, high-demand careers. This national problem resulted in a trickle-down effect on regions, states, communities, school districts, and individual schools. Further interest arose upon recognition of the state of affairs at the high school of employment, which revealed that females were shying away from enrolling in computer science/coding-related courses; so, logically, the question became, "Why were high school female students not signing up for computer science/coding-related courses?" This question, though deserving of a response, was too comprehensive to be considered an answerable query. Consequently, perplexing thoughts on the matter led to additional inquiries that initiated a move toward a more defined scope of investigation, thus the formulation of research questions for this study: (1) Why are female students underrepresented in computer science education at ZBF High School? and (2) What factors do female students identify as influences on their decisions regarding computer science education?

An investigation into literature related to females and computer science unveiled a rich history of female involvement in the field, yet girls and women were conspicuously absent [in significant numbers] in secondary and postsecondary CS classrooms, as well as underrepresented in the computer science and information technology career fields. This situation was attributed to dynamics that were subsequently described as barriers to enrollment—gender, cultural stereotypes, curriculum design/offerings, access to same-sex role models, perceived strengths and abilities, peer pressure, environmental and/or social barriers, policies, and self-efficacy.

The absence or underrepresentation of females in computer science is a multifaceted dilemma that can be equated to the process of separating the layers of an onion. The research pool was clear in its presentation of why college-aged females and women in the world of work were hesitant to select CS as a course of study and/or career choice; however, the available collection of research studies regarding high school females' choices and/or perceptions about CS was not as robust. Acknowledgment of this lack incited an anticipated state of expectation that results of this investigation could be considered a small step toward increasing the available pool of research on teenage girls and computer science.

This transformative mixed-methods study developed out of concern for female students' access to high school courses in the area of computer science, "the only STEM major that has experienced a precipitous decline in the representation of women" (Beyer, 2014). To gauge the pulse of ninth-grade females at ZBFHS, a survey was utilized to collect quantitative data and was followed by focus group interviews to collect qualitative data. When taken in the context in which it was administered, survey results indicated that ninth grade females at ZBF High School were generally interested in computer science. This determination was based on the level of agreement/disagreement with statements that were categorized into four domains on a Likert-style scale: perceived relevance to own future, intrinsic motivation, self-efficacy, and community beliefs and value—friends and families.

It was not until the Likert-style scale results were further analyzed and displayed in divergent stacked bar charts that a real connection to the data and the story it was telling were detected. Theses charts simplified the process of merging and reporting findings while also placing the study in the context of the literature review and the selected research methodology. Although participants mostly saw computer science as being relevant to their future, they determined it was not absolutely necessary for them to accomplish their college and/or career goals. This lack of CS need to achieve was supported by data collected during the focus group conversations: Participants were clearly not attracted to computer science, as each expressed and described an interest in career fields/courses of study unrelated to computer science. In fact, all expressed a desire to enter a vocation that dealt with helping people, a detail supported by current research (Charles, 2017; Cheryan, Master & Meltzoff, 2015). Finally, despite describing certain computer science activities as "fun," it was still not enough to steer participants in the direction of computer science.

Limitations and Delimitations

The location of the study, the high school of service, presented a limitation because it did not allow for the collection of data outside the "home" environment, thus restricting use of the findings and recommendations by other entities. To further impact outside usability of results was the study's design: It only included female students; therefore, no predictions could be made about male students' knowledge of computer science and/or their perceptions of barriers to female access to courses and careers. To account for this in the future, males could be included, and their data compared to that collected from females. An additional limitation that presented itself was a much smaller sample size than was originally anticipated. Finally, the nature of qualitative research is not conducive to generalizability of outcomes; hence, the results of this undertaking cannot be projected onto other subject areas nor onto other schools in the district, region, or state. This, however, would not affect using the results to devise and implement a framework at ZBF High School to increase the enrollment of females in computer science courses, nor would it preclude use of the results to inform work in other places.

As for delimitations, this study was planned within the confines of purposely-selected boundaries. To begin, the transformative mixed-methods design was chosen because of the social justice implications of the investigation and because of the design's intent to "help a marginalized group" (Creswell, 2014, p. 228) improve their situation. In this work, the marginalized group was females, and the issue was their underrepresentation in computer science courses at ZBF High School. It was intended for use of the transformative design to be one of providing a better understanding of the problem.

In keeping with the research design and the affected group, data was only collected from ninth grade female students because of the time that remained in their high school careers. The implication here was that they would not only provide data that could engender change, but they might actually be among those who would help initiate the desired change by choosing to enroll in CS courses that would prepare them for current and emerging technology careers. Furthermore, it was my conviction that the female perspective was key to developing a solution that would increase the number of females enrolling in CS classes at ZBF High School. Finally, because of the nature of problem-of-practice focused research, revisions to research inquiries and goals were permissible, in that unexpected data might have been revealed through the interview sessions.

Implications/Recommendations

Implications of Findings

The anticipated interpretation of results was somewhat hindered because of the lost opportunity to talk with survey participants who declined to be part of a focus group. Their contribution to the survey aided in producing calculations that indicated females have a high interest in computer science; however, participants in the focus group interviews conveyed just the opposite. One has to contemplate whether survey responses were truly what the students believed/perceived or if their responses were ones they felt were expected. Without a chance for additional investigation, no conclusion will be forthcoming in this study.

