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# Success factors and challenges faced by first and second-year undergraduate female students in computer science-related majors

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# SUCCESS FACTORS AND CHALLENGES FACED BY FIRST AND SECOND-YEAR UNDERGRADUATE FEMALE STUDENTS IN COMPUTER SCIENCE-RELATED MAJORS

A dissertation submitted in partial satisfaction

of the requirements for the degree of

Doctor of Education in Learning Technologies

by

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This dissertation, written by

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## DEDICATION

This dissertation symbolizes a significant change in the course of my family's story, a first doctor. This work is dedicated to the Navarro family, especially my parents, Adela and Jose Salomon, and my siblings, Celia and Ascary. This work is dedicated to generations on all branches of my family tree past, present, and future.

This work is also dedicated to my chosen family, my dear friends whom I have been so fortunate to make along my life journey. I also thank them for their understanding, their loyalty, and support.

Having spent every day since I was four years old in education, I want to thank every educator who taught me and formed the type of educator I wanted to be, including educators I have met throughout my career and who continue to teach me.

In wanting to pat myself on the back, I also want to quote Mr. Calvin Cordozar Broadus Jr., who said, "I want to thank me for believing in me…I wanna thank me for never quitting."

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The work of my dissertation the past year and the courses that preceded it for two years had several people behind the scenes who deserve their names in the credits. I remember debating going back to school for a long time. In fact, I started my journey at Pepperdine University a year after I was admitted into the program. While I could have been done a year earlier in my life, I also think of how different my experience would have been given the people with whom I was able to experience these moments. I made the right decision.

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And thank you to the STEM college students, such great young ladies, who participated in this study. Let’s make a difference!

VITA

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ABSTRACT

There is a significant gap in the number of women who go into college as computer science majors and decide to pursue the field in the workforce. There are challenges present for female students since the start of their education that their male counterparts do not face, which ultimately contributes to this gender gap. Such challenges include a lack of mentorship, a feeling of not belonging, and a dearth of resources to engage students in computer science. Research and studies that explore the first two years of college for female students who are majoring in computer science or computer science-related subjects are lacking. By studying this population, there are implications for both retention and success for these students who have already decided on such a major that they can parlay into a career in the workforce. This phenomenological study using qualitative methods aims to inform best practices as identified by first and second-year female college students in computer science-related majors. 15 participants were selected who met such criteria and were interviewed based on research questions addressing their measures of success, challenges, and strategies to inform best practices that could have implications for K-12 classrooms as well as third-year and beyond college students majoring in computer science to address the gender gap in the field.

*Keywords*: computer science, gender gap, university, college, STEM

# Chapter 1: Introduction

## Background

Decisions in technology made for women need to be made by women (L. L. Wang et al., 2021). While the number of women who work in technology, specifically in the realm of computer science, has increased in the last 10 years, data indicates that there is still a large gap between them and their male counterparts in the field (L. L. Wang et al., 2021). Therefore, the question presents itself, why do so few women pursue computer science-related careers? In analyzing the literature, there is a need to conduct research during the educational journey of women who decide to pursue computer science-related majors as part of their undergraduate studies (Yates & Plagnol, 2021). In this chapter, information on female students pursuing computer science-related fields across different educational settings was introduced. Additionally, the statement of the problem, the purpose of this research study, and the research questions that were employed were reviewed alongside the assumptions and the limitations of the study.

While there have been proactive efforts in increasing the numbers for the recruitment and retention of women in the computer science field from several organizations, such as the College Board, a large gap exists when only 20% of computer science US college graduates are women, that informs the workforce in which they will participate (Master et al., 2021). Moreover, once women pursue an education in computer science, that percentage is even lower if they decide to stay in the field. Women are 45% more likely to exit the field than their male counterparts (Florentine, 2018). Hence, it is imperative that the challenges of women studying computer science are noted and that the strategies they use to be successful are studied to inform both college and K-12 institutions of tools with which to equip their students with during their education to close this gap. Awareness of such educational tools among educational leaders could, in turn, affect the types of professional development trainings schools pursue as well as concerted efforts to affect curriculum through, for example, course offerings and available pathways of study.

The issue stands that without leveling the numbers of female computer scientists in the technology industry, concerns about technology services arise (Yates & Plagnol, 2021). With the rise of artificial intelligence, such as the use of ChatGPT as developed by OpenAI, there are concerns by technology leaders and female computer scientists, such as Melinda French Gates, about biases that could arise without the presence of female developers in these services (Hausmann et al., 2022). According to the National Science Foundation (NSF; 2017), historically, while there have been increases in women pursuing computer science from 1995 to 2014 by about 3,000 more awarded bachelor's degrees, there was also a decline as in 2004, the foundation found a peak at about 5,000 more awarded bachelor's degrees than in 2014.

Depending on the years observed, the data on women pursuing a formal computer science education fluctuates  (National Center for Education Statistics, 2023). Regardless of the fluctuation, computer science continues to be a significant 80% male-dominated field (National Center for Education Statistics, 2023). Gates, a female in computer science who ran several of Microsoft's initiatives alongside ex-husband Bill Gates, is the co-founder of the Bill & Melinda Gates Foundation and has also supported women's leadership with projects like her publication *The Moment of Lift: How Empowering Women Changes the World* (Gates, 2019). Microsoft has also taken note of such gender gaps when it comes to women in computer science and, through its own sponsored publication, shared that of those female students polled, 31% of middle school students and 40% of high school students believe that careers in computer coding and programming do not fit their interests (González-Pérez et al., 2020).

Therefore, students find themselves not fitting into coding and programming jobs at 58% when they reach their undergraduate studies (Yates & Plagnol, 2021). Microsoft's research found that girls are 20% more likely to pursue subjects like computer science if they know a woman in the field, but therein lies the concern with the lower number of women in these careers, with most girls envisioning a male in those roles (Yates & Plagnol, 2021). These perceptions are keeping the gender gap in computer science from closing.

According to Microsoft, they also analyzed female K-12 students' perceptions of working computer scientists. Only 17% of students believe that computer scientists get to be creative in their jobs, and about one-third of them believe these types of jobs do good for the world (González-Pérez et al., 2020). Encouragement was a large contributor in K-12 girls wanting to pursue computer science-style coursework throughout their education, whether it was from a parent or from their educators.

Therefore, an inference from González-Pérez et al. (2020) is that of needing to remove misconceptions or provide insight into what working in the field entails is foundational to girls' perception of computer science. A significant contributor to women not pursuing computer science is the challenges they face in their educational journey once they decide to declare computer science as a course of study for their major. The lack of support in computer science programs in colleges for women has included a lack of mentorship, which has added to an absence of female computer science students' confidence in the field, thus compounding the problem (Farheen, 2021).

While prestigious universities like the Massachusetts Institute of Technology (MIT) have seen enrollment by female undergraduate computer science-related majors rise with growth data from 2013 to 2023 showing numbers doubling, there is still an evident gap between the number of males in contrast to females (MIT Registrar's Office, 2023). The gap is still a large one, with female students still only being a third of that student population (MIT Registrar's Office, 2023). While a school like MIT can cite more considerable strides in enrolling a female population of computer science students, given its concerted efforts in its technology programs, other schools that offer computer science pathways alongside its other not math or science-based studies, like state universities, may not see such jumps (Zhu & Kadirova, 2020).

As of March 2023, women in higher education only make up 21% of computer science majors (National Girls Collaborative Project, 2023). When it comes to workforce applications, only 26% of those working in computer and mathematical sciences are women. And according to the National Girls Collaborative Project, there are also implications for women of color as only 14% of Science, Technology Engineering, Mathematics (STEM) majors include students of Black, Indigenous, or Latin descent (2023). Additionally, less than 10% of those women of color result in actually working in the STEM field. Furthermore, analyzing the importance of experiences prior to collegiate pursuits that inform the gaps in such statistics for female students can give insight into the issue as a whole.

Parallel to Microsoft and the National Girl Collaborative Project's findings, it has been shown that intentional advising experiences students have during their K-12 studies have a large influence on their pursuit of STEM-based careers (National Girls Collaborative Project, 2023; Yates & Plagnol, 2021). This is especially evident in low-income areas, where educational resources are already limited in receiving adequate college counseling. Therefore, they are able to make less progress in empowering female students to enter intentional fields like computer science (Schneider et al., 2013). In their findings, Schneider et al. (2013) concluded that in those high-need communities, the priority needs to be allocated funding to support the college admissions process. It is then that underrepresented groups of individuals' academic advising in STEM majors can be intentional in closing the gender gaps.

It was only when counseling partnerships were made with STEM-oriented mentors that the number of female students, including those of color, increased in declaring those majors when the time came in their college application processes (Schneider et al., 2013). The incentives in programs and guidance of this kind are that it also educates students and their families on how to finance their educational endeavors. This further supports that this study's results and recommendations could inform best practices targeting other underrepresented groups.

Globally, the issue stands that while women are obtaining degrees at an increasing rate, only a small percentage obtain degrees in STEM-related subjects (Munoz-Boudet, 2017). According to the World Economic Forum, this has largely to do with the same issues found in the US, including a lack of role models and the field being male-dominated, with girls often discouraged from inclusive STEM class environments. As such, this includes the notion that they will be underrepresented when they enter the workforce (Munoz-Boudet, 2017). If the issue stands that numbers similar to the US of women in computer science are also taking place in countries like those in Europe, then solutions could greatly have a universal impact.

Additionally, from a global standpoint, the lack of women participating in computer science could have an economic impact on the US (Pham & Triantis, 2015). With the US having technological leads within Silicon Valley-based juggernauts such as Twitter and Amazon, the country has made a large global impact when it comes to its influential lead in technology fields (Pham & Triantis, 2015). Competition from American-based companies like Amazon has emerged globally, like Chinese-based Alibaba. In turn, in order to keep innovating and surpass economic competition, the US must be proactive in its actions of recruiting, educating, and retaining female computer science students.

While this study's participants were women in higher education, one must also analyze foundations set in K-12 education that may affect these later-in-life numbers. At the high school level, the College Board has made an effort to provide more opportunities to students when it comes to computer science (College Board, 2022). The College Board offers two computer science courses that students can take as part of their Advanced Placement (AP) program. The AP program allows students to earn college credit during their high school studies if they earn a passing grade, which is a score of 3 or above, on the course's corresponding AP exam. The two courses they offer high school students relating to computer science are AP Computer Science Principles (AP CSP), a course that serves as an entry point for students that does not require prior computer science experience, and AP Computer Science A (AP CSA), which is a more technical course solely focused on programming.

In a study that the College Board itself sponsored, it found that out of the 2019 high school graduates who took their computer science courses, only 31% of them were female for AP CSP, and only 24% were female for AP CSA (Wyatt et al., 2020). A typical computer science course of study for those who take AP computer science courses is for students to complete AP CSP, and then they usually matriculate to AP CSA. This same study found that 37% of male AP CSP students move on to AP CSA, while 22% of female AP CSP do the same (Wyatt et al., 2020).

Moreover, after taking AP CSP, 20% of male students decide to major in computer science, while only 10% of female students decide to pursue that major (Wyatt et al., 2020). However, the College Board has found that by taking these courses, students who take AP CSP are three times more likely to declare computer science as their major when they start college than those who did not take such classes (College Board, 2022). This can be attributed to AP CSP's approach to its curriculum, with prior experience not being a hindering factor for its students to be successful in the course and corresponding exam.

Given the gender gaps they have presented in their research, the College Board has made a concerted effort within its programs to celebrate schools that have increased female student enrollment in its computer science courses, and they are encouraged to promote their contributions to these efforts (College Board, 2022). Hence, this resulted in the College Board's AP Computer Science Female Diversity Award, established in 2018 (College Board, 2022). The award recognizes schools that have 50% or more of their enrollment as female students in one or both of their AP computer science course offerings. In 2022, 1,105 US schools were recognized with the award, an award that schools are allowed to promote with a certificate they received alongside online images to use across schools' social media and websites. In conjunction with their study, the College Board has found that when female students take an AP computer science course, they are five times more likely to have a related major, therefore adding gravitas to the importance of such awards (Wyatt et al., 2020).

In addition to the College Board's efforts and with their providing of curriculum for their AP computer science courses, organizations such as Code.org have also aided in addressing the issue of female presence in computer science. Code.org (2023a), through sponsorship of companies such as Amazon, Google, and Microsoft, provides its curriculum to schools and students with a focus on reaching underrepresented populations. Through their platform, which is one of several that offer curriculum for these AP computer science courses, Code.org has seen their percentage of female AP students grow from just under 20% of their entire student population in 2011 to over 30% in 2021. They have stated that while the numbers are heading in the direction they should go, there is still a way to go (Code.org, 2023a).

In their overall K-12 computer science course offerings, and in concerted efforts to provide computer science education access to as many diverse groups of students as possible, the College Board has found that about half of their students in the 2022-2023 school year are female at about 41% (Code.org, 2023c). However, this is a decrease from peaks like the 2016-2017 and 2017-2018 school years, where female enrollment in their computer science courses was at about 45% for both years. Therefore, they aspire to reach more students by allowing computer science course access not only through providing their resources for free but by not having experience or skill level be a barrier to entry.

In 2023, Code.org (2023b) launched its Computer Science Connections (CSC) program, a way to include teachers in the process of applying computer science skills in other subjects. Through its CSC program, Code.org provides lessons in English language arts, mathematics, social studies, and science that integrate those computer science skills while remaining standards-based. At the time of this study, curriculum materials were only available for Grades 3-5. There are plans to expand grade availability in the future further. The goal of CSC is to serve as a resource that both educators and students can use so that more computer science knowledge is applied across subjects that were not directly deemed as connected to computer science in the past, with all lessons being made available to schools at no cost. Therefore, other than connectivity, finances are less of a barrier to its implementation across its programs.

Other organizations, like Khan Academy, also offer no-cost computer science courses and resources (Khan Academy, 2023). However, they have other programs they promote more on their platform, such as their math offerings, which users normally engage with to supplement their in-class lessons. In their computer science courses, Khan Academy (2023) offers a series called *Meet the Professionals*, in which the organization introduces its users to diverse professionals in the field, including women and people of color. As supported by González-Pérez et al. (2020), this could aid in girls envisioning themselves in STEM roles by, though digitally, offering students a way to see how computer scientists get to be creative in the roles.

However, unlike the College Board and Code.org, Khan Academy does not have materials directly aimed at closing the gender gap (Khan Academy, 2023). Moreover, Khan Academy is not an official College Board curriculum provider for its AP computer science courses as Code.org is. Therefore, the College Board and Code.org have parallel messaging in addressing the lack of female computer scientists. There is an opportunity for large organizations like Khan Academy to have intentional strategies for inviting more female students to STEM and computer science as pathways of study.

There have been efforts made by organizations like the College Board to increase the participation of female students in computer science, given the found gender gaps in majors and careers (College Board, 2022). Large companies, government entities, and universities have also noted the need for more women to be working in computer science, and there are implied hindrances to US innovation if the issue is not proactively addressed. Therefore, the issue must be addressed in girls' K-12 education so that they possess the exposure and mindset necessary to know that there is space for them in the field of computer science.