Although disheartening to concede, “voices” of focus group members aligned with various studies on field/course appeal. Participants gave the impression of little to no interest in computer science education, despite the fact that some used the word “fun” to describe their experience(s) in the computer science-related course in which they were enrolled during the semester of data collection. While self-admission of focus group contributors revealed they were relatively good students academically and despite survey results that indicated interest in CS, future aspirations lay in careers geared toward helping people. Additional revelations disclosed that this group lacked complete knowledge and understanding of the definition of computer science and exposed that they were unaware of other courses considered part of a CS curriculum. This was verified by responses to open-ended questions on the survey and by the general inability of interviewees to articulate the name(s) of the CS course in which they were enrolled and/or their failure to identify other CS offerings at ZBFHS.

Self-efficacy materialized as a major barrier that hindered participants from selecting CS courses in the future or from considering computer science as a viable career option. This impediment bared itself through conversations related to rankings of math skills/abilities, confidence levels in courses that use math, and self-reported phases of low confidence in computer use and computing skills. It was also visible in data collected from the survey where points of agreement and/or disagreement measured below or just slightly above the zero baseline on the diverging stacked bar charts, thus indicating low self-efficacy in CS skills/abilities. If low self-efficacy is left without interventions, females will continue to be in the minority in computer science classes and related professions.

Implications for Practice

Regarding the significance of this study for practitioners and others who work in the area of computer science education, it is not only important to address the meaning for the people involved, but it also becomes crucial to determine how this information should be disseminated to those who are directly involved with content delivery. First, an environment conducive to guiding young minds toward technological careers must be established. These classrooms and/or laboratory spaces should be outfitted in a manner that is neither gender specific nor stereotypically biased. Recruitment and retention of females should be the underlying guide when preparing inclusive teaching and learning areas that incorporate planned educational and co-curricular activities that are rigorous yet appealing to females. Additionally, math and science classes will need to undergo changes that effectively address the redirecting of female perceptions about these subject areas, while at the same time, increasing their self-efficacy toward math and math-intensive courses.

To extend the process of making computer science attractive to female students, selection of instructors must be intentional. "Before teachers can provide gender-neutral counseling, they need training to understand technology themselves as well as the career options provided by IT" (Adya & Kaiser, 2005, p. 27). Ideally, this training should begin during the preservice stage, which would require teacher education programs to update their offerings and to hire professors/lecturers who are versed in the language of computer science pedagogy. Since, however, current in-service teachers are being tasked with the duties of instructing students in CS content and counseling them about CS career options and course selections, their skills and knowledge will need restructuring and updating to adequately and successfully address the specific needs of females during teaching, recruitment and retention events.

Support of instructors who make the cross over to computer science is compulsory. "Infrastructural support is critical in training veteran teachers who tend to use computers less often than those with less experience" (Adya & Kaiser, 2005, p. 27). They will also require opportunities to interact with industry through advisory committees and externships:

> The onus for teachers is to be able to provide equal access to computers; create an environment for computer use that is non-competitive, non-threatening, and engages children in social interaction; supply software that appeals to girls as well as boys; and provide students with female models of competent computer use. (Adya & Kaiser, 2005, p. 27).

A final offering for practice implications is based on a report commissioned by Google, LLC and authored by Blikstein (2018). Based on his reported findings, "advancing CSEd in equitable ways requires a comprehensive approach that ensures all students are well prepared for the future" (p. 34). His recommendations for accomplishing this advancement include (1) creating clarity around the different visions of CS education; (2) making participation equitable; (3) ensuring teachers are prepared and supported; (4) creating continuity and coherence around learning progressions; and (5) committing to ongoing and thorough research. "If access and inclusiveness are addressed effectively, we can meet current and future workforce and citizenship demands . . . that equitably drive technological and social progress and give youth new avenues for personal expression and empowerment" (Blikstein, 2018, p. 34).

Implications for Future Research

When seeking a better understanding of what stimulates females' choices of professions and/or courses of study, particularly in the areas of math, science, and technology (MST), additional research is crucial to "understand career influences and propose policy changes that may serve to increase the enrollment of women in MST careers" (Adya & Kaiser, 2005, p. 28). Along with this, it would be beneficial to determine what really drives the career decisions of high school female students: Is the decision more social in nature, or is research-based data considered during the selection process? An answer to this question has the potential to advance the process to make computer science more appealing to adolescent and teenage girls.

This study, which focused on increasing female enrollment in CS classes at ZBFHS, was designed to gather data from female students only. To get a more holistic perspective regarding barriers that influence females' decisions about course selection and/or career choices in computer science and other technical fields, research that includes input from male students in the same grade would go a long way in determining perceptual differences and/or likenesses. This approach to data collection could possibly uncover supplementary details that would improve the probability of ascertaining answers to the proposed research questions.

Because the sample in this work was very small, a suggestion for future research is to administer the quantitative survey instrument within a larger system, such as across all high schools in the district, throughout the districts in the surrounding area, or even on a loftier statewide scale. By increasing the size of the available pool, the chances of a larger sample size improves, thus lending research results to a more generalized interpretation in the quest to uncover a wider-ranging solution. Based on this need to expand the participant pool, a final recommendation for comprehensive research is for investigators to be more purposeful about growing the available pool of information on adolescent and teenage females and their decisions about computer science and the standards used to influence those decisions.

Implications for Policy

The research presented in this study, as well as that addressed in the literature review, has indicated that it will not be an easy task to remedy the situation of female underrepresentation in computer science courses and careers. To aid interventions of change, policies at all levels will need to be written and/or revised to encourage girls' and women's interest in computer science. Thébaud and Charles (2018) discussed women's underrepresentation in scientific and technical fields from the perspective of segregation and hinted at gender-specific aspirations and choices as influencers. They presented three reasons for this segregation:

> First, history shows that "separate but equal" principles generally produce unequal outcomes. . . . Second, gender segregation has cultural feedback effects, reinforcing stereotypes and limiting perceived educational, family and career options of subsequent generations. And third, women (and racial/ethnic minorities) represent an untapped labor pool globally in fields such as engineering and computer science, where shortages threaten to undermine national development or competitiveness. (p. 10)

They continued by proposing that at the industry level, governmental and organizational interventions to reverse the current backward-sliding trend of women in computer science and other technical fields will be required, thus making CS and similar fields more attractive to females. These intercessions would need to be written in the form of policies that relate to "work hours, flexible scheduling, family and sick leave, and childcare" (Thébaud & Charles, 2018, p. 12).

Industry policy is reasonable and essential; however, educational policy is also warranted. These guiding principles should be specific to the K-12 arena, which serves as the primary "pipeline" to post-secondary institutions. Recognition of the need for policy changes and/or enactments begins with understanding the need for computer science to become part of the curriculum structures in elementary, middle, and high schools. This suggestion is driven by the notion that "computing is a fundamental part of daily life, commerce, and just about every occupation in our modern economy" (CODE.org Advocacy Coalition, 2019).

In their report on the state of computer science, the CODE.org Advocacy Coalition (2019) outlined nine policy ideas to assist the effort of creating comprehensive state policy frameworks that will "broaden the teaching and learning of computer science" (p. 9). The principles upon which the policies are based include equity and diversity, clarity, capacity, leadership, and sustainability (p. 4). As presented and explained in the report, "These ideas are intended to be a menu of choices that states have to ensure that computer science is a central part of K12 education." In addition, they caution, "These policy ideas may require resources in either funding or time" (p. 13). Although directed toward states, the following recommendations are applicable to the process of developing a local solution to the problem of practice presented in this work.

1. Create a state plan for K-12 computer science.
2. Define computer science and establish rigorous K-12 computer science standards.
3. Allocate funding for rigorous computer science teacher professional learning.
4. Implement clear certification pathways for computer science teachers.
5. Create programs at institutions of higher education to offer computer science to preservice teachers.
6. Establish dedicated computer science positions in state and local education agencies.
7. Require that all secondary schools offer computer science with appropriate implementation timelines.
8. Allow computer science to satisfy a core graduation requirement.
9. Allow computer science to satisfy an admission requirement at institutions of higher educations.

For a similar list of policies to be developed and implemented, the school would need to convene an assembly of key representatives from all stakeholder groups to discuss the recommendations for states and then design a viable set of guidelines for increasing the number of females who enroll in computer science courses at ZBF High School.

Conclusion

The purpose of this transformative mixed-methods study was to examine the problem of practice on how to increase the number of females enrolling in computer science education at ZBF High School. Research indicates that the absence of females does not begin at the industry level; therefore, it is incumbent of educators to collaborate to develop strategies that will capture females' interest before they enter high school (Goode, 2008; Computer Science.org, 2018; Margolis & Fisher, 2002; Madara & Namango, 2016). As introduced in Chapter 1 and discussed in Chapter 2, many elements work together as a system to deter females from enrolling in CS education classes. If, however, all stakeholders—students, family, school, community, and industry—were to join forces to address the issue, a framework could be designed that would stimulate change at the high school level. Such a change could have the propensity to affect enrollment of females in computer science at the post-secondary level, with implications for a progressive move toward the hiring of more women in current and emerging technical fields.

Additionally, CS-specific efforts and/or curriculum-based activities should be planned/implemented to direct the attention of middle/junior high school females toward careers in computer science. This deliberate maneuver possibly would help them envision computer science as a viable course of study during their high school years. The desired outcome would be to narrow the central focus of the problem of underrepresentation of females in high school CS classes, hence, improving the outlook for increasing the number of females in university classrooms and in the industry. Since results of this study have presented self-efficacy and interest as key influencers on females' choices in course selections and career options, prioritized attention must be dedicated to activities that will target, inform, and attract females so they can take advantage of a career field that once had a rich history of female involvement. These undertakings could provide a firm foundation for ZBF High School to be successful in rectifying the problem of female underrepresentation in computer science education.

As a final reflection in these concluding remarks, having conducted this study provided an opportunity to develop and refine research skills that are a necessary tool for a transformational leader. It is only when you listen to the voices of those affected by various issues in education that the process of program design, modification, implementation, and/or evaluation can take place. It is worth affirming that unanticipated results of data collection and analysis are not to be viewed as a setback but are to be regarded as outcomes that initiate a deeper dive into the search for answers that could prompt change. Because of this research experience and the processes involved, I am better equipped to operate as a culturally responsive change agent for education and, accordingly, feel more confident in my ability to lead impactful, instructive modifications and adjustments.

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Appendices

Appendix A—Student Survey Protocol

Research Questions:

1. Why are female students underrepresented in computer science education at ZBF High School?

2. What factors do female students identify as influences on their decisions regarding computer science education?

Part 1: ***Directory/General Demographics***

Part 2: ***Assessing Student Interest in Computer Science***
This data collection protocol is a collection of questions/statements from a published instrument that has undergone measures for reliability and validity for use with computer science education. Permissions are granted to use and/or adapt questions to this specific study where applicable. To assess student interest in computer science, a published, validated instrument from LEADS.org, an entity of the University of Chicago will be used in its entirety. Permission for schools/districts/education leaders to use/adapt is granted on the website. The original, categorized document is included, as is the proposed collection copy that is formatted as it will display on the Google Form—each question on a separate page. Aggregated descriptions will be removed prior to administering the survey. As described on the site, "This tool serves as a resource for education leaders to assess and describe student interest in computer science" (LeadCS.org, 2015).