## Statement of the Problem

The number of female students pursuing computer science-related majors and the number of those pursuing those careers largely differ from their male counterparts (L. L. Wang et al., 2021). According to L. L. Wang et al. (2021), even with the numbers continuously rising of women who pursue these fields and, subsequently, those related careers, there is still a significant gap present. The question stands as to what challenges present themselves for these women, and without intentional action geared toward those challenges, it is a gap that may take several decades to close (L. L. Wang et al., 2021). In order to get to the root of these challenges, it is imperative that academic institutions reach these students early enough in their academic pursuits so as not to discourage them from continuing their coursework and careers in the field. Female students in K-12 lack confidence and therefore face challenges envisioning their place in the field of computer science and therefore do not take the continued academic journey to close the workforce’s gap (González-Pérez et al., 2020). As such, the issue stands that there are significantly fewer women who work in the field of computer science than men.

## Purpose Statement

The purpose of this phenomenological qualitative research study was to determine the best practices that female college students with computer science-related majors employ that assist in inspiring them to persist and have the grit to do well and succeed in this male-dominated field. First and second-year college students in computer science-related majors were selected as participants. These participants offer a connection to K-12 education with no more than a two-year time frame since completing high school while still being able to articulate research responses in the midst of their college experience with the added perception of looking ahead in their careers. Factors that inform these best practices will include identifying challenges, strategies to overcome those challenges, metrics for success, and advice for all aspiring female computer science students. Through developed research questions, findings can inform the framework in K-12 education of best practices employed for recruitment and retention of female computer science students to encourage them to pursue those college majors and career paths. Given the purpose of the study and its participants, the following research questions were used to inform this qualitative study.

**Research Questions**

- RQ1. What challenges do female first and second-year college students face in pursuing computer science-related majors?
- RQ2. What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges?
- RQ3. How do first and second-year female college students measure success in pursuing computer science-related majors?
- RQ4. What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science?

**Theoretical Frameworks**

This dissertation research was grounded within the perspective of feminist theory, a sub-genre of critical theory, in which solutions are found for systems and structures of oppression, and though it does not necessarily have to do with systems that oppress women, in this study, that is indeed the issue being addressed (Arinder & Roe, 2020). In this instance, and as defined by Egbert, oppression is more to do with targeting gender inequalities, which this study addresses in computer science education environments, systems, and structures (Arinder & Roe, 2020). The incorporation of feminist theory in this study will allow, as its model articulates, to create understanding, advocacy, and change whilst informing best practices for academic environments (Arinder & Roe, 2020).

Feminist theory also looks for applications in settings like classrooms, which this study looks to affect (Arinder & Roe, 2020). In accordance with Arinder and Roe (2020), results could also simultaneously affect change in other oppressed groups, such as those based on race or ability. Additionally, feminist theory looks to disrupt systems to create change, and this study's goal is to accomplish that with its findings being used to inform best practices. Best practices will indicate to female students ways systems can change so that they can persevere, challenge biases, and how they can pursue their passions for STEM, specifically computer science, without restraints so that they can thrive and remain as critical contributors to the field (González-Pérez et al., 2020).

Rooted in feminist theory, informing best practices will also incorporate appreciative inquiry into how interactions occur with participants and how the study's findings are presented based on their responses (Bushe, 2012). Appreciative inquiry theory provides methodology and process to affect organizational and social change and can be used to ignite engagement (Bushe, 2012). Furthermore, appreciative inquiry examines positive assets over those deemed as negative to overcome existing problems and implement strategies, which in this study will inform best practices.

With roots in social-constructivist theory, appreciative inquiry examines assets through interactions and relationships, which are embedded in this study's research questions (Bushe, 2012). Through appreciative inquiry, learners look to bring strengths to the forefront, as cultural biases may have prevented them from being previously exposed. In its models, appreciative inquiry looks to define the investigation, discover the cultural strengths, and for learners to design so that it will allow for results and the sustaining of new system changes. Therefore, the root of feminist theory allows disruption for gender inclusion for women in computer science, while appreciative inquiry will allow for the identification of strengths that will inform those disruptions, which will result in recommendations of best practices in the spaces for computer science learning.

## Significance of the Study

### *Cultivating Interest in Computer Science Among Girls in K-12*

This study will contribute to informing best practices in K-12 classrooms among primary, middle, and high school students in generating interest in the industry of computer science. Furthermore, while there is interest in earlier grades from girls in computer science, these best practices could be used for retention in that interest so that female students feel like they have a place in the field and can possess the confidence in their inclusion to remain.

While a lack of confidence for girls in computer science stems from a lack of role models, over time, these best practices could increase the number of those who pursue the field and move forward into mentorship opportunities (Forte et al., 2018). Intentional strategies for girls in STEM during their K-12 education could also increase their enrollment in courses like those offered by AP computer science opportunities so that they experience increased exposure to these opportunities. Moreover, by decreasing barriers to girls' inclusivity in computer science, the added diversity in the field could also have implications, such as more diverse hires, for companies as well.

### *Support for Female College Students Pursuing Computer Science*

In having female college students pursue computer science-related majors as research participants, the results look to answer the research questions as they relate to students' challenges and strategies. Through the results, which will inform best practices for this and other groups of female students, support can be established at colleges and universities for computer science alongside other STEM-related programs. This could be especially impactful for schools with those gender gaps present.

Therefore, the opportunity presents itself that through the data collected, colleges and universities can proactively look to improve their gender diversity in STEM populations by addressing their needs in their recruitment and retention efforts. As a result, colleges and universities can operate knowing that they are making a concerted effort to contribute to the closing of the gender gap in computer science, which could be beneficial in assisting with the publicity of their advancement efforts and the allocation of further funds for these programs.

Additionally, college and university programs can also take more significant endeavors to examine their enrollment of underrepresented groups across all programs and majors. Through the study, they would possess a realistic viewpoint of what students' needs are and an understanding of student metrics for success. While universities with high STEM resources like MIT may be able to gain strides in their efforts to diversify their student population in technical majors, having participants' viewpoints stemming from various nationwide universities could prove informative to different types of schools, as these schools could have more limited resources for these types of diversity efforts.

### *Female Exposure to Careers in Computer Science*

With a lack of girls actively pursuing computer science opportunities in schools, a dearth of exposure to possible career opportunities in the field also exists (Munoz-Boudet, 2017). Perceptions of available job opportunities may be limited based on assumptions of what the field looks like or the type of person suited for it, especially as it is male-dominated. Based on the findings, there is an opportunity to employ best practices as it pertains to mentorship based on the challenges and strategies identified. If best practices employed could also challenge misconceptions, like those of computer scientists not being seen as creative, then that could additionally affect recruitment into the field.

The long-term effects of these best practices could consequently impact the field as a whole with the addition of diversity to US technological innovations. The possibility of new innovations arising from the inclusion of females in computer science could strengthen the economy by possessing a global competitive advantage. Therefore, the implications for female retention in computer science careers could have an international impact.

## Assumptions of the Study

Assumptions for this study were as follows:

- It was assumed that the research study's participants that were selected are first or second-year female college students who are studying computer science or computer science-related subjects, and it is assumed they may have similar responses to inform best practices;
- It was assumed that each selected participant would cooperate and be accommodating to the study;

- It was assumed that participants' responses to every question are answered with opennesses and honesty and that they provide an accurate and realistic representation of their lived experience; and,
- It was assumed that with this being a qualitative research study, it will be able to offer insights into the problem by identifying participants' challenges, strategies, measures for success, and advice.

**Limitations of the Study**

Limitations for this study were as follows:

- The possible impact of the researcher's own race, gender, age, and socioeconomic status as it relates to this study was unknown;
- The researcher communicated with each of the study's participants that their information, including but not limited to names, would be kept strictly confidential and stored securely; however, there was no guarantee of assurance in not being identified, and therefore some responses may not fully capture a participant's experiences for fear of being identified;
- When participants signed a consent form for the study, their natural behavior may have changed, which could have impacted the results;
- The researcher possesses biases and prejudices that may influence the study's results, however, every attempt was made to shield from this type of phenomenon from occurring; and,
- Results and theories stemming from the data gathered derived from responses that came from a small subset of female first and second-year college students in

computer science-related majors; therefore, further evaluation and study of additional participants are recommended.

**Definition of Terms**

The following terms were used as they relate to the study. The definitions are provided to readers for reference.

- *Advanced Placement (AP)*: A program available through the College Board allowing high school students to take college-level courses and earn college credit, usually by passing a corresponding subject exam (Discover AP, 2023). This study will specifically look into two AP course offerings: AP Computer Science Principles (AP CSP) and AP Computer Science A (AP CSA).
- *Best Practices*: These are strategies employed in both education and work settings that will foster long-term effects in organizations. Such strategies can then be further utilized to demonstrate results and be used as measurement tools for performance (Cao & Xue, 2013). This study will find best practices for female students in computer science, allowing for implication in K-12 educational settings for success and retention in the field.
- *Challenges*: In this study, challenges are defined as academic difficulties students encounter in pursuit of their academic pathway. These can include but are not limited to anxieties, a sense of belonging, motivation, and course experiences (UC Berkeley, n.d.).
- *College Student*: A college student is defined as someone who is enrolled, either part of full-time, at a two-year or four-year degree-awarding institution (Cornell

University, n.d.). In this study, female college students will be enrolled at least full-time at a two or four-year degree-awarding university.

- *Computer Science*: It is a broad field, typically used to study computers and computational systems, that includes coding, algorithms, and software development (Michigan Technological University, 2023). In this study, computer science-related majors will be included in the participants' course of study, which can be related but are not limited to studies in programming, information technology, cybersecurity, software engineering, artificial intelligence, and data sciences.
- *Diversity*: The way in which one group may be similar or different from another group (Robbins & Judge, 2015). This study examined gender diversity in those pursuing studies in computer science-related majors and fields. Additionally, the study could have implications for addressing diversity efforts for other groups.
- *Explicit Bias*: Explicit bias is an individual awareness of prejudice and attitudes toward a specific group (United States Department of Justice, n.d.). Prejudice and attitudes can be either positive or negative, but they are conscious.
- *Gender*: Unlike sex, which has physical traits as they relate to physiological characteristics, gender may include how a person identifies based on social norms in categories such as male and female (Newman, 2023). In this study, the female gender category will include age identifiers such as girls for children and K-12 students and women for high school graduates and beyond.
- *Gender Gap*: The differences between men and women when it comes to reflections of society, such as those found in finances and politics, among other categories

(Harris, 2017). In this study, the gender gap will be used to identify the difference in numbers between males and females in computer science.

- *Inclusion*: The intentional engagement of diverse groups of people in communities and those affiliated with the curriculum (George Washington University, n.d.).
- *Male-Dominated Industry*: An industry or career that is 25% or less occupied by women than men (Lalier, 2018).
- *Science, Technology, Engineering, and Mathematics (STEM)*: This is an instructional approach that provides students with learning opportunities in those fields through problem-solving and hands-on experiences (Southern Illinois University, 2023). In some institutions, the addition of art is included in this style of approach, giving schools the option to name their programs STEAM. Given its relation to STEM's four subject categories, in this study, computer science is considered a STEM subject.
- *Success*: While subjective, it can be defined as a sense of accomplishment in varying aspects of a person's life, including career, education, and finances (Seltzer, 2021).

**Chapter Summary**

There are evident gaps when it comes to female populations and their involvement in computer science in K-12, higher education, and in the workforce. With it being a male-dominated field, best practices must be employed by both academic institutions, regardless of grade level, and by technology employers; otherwise, the gap will not be addressed, and the untapped potential for this population will not be realized. Therefore, this study will look to inform best practices that will affect change at these levels.

While several researchers, institutions, and corporations have defined the gaps for females in computer science, those best practices can have implications to be employed at all stages, including the experiences of young girls (Munoz-Boudet, 2017). Efforts have additionally been made by nationwide organizations like the College Board and Code.org to address the problem of the gender gap through their programs, but a pathway must be informed to expose students to those programs and for them to find their place.

In order to inform best practices, elements such as challenges, strategies, definitions of success, and guidance from purposeful sampling were incorporated into this study through the participants selected. It is through that basis that research questions, corresponding questions, and protocols for reliability and validity were developed for this phenomenological study. The study's methodology was founded on the analysis of data conducted through coding themes of open-ended questions.

Therefore, it is those findings that contribute to the study's significance in the field of computer science for female students. The acceptance of assumptions and limitations of the study, the researcher, and the participants were also stated to both provide perspective on the findings and to additionally impart recommendations for further research. Moreover, terminology that will be used throughout the study was defined as an access point to readers.

Ethical considerations were applied to the study and to the research process as a whole. These ethical considerations need to be reviewed at all stages of the study, as they can bring forth complexity (Creswell & Creswell, 2021). Lastly, in its five chapters, this study was framed with applications from feminist theory, a subcategory of critical theory, alongside appreciative inquiry to inform best practices.

# Chapter 2: Literature Review

## Background

For the literature review of this phenomenological research study, a range of sources were presented to demonstrate the journey of female students in their studies related to computer science from their elementary experiences to those of the study's participants' current education level; first and second-year college students. Additionally, the literature presented will also give insights into female professionals in fields related to computer science. From these perspectives, the literature will extract best practices in the field of computer science, challenges in the field, including those challenges presented by identified best practices, measures for success for females in computer science, recommendations, and critiques. Using this range of sources, they are unified in addressing the purpose of this qualitative phenomenological study to bring forth the best practices employed by female university students with computer science-related majors that assist in inspiring them to persist and have the grit to do well and succeed in this male-dominated field.

These insights stem from a range of audiences who have ties with female students studying computer science in college that were found within the literature. Some insights will look at the larger computer science industry and the lack of females in that workforce. Next, the literature presented will demonstrate the lack of types of support needed in K-12 education as it relates to computer science implemented in the curriculum. Furthermore, based on findings from the literature, takeaways will be presented as they pertain to primary and secondary education. Informed by this group, the next perspective studied stems from identifying the lack of identified support at the university level for female students in computer science-related majors. The literature has also informed that in some instances, data will be differentiated by lower-class and upper-class university students.

Another identified perspective that will inform best practices is the politically-driven efforts that aim to address the gender gap in computer science from local to nationwide initiatives and their implementation. Next, in wanting to concretely inform best practices and their challenges, as another perspective provided by the literature, this chapter will provide insights through literature that highlights the perception of female students, including all grade and university levels and regardless of them pursuing computer science-related studies, as it relates to computer science as a career option. From reviewing literature that addresses female students who both elect and do not elect to partake in further computer science-related coursework, are the insights of which are the determining factors that lead students to commit to the computer science field.

In order to further address the challenges for students in the field of computer science, the next perspective will analyze the literature from the perspective of student retention as well as the retention of women in the computer science workforce. To also inform the measures of success and how to inform best practices that will be long-standing, the literature review will look at predictions for closing the gender gap for females in computer science. Therefore, with these groupings informing the study's literature basis, they address the research questions built on the selected frameworks and theories.