Student directory/general demographics information

Part I: Directory Information

1. How old are you?
    a. 13
    b. 14
    c. 15
2. What grade did you just complete (2018-2019 school year)?
    a. 8
    b. 9
    c. 10
    d. 11
    e. other
3. Race/Ethnicity—I most identify with this race/ethnic group (Choose one.):
    a. Asian/Asian Pacific Islander
    b. Black/African American
    c. Caucasian
    d. Hispanic
    e. Native American
    f. Other

4. Computer Science-Related Courses: I have taken one or more of the following courses. **Select all that apply**.
    a. Gateway to Technology
    b. Exploring Computer Science
    c. Principles of Engineering
    d. Introduction to Engineering
    e. Computer Programming
    f. Information Technology Fundamentals
    g. I have not taken any computer science-related courses.
5. I am enrolled in English: **I II III IV**; Level: **CP Honors AP Early College**
6. Computer Science-Related Courses: I am currently enrolled in one or more of the following courses. **Select all that apply**.
    a. Gateway to Technology
    b. Exploring Computer Science
    c. Principles of Engineering
    d. Introduction to Engineering
    e. Computer Programming
    f. Information Technology Fundamentals
    g. I am not currently enrolled in any computer science-related courses.
7. Computer Science-Related Activities: I have participated in one or more of the following activities: **Select all that apply**.
    a. Robotics club
    b. Hour of Code
    c. Code.org
    d. Technology support team
    e. Computer science summer camp
    f. Girls Who Code
    g. Girls in Engineering, Math, and Science (GEMS)
    h. I have not participated in any computer science-related activities.

Next

ROLLOUT LEADCS.org

Assessing Student Interest in Computer Science

Student interest in computer science questionnaire

Computer Science Interest Questionnaire

Welcome to the Computer Science Interest Questionnaire!

This research project would like to learn about your interest in computer science. This questionnaire is not a test, and there are no right or wrong answers. Your input is valued. Student responses will help the researcher gain a better understanding about high school females' interest in computer science. Thank you for your participation!

1. Would you like to answer some questions?* (*= required)
   O Yes
   O No

Next

Student interest in computer science questionnaire

2. How much do you agree or disagree with the following? (*Perceived relevance to own future*)

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
Computer science is useful in the real world.	O	O	O	O	O	O
Computer science is important for finding a job in the future.	O	O	O	O	O	O
Computer science is important for finding a high paying job in the future.	O	O	O	O	O	O
Taking computer science is necessary for me to accomplish what I want in school.	O	O	O	O	O	O
Taking computer science will help me reach my goals for college/career.	O	O	O	O	O	O

Previous **Next**

Student interest in computer science questionnaire

3. How much do you agree or disagree with the following? (*Intrinsic motivation*)

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I find computer science to be very interesting.	O	O	O	O	O	O
I enjoy learning about computer science.	O	O	O	O	O	O
I want to be good at computer science.	O	O	O	O	O	O
Learning about computer science is fun.	O	O	O	O	O	O
I think it would be cool to choose a job/career in computer science.	O	O	O	O	O	O

Previous Next

Student interest in computer science questionnaire

4. How much do you agree or disagree with the following? (*Self-efficacy*)

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I have the skills and ability to learn computer science.	O	O	O	O	O	O
I am better at computer science than most of the other kids at my school.	O	O	O	O	O	O
I am very good at computer science.	O	O	O	O	O	O
I can figure out how to solve the most difficult computer science tasks if I try.	O	O	O	O	O	O

Previous Next

Student interest in computer science questionnaire

5. How much do you agree or disagree with the following? (*Community beliefs and values—friends and families*)

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
My friends would approve or think it is cool if I chose a job/career in computer science.	**O**	**O**	**O**	**O**	**O**	**O**
My family members would approve if I chose a job/career in computer science.	**O**	**O**	**O**	**O**	**O**	**O**
My family thinks it would be useful for me to take computer science.	**O**	**O**	**O**	**O**	**O**	**O**

Previous **Next**

Student interest in computer science questionnaire

6. If you had the opportunity to take a computer science course at school, what would influence your decision to take the course? **Select your top 3 reasons**. (*Motivation to enroll*)
   - ☐ My interest in computer science.
   - ☐ I think it is good for me to learn.
   - ☐ I will need computer science skills in the future.
   - ☐ It would help me reach my college and/or career goals.
   - ☐ If it were a prerequisite for another course.
   - ☐ If other students encouraged me to take it.
   - ☐ If a teacher encouraged me to take it.
   - ☐ If a guidance counselor/advisor encouraged me to take it.
   - ☐ If a family member encouraged me to take it.
   - ☐ If my friends were taking the course.
   - ☐ If the course fit well in my school schedule.
   - ☐ Only if nothing else fit in my school schedule.
   - ☐ If I liked the teacher.

7. I would rather take computer science than (**Select all that apply**.):
   - ☐ Media Arts.
   - ☐ Manufacturing.
   - ☐ Marching Band.
   - ☐ Early Childhood.
   - ☐ Sports Medicine.
   - ☐ Culinary Arts.
   - ☐ Finance/Accounting/Entrepreneurship.

Previous **Next**

Student interest in computer science questionnaire

8. What does computer science mean to you?

9. Do you have any other thoughts about computer science that you would like to share?

Previous Next

****

I would be interested in participating in a focus-group interview session. ______Yes _____No

If yes, please provide your name and your Freshman Seminar/English teacher's name.

First Name__________________________ Last Name ________________________________

Freshman Seminar/English Teacher's Name. ____

****

Previous Next

Thank you for your participation today! Please click the "Submit" button below to register your responses.

Previous Submit

Appendix B—Focus Group Protocol

Research Questions:

1. Why are female students underrepresented in computer science education at ZBF High School?

2. What factors do female students identify as influences on their decisions regarding computer science education?

Focus Group No. ________ Date of Session: ______________________

Attendees:

This data collection protocol is an adaptation of questions/statements from two published instruments that were used to collect qualitative data in semi-structured interview settings. One instrument examined urban high school students' reactions to a . . . (STEM) enrichment/career development program, their resources and barriers, their perspectives on the impact of race and gender on their career development, and their overall views of work and their futures (Blustein, Barnet, Mark, Depot, Lovering, Lee, Hu, Kim, Backus, Dillon-Liberman, & DeBay, 2013). The second instrument assessed sources of middle school students' self-efficacy in mathematics (Usher, 2009). Both studies utilized the consensual qualitative research methodology and, both protocols underwent measures for reliability and validity. Because computer science is a STEM course of study which is math intensive in nature, it is believed that these instruments serve as a foundational basis upon which to collect data for this study.

Introductory Script: Hi, I am Mrs. Frazier, and you have been invited here today to share information with me and with the group members about your thoughts/opinions on the area of science, technology, engineering, and math (STEM) and the career field of computer science.

Background/Self-Description as a Student:

1. Share a little bit about yourself as a student: (Blustein et al., 2013)
    a. Name
    b. Attendance
    c. Class participation
    d. Strengths in school
    e. General interest in and motivation in school
    f. Things you enjoy doing outside of school
    g. Your friends
    h. People you most admire

2. What would you say is your best subject in school? Why? Which subject is your least favorite? Why? (Usher, 2009)

Post-High School Plans (Future Goals/Expectations):

3. A lot of students have some idea about what they would like to do after high school. For example, some students want to attend college, some want to join the military, and some students want to get a job right away. What ideas do you have about what you would like to do upon graduating from high school? (Blustein et al., 2013)
4. If you could do whatever you wanted for a career, regardless of the preparation required or talents, what would you do? Elaborate. (Blustein et al., 2013)

STEM Courses and Experiences:

5. I am going to ask you questions about a specific area of study—computer science. Think hard about the STEM (science, technology, engineering, and math) and computer science courses you have taken, as well as other experiences you have had with these types of courses. First, talk about yourself as a math student. (Usher, 2009)
    a. Share a story that explains something about the type of student you are in math. In other words, share something that happened to you that involves the subject and perhaps your parents, teachers, or friends. (Usher, 2009)
    b. If you were to rate your ability in math on a scale from 1 (lowest) to 10 (highest), where would you be? Why?
    c. How would you rate your confidence in courses involving the use of math?
6. Have you explored any career interests in STEM fields in the past few months? If so, name the area(s). (Blustein et al., 2013)
    a. Specifically, have you explored the field of computer science? If so, what prompted you to do so?
    b. If you have not explored computer science, is there anything that has kept you from considering this field further? (Blustein et al, 2013)

Gender, STEM exploration, and social/relational support:

7. How does your sense of yourself as a female affect your career exploration and options? (Blustein et al., 2013)
    a. How do you think your gender influences your interests and what you believe you can do in the future?
    b. What role(s) do you believe females have in STEM career fields such as computer science?
    c. If you were to express an interest in computer science classes or a computer science career, how would your parents react?
8. Think back to conversations you have had with your parents or guardians about your future education and career plans, what sort of discussions did you have? (Blustein et al., 2013)
    a. In what ways have they helped you think about future careers?
    b. How do you think your family's expectations about your future plans are shaped by the fact that you are a female?
    c. Are your parents or any of your family members involved in computer science or some other STEM-related career? If so, what type of work do they do?

9. Think of a time when your interest in something was different from your friends' interests. How did you maintain that interest and your friendships? (Examples could be a particular class, hobby, future aspirations, achieving advanced standing in school, etc.) (Blustein et al., 2013)
10. Reflect on conversations you may have had or might have in the future with your friends on STEM-related issues. (Blustein et al., 2013)
    a. If you were to express an interest in computer science classes or a computer science career, how would your friends react?
    b. How would you respond if your friends told you not to explore the computer science field? Example: What if your friends thought that studying computer science was just not cool. How would you react?
11. Describe how you would handle a situation in which you have to choose between doing well in school and maintaining your friendships.

Personal Perception:

Using the sheet of paper in front of you, please draw a picture of a computer scientist the way you see or visualize it in your mind. (Madara & Namango, 2016)

Wrap-up:

1. Are there any final comments or information that you would like to share?
2. Use the index card in front of you to write down any thoughts or ideas that you did not want to share aloud. Place it in the drop box in the center of the table.
3. As a reminder, the goal of this session is to gather data from you that will help determine why females are underrepresented in computer science classes and/or in the computer science career field. A summary of the shared thoughts relate to ____________. At this time, I would like to ask each of you tell me in your own words which thought you think will be most helpful with achieving the goal of the research study. (round robin style)
4. Thank you for your time and for offering your opinions.

Appendix C—Student Survey Explanation

ROLLOUT
LEADCS.org

Assessing Student Interest in Computer Science

QUESTION

How can I determine my students' level of interest in computer science?

TOOL DESCRIPTION

This tool serves as a resource for education leaders to assess and describe student interest in computer science.

WHY DO YOU NEED TO KNOW THIS?