## Constructs, Frameworks, and Theories

### *Leadership and Theoretical Applications to Diversity*

With the study's focus on addressing the gender gap present in computer science, the literature will also look to support the framework in which the study is grounded, that of feminist theory, a sub-genre of critical theory (Arinder & Roe, 2020). The perspectives of the literature will look to address the oppression defined by feminist theory. Arinder and Roe (2020) state that feminist theory utilizes the term oppression to address the systems and structures contributing to gender inequalities. Parallel to the literature, Arinder and Roe (2020) support González-Pérez et al.'s (2020) findings that feminist theory can inform best practices so that the population addressed, female computer scientists, can pursue those goals without restraint.

According to Duguid and Thomas-Hunt (2010), from the basis of a social-constructivist theory, appreciative inquiry was also utilized in informing the study and data gathering. Social constructivist theory also supports that stereotypes derive from how computer science-related careers, like information technology, are more suited for men than they are for women. Therefore, as demonstrated by Webster (1996), in support of Lev Vygotsky (Prawat, 1999), the industry must have an environment that is inclusive in promoting the advancement of women's careers as they relate to computer science.

Through that lens, the study will identify the cultural strengths of the population so that the Arinder and Roe (2020) addressed oppression can experience significant systemic changes for women studying computer science. Therefore, best practices will be extracted from appreciative inquiry's application within feminist theory. As such, and as support to this, an analysis must be made that defines the context in which women are referred to as leaders and hold top positions in their industries (Eagly & Carli, 2007).

Building on that, and in addressing the gender gap in computer science, the work of Meuser et al. (2016) is applicable as they found that leadership must be looked at through diversity theories. While the numbers are increasing of women in leadership positions, it pales in comparison to that of male leaders, such as executive officers, as women hold less substantial leadership roles with only possessing a quarter of those positions (Warner, 2014). Therefore, one aim is to look at attributes women leaders possess that will assist in addressing the scarcity of women in these high-level positions (Meuser et al., 2016).

A company's ability to initiate and adopt to changes to the workforce, leaders' vision, flexibility, and ability to collaborate tell of its timeliness (Gomez-Mejia et al., 2018). Looking at the environmental changes needed to address the gender gap in fields like computer science proactively, one must also look at the challenges facing women of color, as racial diversity is key when looking at diversity theory (Livingston et al., 2012). Therefore, the question stands if a company's strategic decisions can, in fact, be the driving force to change its organization's demographic to address such gaps (Gomez-Mejia et al., 2018).

Practices found in leadership theory could benefit female participation in computer science if organizations establish strategies, have clear structures and policies, tout their presence in the public, affect the hiring process and promotions, and take part in activities that promote diversity (Hiller & Beauchesne, 2014). However, all practices come from multiple levels, and keeping in mind that leadership changes take time, as does the organization's relations with the outside environment, complexity perpetuates the already existent multifacetedness organizations possess (Meuser et al., 2016). Furthermore, the traits of current leaders could also be leveraged to gain insight into success at the highest level of the organization (Peterson et al., 2009).

## Best Practices in the Field or Industry

### *K-12 Education and Environments for Girls*

Primary education, which in this paper is identified as grades kindergarten through eight, and secondary education, which is noted as grades nine through twelve, and their practices have been viewed as contributors of the gender gap present in computer science. At the start of the education journey for students, there are significant factors that inform children's pursuit of fields as early as kindergarten and can, as stated by Lin and Chan (2018), and set the tone for how they perceive the subject of computer science as a whole. Setbacks that have been present in elementary education for interest in computer science from not just female students but from all students stem from engagement strategies in the classroom.

The first best practice in primary education is introducing tactile supplementary materials to young students as the topic of computer science may be deemed too complex to conceptualize (Friebroon-Yesharim & Ben-Ari, 2018). Therefore, items like robots used in a robotics course allow students to observe coding applications by connecting commands with physical reactions from the robots. Another supplemental best practice stated by Lin and Chan (2018) stated that primary students who could hypothesize and reflect during their learning of computer science outperformed those who used a more traditional approach in their learning. Research by Guzdial and Bruckman (2018) found that the most effective best practice occurs when computer science is part of the primary curriculum as early as it can possibly be presented to students and that this would be the most effective way to increase the number of girls' interest and participation in the subject.

With older primary students in middle school, the gender gaps were more present than those in K-5, which dealt with best practices for all students. More recent efforts, like those by Fox (2021), aimed to engage female middle school students, which mainly came from a lack of self-efficacy and a sense of belonging. Her study was based on programs through initiatives like Project Lead the Way, which looks to give computer science to all students proactively at under-resourced schools, which provides insight into it being effective in engaging all students in the field. The initiative did not address the differences in engaging students through gender differences, and the novelty of such studies has yet to demonstrate the long-term effectiveness of such programs. However, the initiative does demonstrate that proactive engagement and concerted efforts to provide computer science education to schools that may not usually have such programs could indeed increase not just female participation but add diversity to those efforts. When girls are not engaged in the math and science courses that may influence their interest in computer science, it is telling of their decline in interest in later years, with few exceptions (Munoz-Boudet, 2017).

Though information on best practices in primary education proves to be a more significant challenge as several schools still continue to lack intentional computer science curriculum applications, there is more information to inform best practices at the secondary level and their potential (Hutchison et al., 2021). Intentional recruitment must come from the top, as administrators and counselors demonstrate visible efforts in inclusive education geared toward female students (Karlin, 2019). Therefore, intentional recruitment can be classified as a best practice in addressing the gender gap.

With this being acknowledged as a best practice, the College Board also supplies schools and educators with resources to recruit female students into its computer science courses through materials such as pamphlets and strategies for recruitment (College Board, 2022). Furthermore, in all K-12 grade levels, in order to successfully implement computer science into students' educational experience, teachers should receive professional development to make the subject of computer science more accessible and to engage girls (Guzdial & Bruckman, 2018). A combination of not just having the marketing collaterals for recruitment but professionals who exemplify the needed attitudes and strategies can potentially prove effective in these efforts.

As with Project Lead the Way, which addressed the lack of certain educational programs at schools, one of the obstacles some secondary schools face is the lack of computer science options for their entire student populations (Fox, 2021). Best practices for sites with a lack of computer science-related curriculum include intentional implementation through other avenues that allow it, such as other STEM courses (Lee, 2020). Additionally, it has been shown that gamification that is integrated into such subjects as computer science increases interest in the subjects and projects positive outcomes, especially for teenagers (Lee, 2020). But while girls spend more time using social media than gaming when using technology, it will have to be balanced to prevent their further exclusion (Yates & Plagnol, 2021). If educators of other courses include some computer science exposure and lessons, the field as a realistic course of study could potentially become a viable option for female students. Moreover, since some schools and districts may not classify computer science as part of the core curriculum due to it not being deemed critical to education, exposure outside of just mathematics and science courses could be influential (Patterson Hazley, 2016). For example, through availability as an afterschool program or activity, computer science in these ways could have significant implications for female students (Patterson Hazley, 2016).

When computer science course curriculums are emphasized at secondary schools, though, then there are best practices within those classrooms that could increase the engagement of female students (Karlin, 2019). For example, when computer science is applied through the work of Dweck (2008) on growth mindset, it is appealing to girls as it promotes opportunities for them to be able to take responsible risks and build upon their already existing skillset (Karlin, 2019). Karlin (2019) also supports that an approach to computer science by presenting it with problem-solving strategies positively affects female engagement, while Patterson Hazley (2016) supports this with the added factor that lessons be regulated, as many female students gravitate towards structure.

Fitzsimmons (2021) agrees that core STEM experiences during this time and early exposure to a computer science curriculum are pivotal for female students to want to pursue the field as a further course of study. Additionally, with implementing computer science in classrooms comes the recommendation for a best practice in making these classrooms environments of collaboration (Simon et al., 2018). When project-based learning encourages collaboration in a computer science classroom, the setting encourages girls to be more active learners (Lee, 2020). Working together to achieve a common-goal appeals to female students and adds a community-style inclusivity that adds comfort and confidence in their attitudes about computer science.

A recommendation made by Chen et al. (2016) emphasizes that community connections with local businesses could also provide experiences for students to concretely see themselves in their future. This could also be strengthened with mentorships as they have been shown to be very effective when it comes to girls' interest in computer science (Stout et al., 2020). According to Stout et al. (2020), these strategic mentorships in computer science for girls have allowed students to navigate the coursework successfully.

An area of education that could be tapped into is that of recognizing the difference in each gender's learning experiences (Harry & Malepane, 2021). For example, Harry and Malepane (2021) state that there are elements in what can be defined as intelligence based on gender that can predict how successful someone can be and in what areas based not just on biological differences, including university success rates. Gurian (2010) asserts that men and women have different attitudes and behaviors that can be recognized to optimize both education and workplace environments. For example, girls tend to learn better when there is structure, which can be applied to classrooms with the other noted best practices like mentorship (Gurian, 2010). Based on this, all-girls environments that implement these structures and elements of mentorship could be instrumental in influencing retention and interests of students in subjects such as computer science (Gurian, 2010).

***University Education***

Building upon best practices in K-12 education, there were parallel findings in the literature that focused on computer science education for female students in the university setting (Silva et al., 2022). The first parallel was that awareness was found to be a key component, however, the proactive awareness at the university level stemmed from making classmates and education professionals explicitly take notice of the gender gaps in computer science classrooms (Silva et al., 2022). This would, in turn, ignite everyone in the setting of any actions that may deemed as demoralizing or would cause female students to feel unmotivated. Moreover, female students feel more empowered to persevere at this level when they are made aware that they are partaking in a social change in the field (Ruiz, 2017).

Therefore, the learning environment will be enriched for female students with these types of awareness, and the best practices taking place in those spaces are also parallel to those found in K-12. Like Karlin (2019), Fitzsimmons (2021) found that spaces that support female computer science students tend to give a sense of belonging through the implementation of a growth mindset as a practice for their lesson experiences. This is supported by Ruiz (2017), who states that such practices provide female students with the space to flourish. This is further enhanced if female mentors, either in the form of faculty or more experienced students, are present to support students' learning experiences.

Furthermore, environments that combine consciousness of the gender gaps with providing female-to-female empowerment assist with addressing the sense of belonging that female computer science students lack (Yates & Plagnol, 2021). Fitzsimmons (2021) and the work of Yates and Plagnol (2021) both state that a sense of belonging is a strong best practice in addressing the retention of female students as male dominance tends to lead to females feeling less technologically capable and less motivated than their male counterparts. An intentional learning environment in which not one gender possesses superiority is a highly beneficial pedagogical practice for the inclusivity of women studying computer science in a university setting (Yates & Plagnol, 2021).

For best practices in STEM-related courses, one key factor that keeps students engaged is that of experiential learning as the experience acts as a preview to computer science challenges they may potentially face in the workplace (N. J. Kim, 2017). This can be strengthened by collaborative learning, as it has been attributed as a large contributor to subject achievement (Prince, 2004). One pedagogical practice when it comes to computer science, which appeals to women wanting to engage with goals that relate to community, is that of peer programming (Yates & Plagnol, 2021). By having side-by-side programming in the classroom, it increases the positivity of the female experience in tackling coding tasks (Yates & Plagnol, 2021). Additionally, an approach STEM educators take is that of project-based learning, as it combines the benefits of both experiential and collaborative learning through hands-on problem-solving tasks (Buck Institute for Education, 2018).

To emphasize the importance of these best practices, real-world problem-solving built within a strong conceptual framework is shown to improve self-efficacy in females when learning skills related to computer science (Baker, 2013). If female students are taught that their contributions in STEM-related subjects can make a positive impact in the world, such as software for women made by women, then it further sparks interest (Baker, 2013). Skills that allow students to work with diverse students will also benefit their male counterparts, as they begin to gain an understanding of the importance of inclusivity in their future workplace experiences (Ambrose & Sternberg, 2016). Ambrose and Sternberg (2016) add that learning to work in teams will be how companies will be set up, so learners must know how to optimize these diverse teams of contributors. However, the best practices for university students in computer science, which this study addresses, still has a lack in research, especially for lower-class students who are just beginning their journeys into higher education (Yates & Plagnol, 2021).

***Professional Settings***

One of the main themes that inform best practices in professional settings for women working in computer science-related careers is that of belonging through participation. This participation stems from mentorship in both being a mentor and being mentored. Roy (2014) and Koch and Gorges (2016) associate this mentorship being carried out through organizations outside of a private company, such as professional societies. However, it is difficult to determine if a sense of belonging will result in increased numbers of women pursuing these types of careers as this sense could be temporary, and therefore, systemic changes within take place through initiatives like coaching (Hewlett, 2014).

For example, Roy (2014) found that through funding STEM initiatives aimed toward professional women, companies can empower more female engagement and retention in the field whilst allowing for growth in the gender in the company’s future. Roy (2014) cites credible professional affiliations like the National Association of Professional Women and the National

Center of Women and Information Technology (NCWIT), which give professional women the aforementioned sense of belonging and support. This parallels Ruiz's (2017) findings that, like women in universities, a sense of belonging coupled with female mentors allows for the group to prosper.

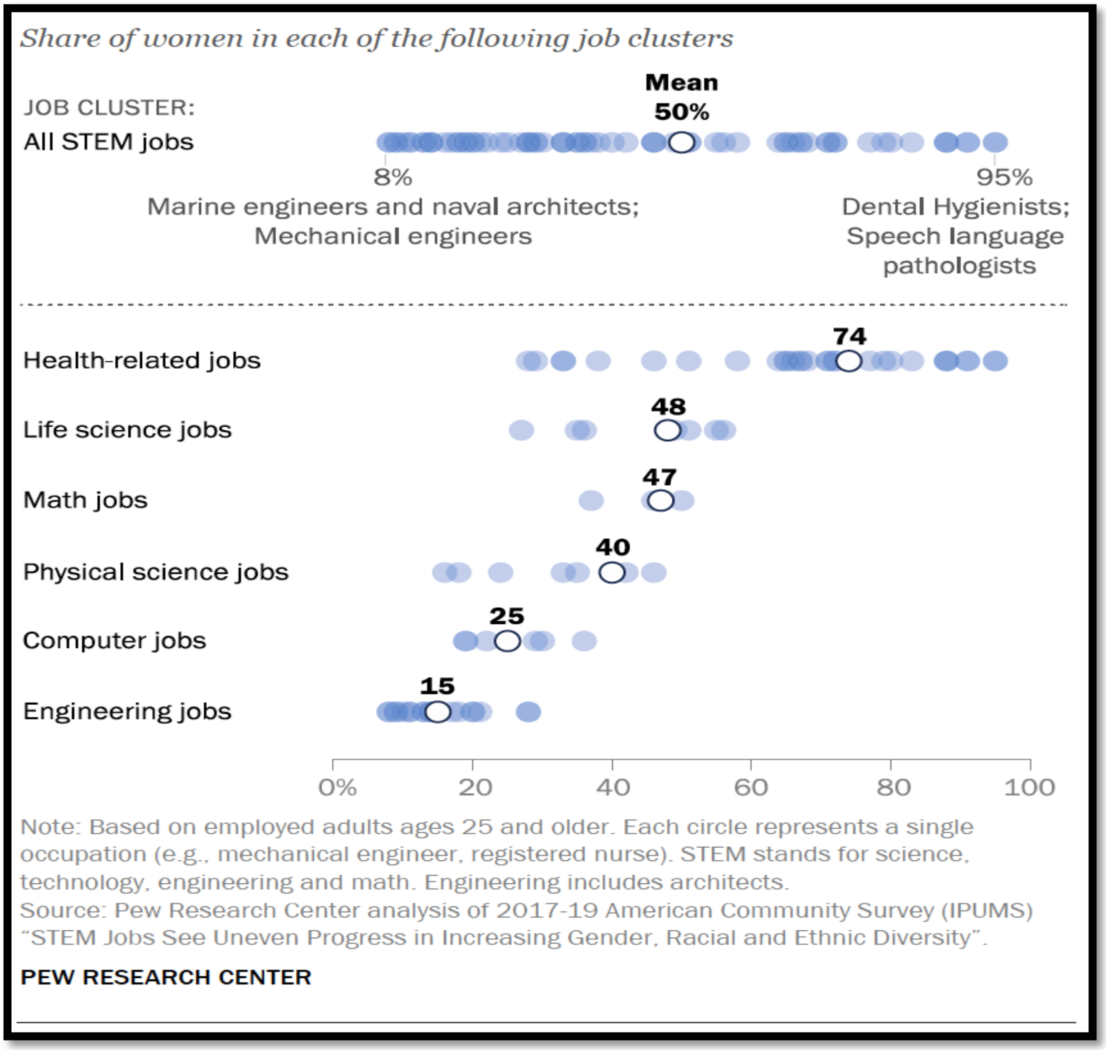
Koch and Gorges (2016) add that private companies can have a two-way advantage through a similar focus on mentorship. By giving professional women who work in computer science-related fields the opportunity to be mentors to younger female students, like those in primary grades, there is a sense of belonging from both the mentors and the students. This is further leveraged in that the sense of low self-efficacy through programs like these for female students of color can be addressed through mentorship. Diekman et al. (2011), support that professional mentorship is crucial so that women can work on skills like assertiveness and negotiation within computer science organizations.

Furthermore, mentorship enables a strong sense of self-efficacy that allows women in computer science to advocate for themselves and overcome a sense of imposter syndrome that could be combated with the confidence that is built via mentorships (Diekman et al., 2011). Mentorships are even more valuable if computer science-based jobs are specified by a mentor who can provide a mentee with guidance toward a specific career pathway, like information technology (Hewlett et al., 2008). An additional benefit is mentorship allows the opportunity for networking, which is essential in impacting the careers of women in computer science through promotion advancement (Hernandez et al., 2023). Hernandez et al. (2023) state that mentorship could prove vital for the retention of women in the field, which would affect the notable numbers of women who are leaving the industry (Silva et al., 2022).

A historically significant case, as articulated by Ireland et al. (2018), for support needed for women in computer science workplaces comes from that of Katherine G. Johnson, née Coleman, whose story was brought into the mainstream through the biographical novel by Shetterly (2016) and the film of the same name, *Hidden Figures*. For Johnson, the support she eventually received in a segregated Virginia had both gender and racial significance and aligned with the literature as it took a culture shift at NASA's Langley Research Center for supervisors to recruit her for calculations of projects, including the successful launch and return of the Friendship 7 spacecraft. In 2017, NASA recognized Johnson's contributions to the space program by naming a computational research facility building after her as a beacon for diversity and inclusion for both women and African Americans. This has the implication of the sense of belonging Fitzsimmons (2021) and Cook-Sather and Seay (2021) emphasize as being crucial to female success in subjects like computer science, and there is higher notoriety that Johnson's accomplishments were recognized via mainstream mediums. The story can also serve as a source of motivation of students and professionals working in STEM, especially with even more marginalizing obstacles like segregation at the time of Friendship 7. All these efforts can contribute to the increase of women in computer science, which, as seen in Figure 1, has one of the lowest numbers of career paths when it comes to women in STEM jobs.

**Figure 1**

*Representation of Women in STEM Across Job Clusters*




*Note*. Pew Research Center. (2021b, March 30). *Representation of women in STEM varies across job clusters*. Pew Research Center Science & Society. (https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/ps_2021-04-01_diversity-in-stem_00-02/). Reprinted with permission.

As such, when it comes to best practices for companies, they need to improve gender diversity not just in leadership but must also stay atop what demographics will look like moving forward (Jazzar & Algozzine, 2007). This allows companies the mindset to stay innovative, not just with products but also with recruitment and retention practices (Jazzar & Algozzine, 2007).

Managerial styles are deemed as strong when they address issues like gender diversity alongside cultural diversity, and if they are addressed in technology companies, it shows strength in being able to stay in competition in the global marketplace, particularly in technology (Combs & Luthans, 2007).

## Challenges in the Field or Industry

### *Sense of Belonging and Gender Biases*

It has been noted that female college students are dropping out of computer science coursework at large rates (Silva et al., 2022). One of the largest challenges women encounter in any STEM field is not having a sense of belonging, coupled with inadequate support in their environment, regardless of academic level aspirations or status in their career journey (Yates & Plagnol, 2021). Price (2022) supports that mentorship is key to female enrollment in computer science but brings forth that there is a lack of mentorship in the entire field, so the problem persists with professional guidance only being able to do so much when there are a limited number of professional female mentors available. These are contributing factors to low self-efficacy, which is a large impetus for both academic achievement and to inform career success for students and entry-level employees (Komarraju & Nadler, 2013).

In literature that analyzes the gender gap in computer science, one aspect that must be addressed that drives the study is one that addresses the gender biases historically and within workplaces (Heim, 2005). A large driver for the current state of gender biases begins with societal expectations set on children since birth that long-term affect their viewpoints as they develop into working adults (Heim, 2005). Childhood interactions with other children, toys, games, and choices largely inform how each gender functions in organizational structures as adults in how they present themselves in situations like meetings (Heim, 2005). Without a sense of belonging, this will continue as it is a significant contributor to university students feeling connected with the subject and following through with a computer science-related major until they graduate (Silva et al., 2022). Additionally, girls do not look to further study and become employees in industries in which they cannot picture themselves, with stereotypes that they cannot relate to, but most boys can, as they are commonly associated with the traits it takes to succeed in the field (Yates & Plagnol, 2021).

As such, an example is that it is likely for a woman to want to discuss ideas in a group setting, which further hinders the organization's experiences with women (Evans, 2009). One practice Criado-Perez (2020) recommends to combat workplace biases is that of blindness. In an academic setting, for example, a blind review could be offered for a faculty member’s submitted paper. It has been noted that women receive more praise during this practice than they would if their names were attached to their work (Criado-Perez, 2020). Along with praise, there would also be the removal of what Criado-Perez (2020) calls brilliance bias, in which men are deemed as more knowledgeable as the characteristics of geniuses tend to be associated with traits connected with males.

There is also the adage that if a woman acts aggressively in a work setting, she is perceived negatively when compared to men who demonstrate similar behaviors (White, 1992). This double standard also hinders women’s advancement in positions and may explain the lack of women in top leadership positions (Swiss, 1996). The work of White (1992) and Swiss (1996) concludes that there is a perception of women as outsiders and that they must continuously work to be deemed competent and skilled at being leaders. If a sense of belonging for females in computer science is not addressed, it could add on top of the already depressing feeling associated with the field (Silva et al., 2022).

Work by Scott and Brown (2006) shows that when looking at leadership, it has been shown that stereotypes emerged based on gender, and concluded that women face many more challenges when thought of as leaders. With a conflicting perspective that leadership is associated with male-dominated environments, women's competence in leadership roles in such environments is then further questioned (Eagly & Carli, 2007). As such, it has been identified that leadership will need to be approached in a way to find a balance so women have a place in such positions (Eagly & Carli, 2007).

Historically, it has been the domestic role and responsibility of children that has been a contributing factor for women to make choices in careers, family, and work-life balance (Bowles & McGinn, 2005). It is historical factors that add to biases that women may not be able to manage the same levels of responsibilities as men do in executive-level positions (Powell & Graves, 2003). During an initial interaction with computer science, several female students experienced feelings of inadequacy, as men are more apt to excel in computer science since they interact with the technology at an earlier age and are therefore more confident in interfacing with computers, adding to women's low self-efficacy on the subject (Yates & Plagnol, 2021). An added challenge for women is the availability and access to networks for mentorships, especially when compared to men (Powell & Graves, 2003).

Therefore, finding female leaders in fields like computer science, where they are underrepresented, can be attributed to not just social obstacles but also to structural obstacles that have been informed by organizations that do not allow for their career growth (Barsh & Yee, 2012). One prominent example of a structural barrier for women is the pay gap, which has been an issue for decades since the era of suffrage when women in the US began working in industries that had previously not had their presence (Glynn, 2014). As such, a sense of belonging is challenging to obtain when such leadership, wage, mentorship, and social hindrances are present.

Additional barriers in addressing such a challenge are that technology companies have disclosed that when they begin to place initiatives toward increasing gender diversity, they still experience difficulties at the administration level and, as a result, create non-inclusive spaces for its users when using the platform (Dean & Laidler, 2013). There is still much room for improvement, as technology companies have revealed and admitted to, and as noted by Obrine (2016) of *CNN*, that they need to make when addressing the gender gap, especially in an explicit fashion as it would assist in features to address issues like women's view of self-esteem when using social media platforms (Bergagna & Tartaglia, 2018). Even large companies like Facebook, now Meta, have female senior executives as less than one-third of their leadership, which provides insight into how other large technology companies' gender gaps are faring, which could affect the room for improvement for the platform's female user experiences (Bergagna & Tartaglia, 2018). Coincidentally, but also related to the female technology leadership number, is the fact that one-third of AP computer science students who take the exam are female (Lee, 2020). Zeiden (2016) affirms that such gaps can be attributed to cultures in computer science industries, like information technology, which encourage more aggressive behaviors that add to the bias as such behaviors are usually associated with men.

Therefore, in such workplaces, it is worth looking at such challenges considering women's point of view as qualities associated with men are more promoted than those associated with women (Ingersoll, 2016). For example, at times companies will provide scholarships and internships aimed toward women, but it has been shown that this actually drives women away, as women want to feel that they earned such opportunities on their own merit (Yates & Plagnol, 2021). Therefore, considerations need to be made when publicizing opportunities for advancement to women, which has implications for other underrepresented groups as well.

Several women-associated workplace incentives, like childcare, have not aided in closing the gender gap in such environments (Bergagna & Tartaglia, 2018). Large technology companies, like Google, have had to rethink their processes when it comes to granting promotions (Criado-Perez, 2020). According to Criado-Perez (2020), Google hosted workshops that encouraged women to nominate themselves for accolades and asked women to amend their mindset, which demonstrated that Google was asking women in technology to approach the workplace so as men instead of addressing the issues in the systems and environment. As a result, that initiative did nothing to close the gender gap as it was deemed ineffective (Criado-Perez, 2020).

***Technological Skills***

One of the compelling issues, even at a global level, involves students graduating from college and into the workforce without the necessary content skills required for them to do well in computer science-related industries, such as information technology (Marginson et al., 2013). This is further demonstrated through data that indicates that IT professionals have some of the highest unemployment rates when it comes to college-educated professionals (Science and Technology Committee, House of Commons, 2016). Furthermore, it has been attributed to there being a disconnect between what programs intended for IT professionals are taught and what the workforce indeed requires, which has serious implications for other computer science-based careers (Hagedorn & Purnamasari, 2012). However, this is also affiliated with the self-efficacy of women as they tend to rate their technical skills lower than those of men, even though they perform just as well, if not better, academically in computer science courses (Yates & Plagnol, 2021).

This problem has even more damaging effects for women in these types of careers as the correlation between the unemployment rate and lack of skillsets has been attributed to underrepresented groups, such as women, not being taught a proper STEM education during their schooling (Hagedorn & Purnamasari, 2012). Insights from the IT field inform researchers that computer science-related gender gaps in such industries can be attributed to girls' lack of engagement in technology during their K-12 years, which leads to fewer of them choosing such majors when they enter college (González-Pérez et al., 2020).

It is not uncommon for teachers and classmates of female students to think less of their capabilities and capacity for such subjects, which are prejudiced by their daily experiences that discourage several young girls from wanting to pursue computer science in college (Silva et al., 2022). Women tend to downplay their own technical abilities, while in contrast, men tend to overestimate theirs, which could add to the perception that women are less competent in computer science (Yates & Plagnol, 2021). It has been shown that stereotypes of women not being suited for computer science are what contributes to the lack of confidence in women's technical skills (Yates & Plagnol, 2021).

## Implementation in K-12 Education

### *Financing Access and Resources*

One of the challenges found in primary and secondary classrooms is access to teachers being properly trained to implement computer science initiatives in their learning environments. There is a large disparity between socioeconomic status access to computer science education, where more affluent areas have a consistent access to it, while schools with students in underrepresented groups and lower socioeconomic resources may not have access at all (Toohey, 2022). Research conducted by Toohey (2022) found that the issue does not lie in the teachers not wanting to be trained. In fact, the study found that regardless of a school's socioeconomic demographics, teachers consistently wanted their students to be taught computer science skills to promote academic success (Toohey, 2022). However, realities in schools' finances may pose a greater challenge as Friebroon-Yesharim & Ben-Ari (2018) state that one of the best strategies for teaching computer science, especially in younger grades, would be by incorporating tangible items, like robotics, which adds to the costs of training and supplies. Quite informative is the fact that poverty levels do not dictate the interest female students have in taking computer science, as Kemp et al.'s (2019) research demonstrates how it is female students who live in areas with less socioeconomic resources who are more likely to want to take computer science courses. Lee's (2020) research also found a parallel conclusion in that low-income and underrepresented students were more likely to select STEM-based majors. This further emphasizes the need to provide resources to as many types of schools as possible to close the computer science gender gap.

Another strain in access is that when computer science is taught, it is generally directed to students in general or enrichment curriculum programs (Hutchison et al., 2021). However, there is a larger gap for populations with identified disabilities (Hutchison et al., 2021). While there is already a challenge in providing computer science education to all students, even less is known about professional development geared toward a design learning approach for students with disabilities (Hutchison et al., 2021). The realities of implementing computer science education in a classroom that has special needs present its own challenge and, as it always has, plans for the future include opportunities to scaffold the content to enhance learning, and like all teachers, educators for students with disabilities are also motivated to have such curriculum taught at their sites (Hutchison et al., 2021). An area for growth across all schools is to support the teachers who are eager to implement computer science-related content into their classrooms by providing them with the necessary professional development to do so (Toohey, 2022).

### *Lack of Engagement*

The inclusivity of female students in all fields faces a challenge regarding classroom practices, such as dialogue (Simpson, 2006). Biases can present themselves when gendered phrasing is presented by educators, even unintentionally, because of traits that have prejudiced undertones (Simpson, 2006). While there is an opportunity to educate students in K-12 on gender equity and inclusivity, some practices are challenging to improve because of traditions and norms in which children are told to behave or that inform their interactions with peers (Aina & Cameron, 2011).