When determining a computer science education strategy for your school or district, it is important to consider student interest in computing. A student questionnaire is one of many tools you may use to inform decision-making related to computer science. A short questionnaire will allow you to collect basic information from students, so you can assess and describe student interest in computer science in your school or district.

HOW DOES THIS TOOL HELP?

This tool includes a questionnaire to assess student interest in computer science. A questionnaire allows leaders to systematically gather basic, descriptive data from students. Use the questionnaire as-is, or select the measures that may be the most informative about the students in your school or district.

There are many possible uses of questionnaire data about student interest in computer science. Data collected directly from students may inform decisions about budgets and a school computer science program strategy, help develop school-wide support for computer science, and provide rationale for requesting external support, such as from business partners or parents or support providers.

TOOL CONTENT

A Sample Student Questionnaire

A student interest questionnaire for middle school or high school students is provided in the appendix (the questionnaire was programmed in Survey Monkey). The measures in the questionnaire (or collection of items that are aggregated into a scale to measure a variable, like intrinsic motivation, or self-efficacy) are also provided as a separate document if you prefer to select those most relevant to what you want to learn. You can use the questionnaire measures as you see fit, in whatever format is most appropriate for your school or district. Free, popular online options for questionnaires include Google Forms and Survey Monkey. Check with your district to see if other options are available.

These items are from instruments developed and used by Outlier Research & Evaluation at CEMSE (Center for Elementary Mathematics and Science Education) at The University of Chicago. Outlier has used these items to learn about student interest in multiple computer science and STEM research projects. The measures have undergone a variety of reliability (i.e., the degree to which a set of items produces the same results on repeated administrations) and validation testing (i.e., how well a set of items measure what they are supposed to measure).

Note that in some schools and districts, approval may be required prior to administering a questionnaire to students. Be sure to check with local administrators to determine if this applies in your school or district.

Analyzing and Using Results

Once you administer the questionnaire or select items from the questionnaire, decide how to summarize and communicate the findings.

If you are interested in looking at differences in how students responded to items across particular student characteristics (e.g., grade level, prior experience, gender), keep in mind that any differences you find may not be statistically significant, but due to chance. Also, remember that there are likely multiple explanations for why different groups of students may respond to items in different ways.

What if students express little interest in computer science?

While a questionnaire is a useful tool for assessing student interest in computer science, some students may initially demonstrate little interest in it simply because they have no exposure to or experience with the subject or because they don't understand what computer science is, and is not. If this is true for your student population, consider opportunities that will introduce them to the subject of computer science and activities that occur in computer science.

Appendix: The Student Questionnaire and Individual Items

Access the complete Student Interest Questionnaire

Access individual questionnaire items

Suggested citation:
LeadCS.org (2015). **Assessing Student Interest in Computer Science.** CEMSE, Outlier Research & Evaluation, University of Chicago. http://www.leadCS.org

Appendix D—Parent Consent Form

Parent or Legal Guardian Permission for Child to Participate in a Research Study
"Increasing Female Enrollment in High School Computer Science Education"

You are being asked to give permission for your child to participate in a research study. Before you give permission for your child to participate, it is important that you read the following information and ask as many questions as necessary to be sure you understand what your child is being asked to do.

<u>Investigators</u>
My name is ***Zenovia Brown Frazier***. I am a graduate student in the Educational Leadership Program at the University of Arkansas, Fayetteville Campus. My Dissertation Director is ***Dr. Ed Bengtson***, Program Coordinator.

<u>Purpose of the Research</u>
The research study is designed to investigate two questions: (1) Why are female students underrepresented in computer science education at ZBF High School? and (2) What factors do female students identify as influences on their decisions regarding computer science education? The data from this research will be used to find answers to the proposed questions. Answers to these questions have the potential to encourage development and implementation of strategies/policies that will eliminate/reduce barriers to female enrollment that will stimulate change in a significant way.

<u>Procedures</u>
If you allow your child to participate in this study, she will be asked to complete an electronic survey that will include questions related to her perception of computer science. Areas to be addressed include self-efficacy, stereotypes, gender, role models, perceived strengths and abilities, environmental and/or social barriers, and peer pressure (concerning course selection).

The survey will be administered via a Google Form during ILT or at another designated non-instructional period. Your child's participation will take approximately 10-15 minutes and will take place in Room 181.

Your child will be asked to assent to participate in this research. She can refuse to participate without penalty or can stop participation at any time just by telling the investigator that she wants to stop.

Your child will also be asked if she would like to participate in a follow-up focus-group interview, which is designed to get clarification/further input on the research topic. Expression of interest in being part of the focus group does not guarantee that she will be invited to participate in this part of the data collection process.

The focus group will convene in Room 181 and will take approximately 45-60 minutes to complete. Again, this will take place during a non-instructional part of the day, and your child can refuse to participate without penalty or can stop participation at any time just by telling the investigator that she wants to stop. Student responses will be recorded on digital sound media and transcribed by the investigator.

Potential Risks

Participation in this study does not pose a risk or discomfort greater than a regular school day.

Potential Benefits of the Research

Participants in this study will help educators determine why females are underrepresented in high school computer science courses so that strategies can be developed to attract more females into courses that will prepare them for current and future technology careers.

Confidentiality and Data Storage

Your child's name will only be collected on this permission form and will not be connected to her survey in any way. In addition, your child's teacher and school district will be kept confidential to the extent allowed by law and University policy.

Completed surveys will be downloaded to an Excel spreadsheet, which will be kept on an external hard drive owned by the principal investigator. No individually identifiable data will be downloaded—assigned number/pseudonym. When not being used during statistical analysis, the drive will be kept in a locked case that is only accessible by the investigator.

Recorded responses and typed transcriptions will be kept in a locked case that is only accessible by the investigator. For areas needing clarification of a recorded response(s), it might be necessary to consult a professional transcriber who will only be listening to help distinguish an unclear word/phrase. He/she will have no access to the full recordings or to the transcribed material.

Participation and Withdrawal

Participation in this research study is voluntary. You may refuse to allow your child to participate without penalty to you or your child. If you decide to allow your child to participate you are free to stop her participation without penalty by just telling the investigator. In addition, your child may stop participating by telling the investigator that she wants to stop.

The student cannot withdraw from the study after data collection has been completed since her name is not linked to the data.

Questions about the Research

If you have any questions about the research, please ask them now. If you have questions later, you may contact Dr. Ed Bengtson, egbengts@uark.edu or Zenovia Brown Frazier, zbfrazie@uark.edu.

This research project has been reviewed and approved by the Institutional Review Board for the Protection of Human Subjects at The University of Arkansas. If you have any questions or concerns about your child's rights as a research subject, you may contact the University's Compliance Coordinator at (479) 575-2208.

<u>Child's Permission</u>

I have discussed this study with my parent/guardian, and I agree to participate in this study.

____

Signature of Participant

<u>Parent or Legal Guardian Permission</u>

I have read the information provided above. I agree to let my child participate in this research study. I also understand my child's assent to participate in this study will be sought. Please return one copy of this consent form and keep one copy for your records.

____

Name of Child (please print)

____

Name of Parent/Legal Guardian (please print)

____ ________________

Signature of Parent/Legal Guardian Date

____ ________________

Signature of Investigator Date

Appendix E—Student Consent to Participate in a Research Study

Study Topic: Increasing Female Enrollment in Computer Science Education Courses
Principal Researcher: Zenovia Brown Frazier
Faculty Advisor: Ed Bengtson, Ph.D.

INVITATION TO PARTICIPATE
You are invited to participate in a research study about increasing female enrollment in high school computer science education. You are being asked to participate in this study because you are in a position to provide information that will (a) help determine why so few females are enrolling in computer science education and (b) help develop strategies to capture the attention of females so they elect to add computer science courses to their course selection list.

WHAT YOU SHOULD KNOW ABOUT THE RESEARCH STUDY

Who is the Principal Researcher?
Zenovia Brown Frazier: University of Arkansas; zbfrazie@uark.edu

Who is the Faculty Advisor?
Dr. Ed Bengtson: Program Coordinator for Educational Leadership, University of Arkansas, PEAH 106, University of Arkansas Fayetteville, AR 72701; 479-575-5092; egbengts@uark.edu.

What is the purpose of this research study?
The purpose of this study is to examine the problem of practice on how to increase the number of females enrolling in computer science education (CS) at this school. The focus of the problem will be on capturing the interests of female middle/junior high school students so they elect to enroll in CS courses once they enter high school.

Who will participate in this study?
Expected participants are first-year ninth-grade female students, ranging in ages 14-15. The number invited to participate is 450.

What am I being asked to do?
Your participation will require the following:

> You are being asked to answer questions via a Google Form. Other than determining which students have returned consent forms, no student identifying characteristics will be gathered as a result of this survey. If, at the end of the survey, you indicate your interest in being considered to provide additional information related to the survey questions, you might receive an invitation to participate in a focus group interview session(s) with six-eight other female students.

What are the possible risks or discomforts?
Participation in this study does not pose a risk or discomfort greater than a regular school day.

What are the possible benefits of this study?
Participants in this study will help educators determine why females are underrepresented in high school computer science courses so that strategies can be developed to attract more females into courses that will prepare them for current and future technology careers.

How long will the study last?
The survey will take approximately 10-15 minutes to complete. If you are invited to participate in the follow-up focus group, that portion will take approximately 45-60 minutes to complete.

Will I receive compensation for my time and inconvenience if I choose to participate in this study?
No compensation will be provided for participating in this study.

Will I have to pay for anything?
There will be no cost associated with your participation in this study.

What are the options if I do not want to be in the study?
If you do not want to be in this study, you may refuse to participate and no one will be upset with you. Also, you may opt out at any time during the study. Your grades will not be affected in any way if you refuse to participate and information that you provide will not be used. No one will be upset with you if you withdraw from the study.

How will my confidentiality be protected?
All information will be kept confidential to the extent allowed by applicable State and Federal law. Any data that is collected will be compiled anonymously in an Excel spreadsheet and will be used for statistical purposes only. No identifying indicators will be used, and data will be compiled in a manner that does not allow identification of any individual student. All hard copy paperwork will be kept in a locked file cabinet. If chosen to be part of the focus group, recorded responses will only be heard in their entirety by the investigator. The recording media will be kept in a locked case that is only accessible by the investigator.

Will I know the results of the study?
At the conclusion of the study you will have the right to request feedback about the results. You may contact the faculty advisor, Dr. Ed Bengtson—egbengts@uark.edu or Principal Researcher, Zenovia Brown Frazier—zbfrazie@uark.edu. You will receive a copy of this form for your files.

What do I do if I have questions about the research study?
You have the right to contact the Principal Researcher or Faculty Advisor as listed below for any concerns that you may have.

Zenovia Brown Frazier: zbfrazie@uark.edu

Dr. Ed Bengtson: Program Coordinator for Educational Leadership, University of Arkansas, PEAH 106, University of Arkansas Fayetteville, AR 72701; 479-575-5092; egbengts@uark.edu

You may also contact the University of Arkansas Research Compliance office listed below if you have questions about your rights as a participant, or to discuss any concerns about, or problems with the research.