This has also been noted with formal College Board-offered AP courses, such as AP CSP and AP CSA, which allow students to take college-level computer science courses while they are in high school (College Board, 2022). While there have been efforts and campaigns to recruit female students through accolades schools receive from the College Board that recognize schools with over half female enrollment in both AP computer science offerings through the Female Diversity Award, there is still much to be done to increase the numbers of those registering for those courses (College Board, 2022). Bahar et al. (2022) noted that even though there is still a gender gap, the content is not the challenge as females pass the corresponding AP exam at a parallel rate to their male counterparts.

As of 2018, only one-third of those who took an AP computer science exam were female, whereas female students were more than half the test takers for other AP subjects (Lee, 2020).

While computer science is a subject within those categorized as STEM subjects, low numbers in STEM as a whole from female students have contributed to low computer science numbers (Lee, 2020). It may take more institutional efforts, not just those from the College Board, to engage female students to see themselves in a place to enroll in such courses, given they are just as likely to succeed in them as their male counterparts. To address inclusivity, companies must design their organizations keeping in mind the goal of a workplace culture that they desire, with a value placed on each person's individuality and how they are welcomed into the organization, which adds to their sense of belonging (Dhillon, 2009). Dhillon (2009) adds that, in comparison, diversity addresses companies having a blend of people who have the skills that are the right fit. Therefore, inclusivity looks to embrace the aspects of diversity that benefit both individuals and the organization. For that reason, companies must strive to have diversity in the workplace with a culture of inclusion and respect (Dhillon, 2009).

While there have been strides in the increased diversity in companies across the country, such and Amazon and Barclays, an industry where this has been consistently challenging has been that of technology companies and the female population of technology companies (McConnell et al., 2016). Consequently, there is talent that goes underrepresented and could, in turn, affect the retention of the few women already working in computer science-related jobs (Hastings, 2009). Additionally, this becomes problematic for the company as they have a lower lens for untapped clients if they lose the perspectives of women in the creation process (Hastings, 2009).

Hence, these numbers could be deemed as discriminatory even when that is not the intention behind the low numbers. Discrimination can be further inferred if women are paid less than men in industries like information technology (Moody et al., 2003). While the pay gap is further addressed in the next section, it is important to note that it further isolates potential female employees, which can affect both a lack of engagement for women but also a loss in potential economic profits for companies as they may not know how to reach underrepresented markets (Cheng, 2015).

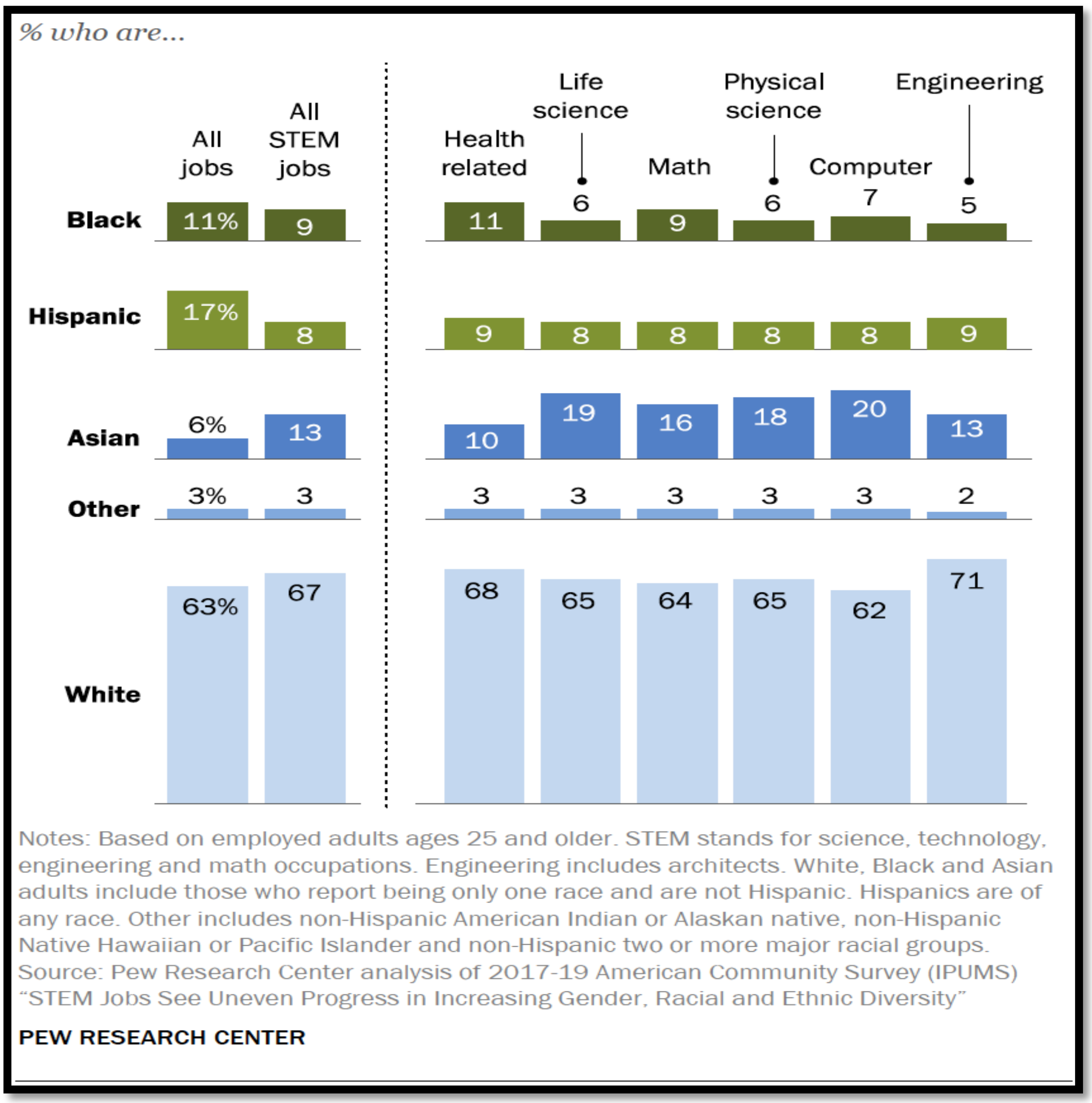
**The Wage Gap and Workforce**

While the labor force primarily consists of women in the US, they are underrepresented in computer science careers compared to men (Pew Research Center, 2021c). The same goes for the presence of women in STEM careers, and they are still not being evenly represented across STEM branches (NSF, 2017). Combating discrimination in the workplace, including with candidates employers decide to hire, needs to be intentional so that the environment recognizes a shift over time of a changing demographic (Green, 2017). As such, employers must also make a noticeable change in how they promote in order to promote the inclusivity of underrepresented groups (Green, 2017). This is especially true when women have been found to be less likely to be awarded a promotion, even when accounting for comparisons such as education and seniority, deeming men to seem more qualified and progressive in their careers (Blau & Kahn, 2016).

Nationally, while there have been efforts in closing the gender gap through federal statutes as recently as 2009, there has been little movement to close said gap (Kulow, 2013). Furthermore, women are not matching up to men, at times upward of 20%, cents to the dollar of what their male counterparts would earn (Kulow, 2013). The wage gap is even larger when comparing the salaries of women of color to those of White male counterparts (National Women's Law Center, 2018). Therefore, challenges for women to work in computer science and their sense of belonging are further amplified when the earnings are deemed unfair for performing in such an innovative field. See Figure 2 for racial disparities in STEM jobs, including those related to computer science, from the Pew Research Center.

**Figure 2**

*Black and Hispanic Workers in the STEM Workforce*




*Note*. Pew Research Center. (2021a, March 30). *Black and Hispanic workers remain underrepresented in the STEM workforce*. Pew Research Center Science & Society. (https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/ps_2021-04-01_diversity-in-stem_00-01/). Reprinted with permission.

As stated by Kulow (2013), while the Equal Pay Act, which included prohibiting discrimination of sex with a standard minimum wage, did aid in increasing the number of women in the workforce, it did little to really ensure actual equal pay even after its implementation 60 years ago. Stanberry and Aven (2013) find that there needs to be a modern legislative approach that intentionally addresses workforce gender discrimination in order to affect present gaps. Proposals like the Paycheck Fairness Act directly addressed the pay gap; however, it did not pass, with individual states taking their own actions to address the pay issue (Stanberry & Aven, 2013).

It has additionally been found that women earn 82 cents per dollar than men earn as first-year college graduates (Corbett & Hill, 2012). Not only is that a financial disadvantage of money going in, but women also pay more towards student loans so they are under a fiscal limitation up until they retire (Corbett & Hill, 2012). Pay gaps like these have further significance if they are not directly addressed and they will cause future pitfalls for women entering the workforce (Powell & Graves, 2003).

The lack of successful actions to pass legislation could have negative consequences for the US economy (Dennehy & Dasgupta, 2017). Without being able to tap into the talents of the female workforce, which includes those in the field of computer science, they themselves cannot develop their own career growth, and this results in hindrances in economic innovation (Houston, 2019). It is predicted that the pay inequalities that are present for women could cost the US trillions of dollars (Dennehy & Dasgupta, 2017). Additionally, pay inequalities could lead to more products produced for women not being made by women (Dennehy & Dasgupta, 2017).

Directly related to legislation comes the inferences that derive from such noticeable actions. For example, it is deemed that once women begin to increase their presence in a field, gender bias presents itself in that the job may not require as sophisticated of a skillset or training as it once did (Borghans et al., 2014). Therefore, a connection can be made that the lack of women in fields like computer science could be rooted in the fact that women have a higher presence in other fields that may deemed as more suitable or a better fit (Blau & Kahn, 2007). This further emphasizes the perception that women do not have a place in technology.

In the work environment, women in computer science face biases based on stereotypes, including implicit bias (Forte et al., 2018). Such biases affect women's advancement through fewer promotions, which further damages the potential their female colleagues could envision for themselves within an organization (Forte et al., 2018). The stereotypes also communicate the idea that computer scientists have lower emotional intelligence, focus only on technology, and are academic geniuses (Silva et al., 2022). Such stereotypes are emphasized because women in computer science lack mentors and role models that allow them to model their own breaking of those stereotypes for their environments, and furthermore hinders the organization itself from improving its workplace culture, which further solidifies the associated stereotypes (National Center for Information Technology, 2016). Forte et al. (2018) support that this issue is long-standing and cannot progress unless the support of other female computer scientists is evident.

Regarding biases, it is a company's responsibility to establish and promote these programs for mentorship in order to positively impact their workplace culture (Hernandez et al., 2023). However, such mentorships will mostly prove effective when companies themselves also take larger initiatives into their environments by providing training in diversity, equity, and inclusion in their practices and instituting policies that directly address these biases in a way that it is evident to its employees (O'Brien et al., 2015). It has also been noted that it is not uncommon for women in computer science-related workplaces, such as information technology companies, to be exposed to sexual assault and harassment within that workplace (Silva et al., 2022). Additionally, Milkman et al. (2015) state that gender-neutral policies must be made evident by companies to inform employees but also to act upon closing the gap.

O'Brien et al. (2015) also state that through these practices, companies benefit as strengthening diversity has been shown to bolster creativity and innovation simultaneously. While it takes monetary investment for companies to integrate diversity and inclusion initiatives into their environments, it provides equity for all (Dobbin & Kalev, 2016). Such investments result in employees recognizing that the organization has clear diversity goals for diversity and that leadership is holding itself accountable for its inclusion practices, which could affect the unconscious biases present in the industry (Dobbin & Kalev, 2016).

While the gap is wide in earnings between men and women, gender discrimination is not seen as a factor, with a noted significant decrease in the 2000s onward (Grossman et al., 2019) Women are thought to be highly underrepresented in CEO positions at top companies, and the gap is even more alarming for women of color (Grossman et al., 2019). Therefore, it is not women in the workforce that is a hindrance to the gender gap in fields like computer science, but rather the advancement of women to top positions is a larger issue contributing to this disparity (Elmuti et al., 2009).

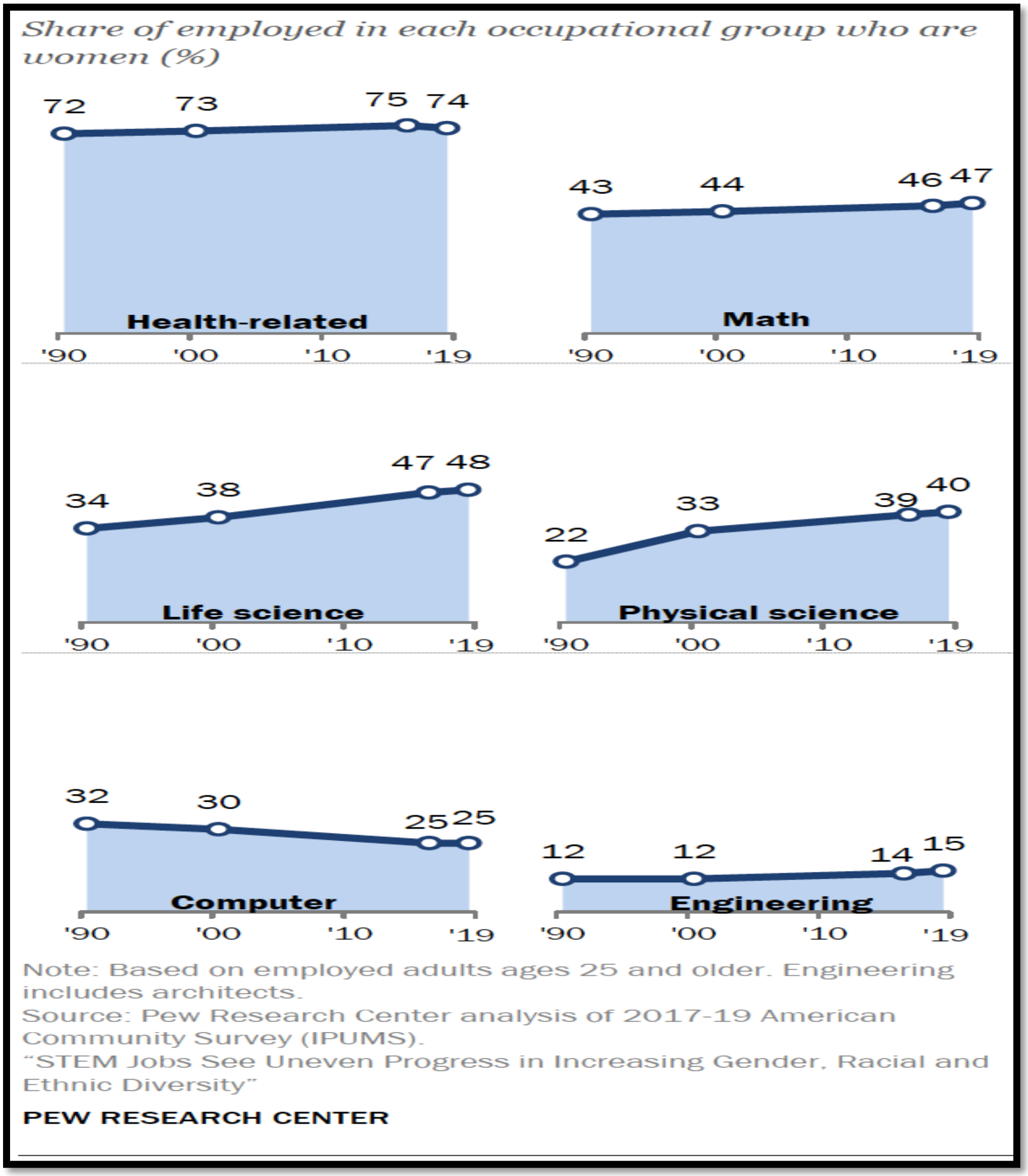
In time, there will be changes to the workforce as not only gender but ethnic, racial, and age diversity will grow alongside a widened skillset (Bureau of Labor Statistics, 2017). Human resource departments will need to act accordingly with these changes, by ensuring that underrepresented individuals have clear ways to progress in their career paths and ensure that they are being treated fairly and with dignity in their environments (Grissom, 2018). To remain competitive in the global market, workplaces, both in the US and internationally, must now make concerted efforts to address diversity and inclusion, including those in the hiring process, retention, customer service, and interactions with outside stakeholders (Blake-Beard et al., 2021).

And while these diversity initiatives grow, it is still unclear as to how corporate leaders should go about specifically addressing the gender gap in a form that is appropriate and inclusive while implementing ways for women to move forward through advancement (Farndale et al., 2015). This further drives a sense of urgency as federal actions, like the American COMPETES Act, which added supports for research in STEM companies, attempt to address such concerns that the US remains competitive globally when it comes to fields like technology (NSF, 2017). See Figure 3 for the percentage of women in STEM jobs, with computer science coming in low only next to engineering, from the Pew Research Center.

An additional challenge for women in computer science is that they are part of what Campa and Harrington (2018) have identified as occupational segregation. This is described as companies allowing women to accept lower-paying positions, such as supporting roles, rather than higher-paying positions, which in computer science could be those positions that include software engineering and engineering (Campa & Harrington, 2018). Furthermore, these wage gaps that are made evident by occupational segregation highlight women's low self-efficacy in such fields, which hinders their advocacy for wage negotiations (Gino et al., 2015). Overall, and in a clear consensus, Silva et al. (2022) express through literature search findings that the challenges women face in computer science are placed into the categories of underrepresentation, stereotypes, self-efficacy, underappreciation, and related injustices, indifference, and a lack of sense of belonging.

**Figure 3**

*Women in Physical Sciences, Computing and Engineering Jobs*




*Note*. Pew Research Center. (2021c, March 30). *Women remain underrepresented in Physical Sciences, computing and engineering jobs*. Pew Research Center Science & Society. https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/ps_2021-04-01_diversity-in-stem_00-03/. Reprinted with permission.

## Measures of Success

### *Technology Initiatives Made by Women*

Criado-Perez (2020) states that one of the challenges that has kept women away from data-driven decisions is the fact that they themselves are not taken into account, so neither are their experiences. Therefore, changes to environments such as K-12 classrooms and adding what Lee (2020) has found ideal like collaborative and project-based learning for girls cannot be achieved if they are not informed by women in computer science who have lived experiences that could greatly inform the education system. The same can be said for corporate environments, and with low numbers of women in leadership positions, best practices that promote women's inclusivity cannot be promoted at the workplace unless there is a pathway to promote more women into those positions (Criado-Perez, 2020).

### *Computer Science Enrollment*

In high schools, where AP computer science courses can now take the place of third-year science requirements for college applications, there is still a need to fill the gap of how many female students are enrolling in such classes (College Board, 2022). Therefore, the College Board founded the Female Diversity Award in the hope of addressing the fact that only one-third of students who take AP computer science exams are female (Lee, 2020). As such, an indicator that best practices are effective is if long-term initiatives like the Female Diversity Award are no longer needed in schools for the promotion and recruitment of girls in those courses. Additionally, memorandums like The White House's Computer Science for All would not be deemed needed, especially with such fiscal commitments required for it (The White House, 2017). With such from the College Board and the US government being deemed with their importance, a measure for success would be the time when education will no longer need these as it would cease to be an issue that needs to be addressed, guiding a shift of focusing on other educational disparities.

### *Female Technology Leaders*

In 2022, it was reported that a fluctuation of women first gaining more presence in technology leadership positions, such as CEOs, but now recent shifts have seen a steady decline of women leaders leave those coveted positions (Hausmann et al., 2022). Criado-Perez (2020) adds that the practices in these top technology companies, like Intel and Google, affect other aspects for females, which could have implications from human resource departments to early education practices. Top female technology leaders, like Melinda Gates, have advocated for a higher female presence in technology as decisions in technology, particularly as those in artificial intelligence, will be made for women and not by women (Hausmann et al., 2022). As such, it will take a higher presence of female executives for these issues to cease being of concern, with a measure of success being their increased presence in large technology companies.

## Existing Literature Around Recommendations

### *Addressing the Issue*

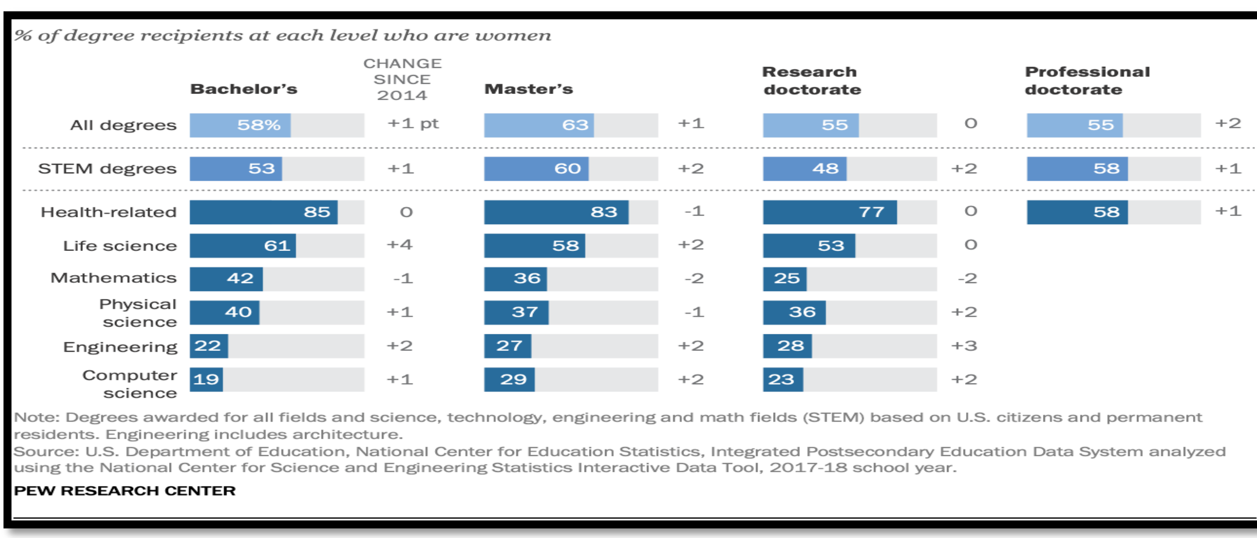
Because innovation coupled with the content knowledge and skillsets that derive from those learned in STEM subjects, having professionals in STEM is crucial for the US to remain competitive in the global economy (Tulsi, 2016). Through the intentional addressing of women in the workplace, this would have a corresponding impact on increasing numbers of women in STEM (Tulsi, 2016). However, addressing the gender gap is not seen as a less challenging feat by any means, as it will take national efforts to make strides in closing the gap (Gould, 2015).

As such, Seepersad (2016) agrees that the best way to do this is through early exposure to STEM by creating environments for primary students that both provide a gender-neutral environment and that such environments have purposeful project-based learning tasks for students (Williams & Casey, 2014). An intentional practice could also include tasks in which women are portrayed in computer science-related roles so that not only girls could see themselves reflected in those figures but also so that boys may envision female students as having a place in those environments (Seepersad, 2016).

This may be especially important when it is more common to see women in STEM roles that involve the physical sciences as opposed to computer science (Fountain, 2000). See Figure 4 for women's underrepresentation in various sciences, including the lowest numbers being in computer science, during their educational journeys from the Pew Research Center. Moreover, practices like these would be beneficial as it has been proven that girls learning the content is not really the issue.

**Figure 4**

*Women Underrepresented Among Graduates in Math, Physical Science, Engineering and Computer Science*




*Note*. Pew Research Center. (2021, April 14). *Women are underrepresented among graduates in math, Physical Science, Engineering and computer science*. Pew Research Center. (https://www.pewresearch.org/short-reads/2021/04/14/6-facts-about-americas-stem-workforce-and-those-training-for-it/ft_2021-04-14_stemjobs_04/). Reprinted with Permission.

Not just nationwide but internationally, McNally (2020) found that girls outperformed or were equal to boys when it came to test scores applicable to computer science skills like math and science assessments. Therefore, aptitude is not the issue, and the issue is encouraging girls to pursue STEM and computer science (Larson, 2021). Larson (2021) states that early exposure will be a large contributor to closing the gender gap in all STEM fields.

Building on these environmental findings, Koca (2016) states that classrooms should also be a setting in which boys and girls can see one another's strengths as they can grow to appreciate the diversity needed in subjects like computer science. This can also be done outside of the classrooms, with parents being the primary educators and being attuned to the influential role models they place for their children at a young age (Koca, 2016). Socially-based interactions and community-style activities inform children greatly in their perceptions of concepts, such as girls belonging in STEM and computer science settings (Yates & Plagnol, 2021). While female-to-female mentoring has been found effective, girls also feel more confident in their computer science schools when they are mentored by male family members, such as older brothers, as it feels more organic and empowering (Yates & Plagnol, 2021).

To support an already existing interest in the physical sciences over a technical one like computer science, there are strategies that can be implemented in the classroom to widen the interest. For example, Lin and Chan (2018) found that more laboratory-based practices, such as the scientific method, which incorporates elements like a hypothesis, could use that same foundation to build a collaborative theory-building practice as it relates to computer science. Also, best practices in project-based learning can be implemented in computer science courses, such as student autonomy connected to design thinking and the process of iterative processes

(Ozturk et al., 2018). Therefore, by having these bridges that build on a student's interests, a shift could happen in their learning to make computer science more appealing to them.

### *Educational Recommendations*

As with best practices for academic institutions, a leading education-based recommendation is that of early exposure to younger primary students in STEM and computer science-related curricula (Stewart-Williams & Halsey, 2021). As Parette et al. (2013) state, this could also include problem-solving through playing as early as early elementary education. It is by playing that young children can envision themselves in roles like technologists, especially when in such grades, it is a challenge to have computer science-related coursework (Stewart-Williams & Halsey, 2021).

Parette et al. (2013) state that it is never too early to get children to start thinking about subjects related to STEM, like computer science, as their conceptual understanding has been shown to manifest itself in later grades. With play being the main actor for these young children, it allows them to have the propensity to significantly impact their development in subjects like computer science (Stewart-Williams & Halsey, 2021). Therefore, earlier exposure to skillsets needed in computer science through age-appropriate exploration could provoke interest and prowess in the field (Froschl & Sprung, 2014).

In the classroom, materials must be intentionally inclusive for girls, and projects must be able to provide connections for diverse students (Margolis et al., 2019). Master et al. (2021) state that girls studying computer science need to have role models in the field that they can relate to, which is where one could make the connection to stories like that of Katherine Johnson, as presented by Shetterly (2016) could have an impact for those students. It is through students envisioning themselves that could provide the strongest connection to computer science, and it could be further supplemented by aforementioned mentorship and classroom visits from women in the industry (Master et al., 2021).

When it comes to education from an entire K-12 perspective, one must look to initiatives that aim to first bring subjects like computer science into classrooms, as that will be needed before addressing the issue of the gender gap (Borko, 2004). The first step will be to provide teachers with professional development that aims to include STEM-based subjects, like computer science, into their curriculum (Estapa & Tank, 2017). In order to achieve this, there needs to be a continued effort to advocate for computer science in the classroom in order to affect K-12 classrooms with initiatives stemming from the United States Department of Education (2015) in continuing its efforts to empower school leaders, such as superintendents, to address both the need for more STEM availability and to push the initiative to be inclusive of girls in STEM-based environments. In 2017, the White House moved forward with a memorandum to increase funding for computer science education under the umbrella of improving STEM education in K-12 schools (The White House, 2017). This memorandum addresses the viability of the US as a competitor in technology as it states a goal of $200 million dollars per year to improve accessibility to such courses (The White House, 2017). While such a measure has increased in US states incorporating computer science as a qualifier for some high school diploma requirements, this measure has only occurred in 33 states, with one-third of the states to go (Lee, 2020). Additionally, with STEM including mathematics, data has shown that high ACT math scores have shown a negative relation to students pursuing STEM majors, in fact, they are more likely to select liberal arts-based university programs (Lee, 2020).

Professional development needs not just to address the content of STEM subjects and computer science courses. Still, it must address the environmental biases and stereotypes teachers could bring into those classrooms (Sap et al., 2016). Girls need to feel that computer science is a field they belong to and have a place in. Therefore, inclusivity efforts must be placed to combat the stereotypes of what someone in the field looks like, mainly a White male (Sap et al. 2016). Similarly, another proposed implementation schools can partake in is that of creating community connections with local universities and businesses that allow students to collaborate in a hands-on fashion but allow students to envision themselves in a computer science pathway (Dede, 2015).

Additionally, to address the gaps presented earlier in computer science courses, like those the AP program offers, Bibeau (2014) states that educators could directly benefit from professional development aimed at strategies for recruiting female students for such courses. Karlin (2019) provides helpful information indicating that in order to recruit more female students to close this subject-based gender gap, schools must enlist counselors in the recruitment process. In Yates and Plagnol's (2021) study, counselor interactions were deemed as very informative when it comes to students' attitudes as one participant stated that she did not receive much support in her college application process because educators seemed to express to her that she wasn't going to get in or be successful in computer science anyway. Additionally, this process should include that a computer scientist does not fit one mold or one stereotype and that all students fit the description to contribute to the field, which breaks down the stereotypes normally associated with the subject (Karlin, 2019).

With this in mind, some female scientists credit their interests in science to their early exposure to hands-on experiential learning opportunities like competitions (Maltese & Tai, 2011). Having a variety of these types of experiences also allows girls to build their inquiry into other STEM opportunities (Maltese & Tai, 2011). Honing in on their skills at such an early age ensures students will transfer these valuable skills into their future college and career stages (Subotnik et al., 2011).

Once a school has adopted computer science-related courses, mainly in STEM subjects, students who take the rigorous levels of these courses, like those offered by AP programs, have been shown to increase students' interest in professions like computer science (Schneider et al., 2013). Additionally, a clear correlation between students' interest in STEM subjects and pursuing a parallel college pathway is present, which increases the optimism in addressing the gaps in STEM for the future (Schneider et al., 2013). To supplement this interest, extracurricular opportunities, like afterschool programs that engage students in STEM subjects like computer science, have also demonstrated an increase in students having better attitudes towards STEM subjects and careers (Howard-Brown & Martinez, 2013).