Ro Windwalker, CIP;
Institutional Review Board Coordinator
Research Compliance
University of Arkansas
109 MLKG Building
Fayetteville, AR 72701-1201
479-575-2208
irb@uark.edu

I have read the statements about the research study and have been able to ask questions and express concerns, which have been satisfactorily responded to by the investigator. I understand the purpose of the study as well as the potential benefits and risks that are involved. I understand that participation is voluntary. I understand that significant new findings developed during this research will be shared with the participant. I understand that no rights have been waived by signing the consent form. I have been given a copy of the consent form.

____

Printed Name

____

Signature

____

Date

Signature of person obtaining consent: ______________________ Date: _____________

I agree to be interviewed and to be audio recorded for this study.

Name of Participant (print): ____

Signature of Participant: _________________________________ Date: _______________

Signature of person obtaining consent ______________________ Date: _______________

I do not agree to be interviewed for this study.

Name of Participant (print): ____

Signature of Participant: _________________________________ Date: _____________

Signature of Investigator(s): _______________________________ Date: _____________

Appendix F—Request to Conduct Research

February 25, 2019

Dear ________________________:

I am writing to request permission to conduct a research study at __________________________. I am a student in the Educational Leadership doctoral program at the University of Arkansas, Fayetteville, AR, and am in the process of writing my dissertation, entitled "Increasing Female Enrollment in High School Computer Science Education Courses."

I would like to utilize English I/Freshman Seminar classes to recruit a maximum of 300 freshmen females to complete an electronic survey. Additionally, I will need to interview 5-7 of the eligible females to collect supplemental data. A copy of the survey and the interview protocol are attached. A consent form (copy attached) requiring parent permission will be given to students in the targeted population, and only those who return the consent form will be invited to participate in the study. No costs will be incurred by the school or by the participants.

If approval is granted, the survey and subsequent interviews will take place in Room 181 during SLT or at another designated time when instruction is not taking place. The survey should take no longer than 15-20 minutes, while the focus group session(s) will last 30-45 minutes over a period of 3-4 sessions. Individual results of this study will remain absolutely confidential and anonymous, and only pooled results will be documented and pseudonyms used when necessary.

Your approval to conduct this study is greatly appreciated, and I will gladly answer any questions or address concerns that you may have. If you agree, I will need a signed letter of permission on the school's letterhead acknowledging your consent and permission for me to conduct this survey/study at ___________________________.

Thank you for your consideration of this request as I work to fulfill this partial requirement for the degree of Doctor of Education in Educational Leadership.

Sincerely,

Zenovia Brown Frazier

Zenovia Brown Frazier, Doctoral Student
University of Arkansas, Fayetteville Campus

Enclosures

pc Dr. Ed Bengtson, Dissertation Committee Chairperson

Appendix G—Approval to Conduct Research

June 10, 2019

Institutional Review Board
c/o Ed Bengtson, Ph.D.
Program Coordinator--Educational Leadership
College of Education and Health Professions
216 Peabody Hall
University of Arkansas
Fayetteville, AR 72701

Dear Dr. Bengtson and Institutional Review Board:

The purpose of this letter is to inform you that I give ***Zenovia Brown Frazier*** permission to conduct the research, titled ***Increasing Female Enrollment in High School Computer Science Education Courses***, at ____________________. This also serves as assurance that this school complies with requirements of the Family Educational Rights and Privacy Act (FERPA) and the Protection of Pupil Rights Amendment (PPRA). (See page 2 of this document for specific requirements.) I will ensure that Mrs. Frazier understands and follows these requirements as she conducts this research.

Sincerely,

Principal

pc Zenovia Frazier

Page **1** of **2** June 10, 2019

The Protection of Pupil Rights Amendment (PPRA) requires that local education agencies (LEAs), in consultation with parents, develop the following local policies concerning student privacy, parents' access to information, and administration of certain physical examinations to minors:

- The right of a parent of a student to inspect, upon the request of the parent, a survey created by a third party before the survey is administered or distributed by a school to a student, and any applicable procedures for granting a request by a parent for reasonable access to the survey within a reasonable period of time after the requires is received;
- Arrangements to protect student privacy that are provided by the LEA in the event of the administration or distribution of a survey to a student containing one or more of the eight protected areas of information;
- The right of a parent or student to inspect, upon the request of the parent, any instructional material used as part of the educational curriculum for the student, and any applicable procedures for granting a request by a parent for reasonable access to instructional material within a reasonable period of time after the request is received;
- The administration of physical examinations or screenings that the school or LEA may administer to a student;
- The collection, disclosure, or use of personal information collected from students for the purpose of marketing or for selling that information, or otherwise providing that information to others for that purpose, including arrangements to protect student privacy that are provided by the LEA in the event of such collection, disclosure, or use;
- The right of a parent of a student to inspect, upon request, any instrument used in the collection of personal information (a student or parent's first and last name, a home or other physical address, a telephone number, or a Social Security identification number) before the instrument is administered or distributed to a student, and any applicable procedures for granting a request by a parent for reasonable access to such instrument within a reasonable period of time after the request is received.

Appendix H—University of Arkansas IRB Expedited Approval Letter

UNIVERSITY OF ARKANSAS

To:	Zenovia Brown Frazier
From:	Douglas James Adams, Chair IRB Committee
Date:	10/22/2019
Action:	**Expedited Approval**
Action Date:	10/15/2019
Protocol #:	1902174639
Study Title:	Increasing Female Enrollment in High School Computer Science Education
Expiration Date:	10/14/2020
Last Approval Date:	

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Ed Bengtson, Investigator