Furthermore, Howard-Brown and Martinez (2013) state that afterschool initiatives have demonstrated an increased chance of students moving into college to graduate with a STEM-related major, such as computer science. Along with those benefits, Mosatche et al. (2013) state that afterschool and summer programs also have the benefits of giving students those best practices in hands-on activities and collaborative learning, all the while also being spaces for focused academic and career guidance. These types of programs can be implemented at schools by leveraging faculty who already work at the site and incentivizing teachers, which can in turn increase teachers' academic goals for their students (Sahin et al., 2014).

Moreover, supplemental extracurricular activities like these could be targeted for girls to be able to work in collaboration with boys, allowing the added benefit of removing gender-driven stereotypes (Sahin et al., 2014). Sahin et al. (2014) also add that programs like this circle back to high-quality professional development for educators so that the programs' norms and culture around gender bias are addressed, including the personal biases of the educators themselves. When women see that there have been systemic changes that specifically address gender biases, they are, as a result, more likely to invest in their careers (Young et al., 2013). There is the added benefit that if female professionals reach out to girls for guidance into these career paths, it will have a greater impact based on their experiences from these focused mentorships (Mosatche et al., 2013).

When it comes to the transition between high school and university experiences for girls, there is an added benefit for programs called bridge as they focus on preparing students with STEM-based experiences (New York University, 2018). New York University (2018) has defined such programs as encouraging students to have computer science experiences, like cybersecurity, and also to show the demand there is for those careers. With this in mind, bridge programs allow students to be better prepared post-college for skills their industries will require of them (President's Council of Advisors on Science and Technology, 2012).

Once students decide to major in a subject that is STEM-based, they tend to excel with high-level grade point averages and with a high level of self-efficacy as they also tend to be prepared at a higher level for college than their peers who do not yet have a course of study (Eagan et al., 2014). Eagan et al. (2014) also state that students who have already decided to major in STEM-based subjects tend to have taken college-preoccupied courses, like AP offerings, at the high school level, further engaging them in subjects that prepare them for computer science. Therefore, the problem therein lies not in interest or being able to achieve academically in the subject but rather in having an interest in the subject in the first place, which is why mentorships, collaborative environments, and role models need to be included in the professional development Estapa and Tank (2017) recommend schools hosts. Computer science classrooms are not designed to engage collaborative and communal learners, which has been shown to engage more female students, and therefore addressing the issue needs to include a reform of the culture within those classrooms (Yates & Plagnol, 2021).

Furthermore, Killpack and Melón (2016) have found that universities lack training where inclusivity of gender, race, and economic status is lacking among faculty members. This could have negative implications for retention, as compared to students of color, the levels for White students to stay in a science-based major are significantly smaller for first-year college students (National Science Board, 2016). To emphasize this lack of retention through a sense of belonging, a recommendation made by Killpack and Melón (2016) is that college professors could have explicit training inclusivity practices articulated in their syllabi, which can have a positive impact on the attitudes a female student may feel towards a subject like computer science, further adding to that sense of belonging.

On a positive note, diversity has increased in university leadership across the US, and those administrators have the potential to be key in diversity and inclusion efforts for female students in computer science (Ortiz & Santos, 2010). Ortiz and Santos (2010) encourage university leadership members to engage and encourage students in such initiatives. However, it cannot just be a feat of the leadership as they must encourage all faculty members to collaborate in such efforts (International Society for Technology in Education, 2012).

A large contributor to supplement such initiatives is the addition of genuine faculty-to-student experiences where, if a strong and approachable rapport is developed, that adds positivity to the academic experience (Komarraju & Nadler, 2013). In contrast, data has shown that when students associate faculty members with distance, that has contributed to a lower self-efficacy alongside a general disinterest in school (Litzler et al., 2014). Therefore, something like teacher relations that could affect any university student's attitude toward school has the implication for a grave effect on already underrepresented groups like females in computer science (Litzler et al., 2014).

However, initiatives to improve the gender gap present in computer science in universities need to not just come from administrators, faculty members, or students but should be a combination of all these stakeholders to be effective in resonating with a diverse audience (Savaria & Monteiro, 2017). For example, university programs could encourage their female students to attend presentations both on and off campus that are centered around STEM subjects (Savaria & Monteiro, 2017). Additionally, having women be involved in STEM-centric societies and organizations, as there are some that have an added cultural connection, has demonstrated a larger sense of belonging (M. T. Wang & Degol, 2017). Currently, several initiatives to improve female engagement with computer science have been local to the university and temporary. Therefore, a recommendation is made to create more initiatives nationwide to increase undergraduate course participation in the field (Silva et al., 2022).

***Professional Recommendations***

While the challenges Kulow (2013) presented regarding the Equal Pay Act and the fact that it did not really help close the wage gap between genders, recommendations have been made for companies to be the ones that make the changes needed to close that gap. One solution Smith (2012) present is that companies should have routing audits that allow them to reflect and act upon any gender inequities taking place. This, in turn, will address the gender biases within the field of computer science and could lead to more women in leadership roles (Smith, 2012).

Building on the wage gap, a recommendation by Peeters et al. (2020) is that companies be transparent about their salaries. Implementing this practice explicitly assists in both reducing disparities in wages and empowering women to advocate for themselves in salary negotiations, which could result in pay equity (Peeters et al., 2020). Additionally, companies also have a role in creating avenues to retain female employees in STEM-related fields (Buse et al., 2013).

As defined in educational recommendations, corporate-based bridge programs can also benefit professional settings as they inform recent graduates of the skills they will need to build to be successful in industries like technology, such as creativity and innovation (Gerhart & Carpenter, 2014). Corporations have benefited from this, as they see innovation as a skill that should be emphasized during university experiences (Runco & Jaeger, 2012). Additionally, this would assist in dispelling the stereotypes that men are more innovative and creative than women, and if women are targeted in such bridge programs, they can stop being overlooked for career opportunities related to STEM (Hathaway & Kallerman, 2012).

In addition to bridge programs, internships are another way to prepare young workforce-bound college upper-class students and recent graduates, especially if such an opportunity is offered to females, including those of color, so that they can acquire the scientific skills, like those necessary for computer science success (National Academies Press, 2012). This offering needs to be made available from companies in an evident way to show that they are indeed being proactive about equity in STEM (Tan et al., 2013). Likewise, the same can be said for early exposure to education from companies if they indeed want to act upon closing the gender gap (Tan et al., 2013).

A recommendation from Buse et al. (2013) would be that once women are in the field, there be clear pathways toward advancement within organizations. This is further supplemented with an evident form of mentorship or sponsorship (Hewlett, 2014). Sponsors can leverage their expertise by providing mentorship with a combined way for women to be able to advance in the workplace while removing stereotypes of females in STEM through this type of partnership coming from the senior level (Hewlett, 2014).

One area that could be leveraged for recommendations is the women who are themselves working STEM-related jobs, like computer science. According to Vilorio (2014), many professionals who work in the STEM field enjoy the work as it speaks to their intellectual talents. A large motivator for women in the field is their knowing that they are, in fact, building a career in an industry that needs them (Vilorio, 2014). In support of these companies, funding of computer science shows promise as these organizations have move begun their work in impacting the gender gap with planned gifts in the tens of millions to hundreds of millions coming from Intel, Apple, and Google to directly address issues in the field for women and for improving diversity efforts (Heilman & Caleo, 2018). Therefore emphasizing, as research has indicated, gender diversity, especially in leadership, contributes greatly to the value of an organization by being able to leverage talents that otherwise would go untapped (D. Kim & Starks, 2016).

When companies make notable contributions that could greatly take part in closing the gender gap in computer science, it is important that it comes from the leadership, as they are seen as the biggest promoters of such diversity and inclusive initiatives, especially for technology companies (Davis, 2009). It wasn't until the current Meta Chief Operating Officer, who at the time was the COO of Google, Sheryl Sanberg, became pregnant while working for Google that the company looked at its treatment of women during family leave as most of their data were informed by their male employees and their experiences in the workplace (Criado-Perez, 2020). It was not until a woman was at the senior level that the environment, both physically and in culture, changed to create more optimal conditions for more of its employees (Criado-Perez, 2020). This supports the adage that women should make decisions in technology for women. It is these leaders who exhibit inclusivity who tend to do the most with human capital built with diversity and also tend to increase profitability for their organizations (Nishii & Mayer, 2009). An inclusive initiative could additionally promote higher morale, job satisfaction, and productivity for all employees (Avery et al., 2007).

Initiatives like these that companies are looking to make allow for widening access to more prestigious positions for women, which not only adds to the organization's diversity but also increases the chances of onboarding employees with innovative talents and skills (Forsyth, 2010). It has been shown that by increasing gender diversity, there is a strong correlation to increasing profitability when women are promoted to leadership positions (Diehl et al., 2020). However, Warner (2014) states the level at which women have achieved organizational growth has been stagnant, so funding proposed by these companies could affect future numbers for the betterment of closing the gap.

## Critiques of Topic

### *Gender Differences in Education*

While research, like that which has informed best practices of female students working better in collaborative environments from Simon et al. (2018), can impact the field of computer science, arguments have been made that changes should be made not to cater to one type of audience as that could isolate another group from pursuing the field. For example, Simon et al. (2018) explain that recent research gives the impression that there is much overlap between how male and female students learn in school. Therefore, if attention is brought only to improving the educational experience of female students, the question stands if it is contributing to schools further failing male students. This can have further implications as the research has demonstrated that computer science is a topic boys are inherently interested in, and by reforming its structures with recommendations, they could feel excluded from a subject in which they have historically been successful.

The Gurian Institute, founded by Michael Gurian, has based its practices on the foundation that girls and boys learn differently and supports the call to single-sex schools and classrooms based on their own psychology and neuroscience research (Gurian et al., 2009). Gurian is further supported by Yates and Plagnol's (2021) research as to when feminist principles are infused into pedagogical practices that are founded more on intention rather than authoritative, often deemed patriarchal, practices. While his work supports the environments promoted by best practices for each gender, when it comes specifically to computer science, Lee (2020) recommends that all students should be engaged in and exposed to a computer science curriculum, regardless of gender. However, while attempts to make everyone engaged regardless of gender so that everyone in technology is treated in an equitable fashion, the reality is that those attempts often favor males (Yates & Plagnol, 2021). Yates and Plagnol (2021) further support their stance as they note that males are mostly driven by agency while females are motivated by their community and, therefore, gender-neutral settings are ineffective in creating environments in which these goals are reached and actually not neutral.

### *The Need for More Data*

L. L. Wang et al. (2021) state that current trends indicate that the computer science gender gap may not close for another 100 years. However, with the gender gap being a recently addressed issue, and one that will take several stakeholders at the education and professional levels to effect, there is the critique that more data is needed to see what indeed will impact the closing of the gender gap the most. While Silva et al. (2022) state that recent measures to close the gender gap have been local and temporary, this is an issue that has only been brought to light in the last few years and is being proactively addressed. Lee's (2020) and Silva et al.'s (2022) research further demonstrate the lack of research on the topic by indicating that any literature and studies that would be currently applicable in informing practices will have to be from 2009 onward. Therefore, while it may take more of these currently defined temporary initiatives to get to a more permanent one, more data must be collected in real-time as initiatives are being implemented in order to really have a better understanding of when the gender gap in computer science will predictably close.

### ***Responsibility for Minimizing the Gender Gap***

One aspect researchers cannot seem to agree on is what the root cause is that is affecting the gender gap in computer science (Silva et al., 2022). Data reviewed has found causation in already established societal systems throughout history to how large companies like Google have historically operated (Criado-Perez, 2020; Powell & Graves, 2003). With such a wide range of eras and stakeholders like educators, K-12 schools, universities, companies, role models, and structures, it is a challenge to pinpoint what the cause will be, therefore making the solutions more challenging to obtain and hence why they tend to be more temporary (Silva et al., 2022).

## **Conclusion**

The cause of what can close the gender gap in computer science is difficult to determine of where the change needs to take place (Silva et al., 2022). Research and literature reviews on the subject explore several solutions associated with problems that start in early childhood and continue on to retirement (Silva et al., 2022). With causes being addressed across such a variety of life stages, it is difficult to precisely define the causes that must be solved to increase the number of female students who are pursuing computer science (Stewart-Williams & Halsey, 2021; Tan et al., 2013).

While the literature presents several challenges facing female students as professional women, there is a gap in what measures of success look like in addressing those challenges (Hausmann et al., 2022). For example, there is a gap in knowing what first and second-year students experience, which can be very informative to the field. First and second-year female computer science students have selected a major, however, they are not at a point where they have completed so much upper-class coursework that it seems like they have committed. Therefore, this is a pivotal time for these students as they can decide to no longer pursue computer science, which has very serious implications for their major, their university, and the overall field (Fitzsimmons, 2021).

Lee (2020) states there is a gap in the literature in looking at computer science at the secondary level. This is especially true when it comes to allocating equipment and resources. Lee (2020) also notes there is not enough research that focuses on why a specific gender decides on a STEM-based major in their journey from high school to college.

Yates and Plagnol (2021) address that while there are noted best practices at the university level, like peer programming because it is collaborative and speaks to female students, there is still a need to address the root reasons that cause the barriers for females to not be underrepresented in computer science. Lee's (2020) work supports this by stating that there are additional gaps in K-12 education as well, especially at the secondary level. With that, there is an opportunity to bridge both these areas of research.

With these works in mind, it justifies the value of looking at this study's participants as they are first and second-year female computer science students. This level can serve as a middle ground to feed into the work needed to fill the gap on the subject. These students are not that far removed from their secondary school experiences that they can still speak to them, but are still participating in full college experience in their currently declared majors, and with already present research in mind, and may possess possible indicators and predictors for their retention in this course of study.

In comparison to other STEM subjects, there is relatively little research when it comes to computer science at the secondary level (Lee, 2020). As such, as females decide to continue their computer science studies after high school, the study's participants can inform what their motivators are for remaining in the field that doesn't have much research connected to it. With challenges also being asked via the research questions, there are not just implications for computer science, but there is the potential that, in turn, there may be implications for all STEM subjects.

Even recent studies on females in computer science, like that of Silva et al. (2022), note that there are still wide gaps present in addressing the gender gap from all perspectives. With the decline of women leaving computer science studies and careers, it adds more urgency to this type of study. Hence, the research questions also address what the subjects define as success in the field. With the open-ended qualitative nature of the questions, responses could look at several ways to address the gap such as academic and professional measures for success.

The literature has takeaways on computer science ecosystems for females that are heavy in the classroom setting. The needs of women in educational environments are the ones not usually being met in the classroom and in the field and most motivators for men have been used to build those ecosystems, such as being driven by agency and not by the community (Yates & Plagnol, 2021). Therefore, creating such classrooms in which girls can thrive in will be important, but it is argued that it cannot isolate male learners as all students should have access to computer science education.

Best practices in those classrooms build on that sense of being driven with the purpose of community by being classrooms that engage girls through collaboration and project-based learning. To do so, would take teacher training, and when surveyed educators at all K-12 grade levels were open and interested in incorporating computer science skills into their curriculum. Classroom engagement can be further enriched with the use of tangible resources such as games and robots. Therefore, resources must also be allocated to fund both materials and professional development so that computer science education is implemented correctly.

To address this, there have been initiatives from the US government to fund such access to education (The White House, 2017). While a formal law or act has not been passed, these have been recorded via a White House memorandum and have seen success in funding more computer science courses across more states since its publication (The White House, 2017). While such measures do address more computer science access they do not address the gender gap.

In the workforce, there are several obstacles present which can be internal within female employees and could be systemic through the operations of companies. Stereotypes of what makes a computer scientist, which is mostly made up of male characteristics, feed into a lower self-efficacy and low confidence for women and take away from their sense of belonging in the field (Hewlett, 2014). Additionally, because of the low number of female executives at top technology companies, the practices to promote women into leadership positions give the company the presence that they are not proactively being inclusive of women.

An additional workplace obstacle is that of practices not being made with women in mind, though on the surface may be promoted as such (Hernandez et al., 2023). This includes initiatives that are intended to fill the necessities of maternity leave, but such policies were informed by data gathered from men. And with the already saturated presence of men in technology companies, data has shown that women have been privy to sexual harassment in these environments.

As such, this study looks to fill the gaps in the literature that exist in educational environments, especially when it comes to older secondary school grades and younger college levels. Moreover, with the study participants potentially looking to work in computer science-related industries, they could also inform best practices for their future work environments. Their information could potentially provide concrete insights and recommendations on how to address the challenges, ignite motivation, and measure the success of future female computer scientists.

## Chapter 3: Research Design and Methodology

### Introduction

This qualitative research study has the desired outcome to determine the best practices and strategies utilized by female computer science students who are partaking in a male-dominated field. This study delved into the lived experiences and perspectives held by first and second-year female university students focusing on a computer science-related major and therefore using a qualitative research methodology was suitable as it captured the phenomenon and its realities.

This chapter discusses the process of participant selection by defining the unit of analysis and the population, the sample and sample size, the strategy of purposive sampling, criteria for inclusion and exclusion and maximum variations, the sampling frame, and the process for having a final list of participants. The chapter then goes on to discuss the protection of human subjects and the process of obtaining Pepperdine University's IRB approval. Additionally, this chapter describes the process of data collection, interview techniques and protocols, the author's statement of personal bias, bracketing, and epoché. To conclude, the chapter discusses the analysis of the data, unstructured coding, the coding process, external validity, and the process of obtaining inter-rate reliability and coding results.

### Re-Statement of the Research Questions

The purpose of research questions adds both structure and boundaries to a study (Gray, 2018). This study aims to answer the following research questions:

- RQ1. What challenges do female first and second-year college students face in pursuing computer science-related majors?

- RQ2. What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges?
- RQ3. How do first and second-year female college students measure success in pursuing computer science-related majors?
- RQ4. What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science?

## Nature of the Study

### *Assumptions*

For this qualitative study, the criteria chosen for its research design are based on the research problem based on the phenomenon, the audience for whom it was written, and the researcher's own familiarity with the field of computer science and working with the study's population (Creswell & Creswell, 2021). Because the phenomenon needs to be analyzed and understood, a qualitative approach was used for it (Creswell & Creswell, 2021). Additionally, a qualitative approach to the study allows for an analysis of the details from the researcher's assessment of the participants' lived experiences through both understanding and creating meaning from those experiences (Sutton & Austin, 2015). However, qualitative research could require that elements of the study, such as research questions and their corresponding interview questions, be adjusted as it looks into the natural context and functioning of these elements and their subjects (Sutton & Austin, 2015). Therefore, questions are phrased in such a way that they are broad, and they may uncover unexpected results (Korstjens & Moser, 2017).

The main elements that make up a qualitative research study include observations, questions, interviews, and analysis of responses (Gray, 2018). For an effective qualitative study, one must have research that includes emerging methods, interview data from open-ended questions, patterns, themes, and information interpreted from the data (Creswell & Creswell, 2021). Because of its interpretive nature, qualitative research can be viewed as less accurate or reliable when compared to quantitative research methods, however, qualitative research has a lot of value given its real-life context as it gives insight into the phenomenon (Gray, 2018). As such, this research study utilizes qualitative methods to address and provide insight into the research questions based on responses from participants given their perspectives, experiences, feelings, insights, knowledge, opinions, and additional information provided. It is through understanding these aspects that allow the researcher to achieve the objective of a qualitative study (Creswell & Creswell, 2021).

Given that the experiences of participants are what drive a qualitative study, it is constructivist in that the researcher is creating meaning from interpretation (Creswell & Creswell, 2021). Furthermore, a constructivist approach allows for there to be a variety of perspectives and explanations, further constructing patterns that will inform the results of the research questions (Creswell & Creswell, 2021). According to Walker and Shore (2015), social constructivism, founded by Vygotsky and Dewey and built upon the work in constructivism by Piaget, allows learning to take place in the community, and in this case, it is the community in which participants partake, that of being female first and second-year computer science college students (Deulen, 2013). According to social constructivism, the content must meet learners in a place they are comfortable, and by meeting them where they are, it in turn can result in motivation, as this study looks to inform the field of computer science and its education pathway (Bozkurt, 2017). And by applying this learning community with this theory, other computer science students would create their own meaning from the experiences.

### ***Strengths***

Unlike a study that utilizes quantitative methods, a qualitative study's open-ended nature allows for the encouragement of having participants express their own views derived from their experiences, and the results will be used to inform best practices (Creswell & Creswell, 2021). This study will spotlight the opinions of female first and second-year computer science students to address the gender gaps in education and the workforce. The eight interview questions that correspond to the study will be presented to participants using a semi-structured interview protocol that will take place one-on-one online with the researcher and each participant being face-to-face. With this format, it allows the researcher to gauge the best practices based on in-depth responses from participants and their corresponding contextual data (Creswell & Creswell, 2021).

Additionally, a qualitative approach serves the study's purpose best as Creswell & Creswell (2021) noted that topics dealing with marginalization, and in the case of this study, oppression as defined by feminist theory, and solutions for them are better suited to this design (Arinder & Roe, 2020). However, it should be noted that given the open-ended nature of the study, the researcher must be conscientious of research bias, such as differences in backgrounds that could affect the data's interpretations, including but not limited to perspectives of politics, education, and culture (Creswell & Creswell, 2021). A pitfall of this would be if the researcher used personal experiences instead of those provided by the participants to inform best practices and used research into multiple sources to draw conclusions (Maxwell, 2012).

### ***Weaknesses***

Qualitative research does possess several advantages and strengths as Creswell & Creswell (2021) state that it allows gathering information of participants' meanings from their experiences, adds personal perspectives, allows for confirming truth in findings, allows them to partake in future change in their field, and allows for the researcher to collaborate with said participants. However, its open-ended nature can be seen as a disadvantage as the data may be interpreted in several ways, and because it is subjective, the validity and reliability of such studies are questioned (Gray, 2018). Therefore, in comparison, quantitative research can be regarded as more accurate than qualitative in looking at the results of the outcome rather than the process while not having to involve fieldwork or be as descriptive in its processes (Creswell & Creswell, 2021).

**Methodology**

For this study, a phenomenological design was used, with it emphasizing the participants' experiences within the phenomenon (Creswell & Creswell, 2021). This approach was used as it allowed the participants to share their stories and for readers to learn about their experiences and the importance of those stories (Creswell & Creswell, 2021). The study was established using protocols and methods that provide the empirical evidence needed to allow for the study's organization, systems, and research. The procedures built from the protocol and methods include

- Developing a topic and research question based on the researcher's own experience with the topic and its audience;
- Conducting a thorough and comprehensive literature review;
- Creating questions based on the literature review to guide interviews and develop protocols for those interviews;
- Coordinating and conducting digital face-to-face one-on-one interviews with participants; and

- Organizing, coding, and analyzing the data based on participants' responses (Creswell & Creswell, 2021).

As is the case with this qualitative study, and with constructivism being incorporated into how it is conducted, the researcher must understand the importance of what methodology is best to address what the best practices are for first and second-year female computer science college students (Creswell & Creswell, 2021).

### *Structured Process of Phenomenology*

The structure of a qualitative research study that utilizes a phenomenological design is one in which the researcher emphasizes the lived experiences of people and their idea of the world as it relates to the phenomenon (Creswell & Creswell, 2021). Open-ended questions in an interview are a frequent method for obtaining qualitative data, as is identifying themes and patterns based on those responses (Maxwell, 2012). This allows the researcher to use a descriptive approach that incorporates the interview responses with content analysis. Therefore, there are assumptions that participants in phenomenological research must take part in the experiences and events and that there is a uniqueness in their ideas and interpretation of those experiences and events (Creswell & Creswell, 2021).

### *Phenomenological Approach*

According to Maxwell (2012), qualitative research can be suited for a phenomenological design as it conducts research to capture the phenomenon based on their accounts via interviews. Additionally, phenomenological methodology allows for capturing the richness of the experience of first and second-year female computer science college students. Through the participation of the sample size of 15 participants for this research study, details can be captured as they relate to best practices, strategies, measures for success, and challenges using this phenomenological approach.

***Weakness of Phenomenological Approach***

Though this is the best-suited approach for this study, limitations in using this approach can be anticipated. A significant limitation would be the researcher's own biases, although that will be prevented as best as possible. Next, bracketing may compromise how the data is interpreted. However, to address this, the researcher will be cautious of allowing personal experiences to affect perceived bias, including experiences with the sample population so that it does not affect the interpretation of the data. Therefore, through this awareness, it will make certain that the lived experiences of the participants are conveyed as accurately as possible.

**Research Design**

***Participants and Sampling***

**Analysis Unit**. The unit of analysis for this qualitative research study was a female student in a computer science-related major in her first or second year of college. Purposeful selection was used in helping to understand the problem addressed by the research questions and gain an understanding of the population and their characteristics (Creswell & Creswell, 2021). The researched study attempted to identify the best practices for female students studying computer science given present gender gaps. Therefore, to achieve this objective, the unit of analysis consisted of the following components:

1. Enrolled full-time at a community college and/or four-year university; and
2. Were in the first or second year of their collegiate studies as a computer science-related major, based on length of time of enrollment.

### *Population*

For this study, the population and the source of data consisted of female students who are enrolled in colleges with computer science-related majors. The purpose of this study was to calendar interviews with 15 participants who were willing to share their lived experiences as females studying the subject of computer science. Through their experiences, they would also be able to inform best practices for their population based on their experiences in their first or second year of college.

The population for this study included participants from diverse ethnicities, and there were no restrictions placed based on socioeconomic status, family, health, student or professional affiliations, or political affiliations. As such, participants were selected for the study based on their ability to provide an understanding of their knowledge and lived experiences through interviews and offer best practices for female students in computer science-related majors.

### *Sample Size*

The purpose of qualitative research is to select participants who will likely provide a deep level of understanding through their responses (Creswell & Creswell, 2021). With the purpose of the study in mind, the unit of analysis was identified as female first and second-year college students in a computer science-related major. A qualitative approach was used for this study as it defines and looks to a sample as representative of the desired population that is being studied (Creswell & Creswell, 2021).

Therefore, purposeful sampling was applied to identify a sample of 20-25 participants with 15 participants used for this study. In support, Creswell & Creswell (2021) state that in a phenomenological study, a researcher should explore the lived experiences of three to ten participants. With that, Gray (2018) states that sample sizes should include 10 to 20 participants.

Therefore, the researcher found that, in practice, to gain a deep understanding of the participants' descriptions, the sample size would be 15. The 15 participants were reviewed using the selection criteria by the research study's chairperson and the dissertation committee.

***Purposive Sampling***

Purposive sampling, is used to identify participants and communities to best answer a study's research questions, included individuals from various colleges who represented female students studying computer science-related majors, which allowed the researcher to utilize knowledge to identify and select the prospective participants to engage with the study (Gay et al., 2012). As such, purposive sampling's value is that it facilitates the gathering of insights from responses produced by the well-informed sample to problem solve (McMillan & Schumacher, 2014).

**Participant Selection**

When it comes to a qualitative research study, the participants can be selected utilizing a probability or nonprobability style approach. Additionally, the sample size is dependent on the purpose of the inquiry. Moreover, and perhaps most crucially, a phenomenological study has participants' lived experiences and knowledge relative to the phenomenon being studied (Creswell & Creswell, 2021).

***Sampling Frame***

The following measures were executed to reach out to first and second-year female college students majoring in computer science-related major through the list servers and information management systems of High School X:

- High School X, an all-girls high school, allows for a larger selection for the goal of 15 participants for the study, provided site permission to access its list servers and information management systems, which included those of graduates now regarded as alumna (see Appendix A).

- Based on information provided through the servers and systems, that gave insight into the graduates' intended majors and colleges they are attending.
- Information in the server also provided their graduation year, informing the researcher of the alumna being a first or second-year college student.
- A letter about the research study was sent to prospective participants, informing them about the study's purpose and their role in being a participant in the study.
- Data about the participants was reviewed by the researcher to ensure they fit the inclusion criteria, which provided the study's participants.
- After the participants were identified, they were contracted using the IRB approved recruitment script sent via email for the purpose of scheduling their interviews.

**Criteria for Inclusion**. The standards for inclusion for this research study, given the research design, were as follows:

- female who graduated high school and matriculated to a four-year university or community college as a full-time student in the last two years; and
- are pursuing a bachelor's degree in a computer science-related field;

The aforementioned criteria for inclusion permitted verification of the prospective participants in the study based on information received and based on their understanding of the issues in the field of computer science. Furthermore, these individuals offered their academic experiences in computer science, where they are acquiring knowledge in the field.

**Criteria for Exclusion**. Standards for exclusion after the criteria for inclusion were applied were as follows:

- female college students who are not enrolled full-time; and
- female college students who are enrolled full-time but are considered as upper-class students.

**Criteria for Maximum Variation**. Heterogeneity sampling of participants' locations in their studies allowed the researcher to examine a comprehensive and diverse range of insights from participants (Creswell & Creswell, 2021). Additionally, the participants for the study were determined by applying maximum variation to ensure the 15 respondents reflected maximum saturation to provide valuable data as it represents the beliefs and experiences of female students who are pursuing computer science-related majors in college to address the gender gap, which according to Silva et al. (2022) needs to be proactively addressed with data that informs current-day practices (Lee, 2020). Standards for maximum were applied were as follows:

- female students either in a two-year or four-year degree-awarding college or university, regardless of geographic location.

## Protection of Human Subjects

The protection of human subjects is extremely significant to conducting ethical research, which the researcher has agreed to adhere to at the highest standard (Breault, 2006). With the role of the Institutional Review Board (IRB), the nature of this took steps to ensure the protection of subjects that would allow for minimal risks, including economic, legal, or social, for their participation. Approval from the IRB office (see Appendix B) was granted before data collection took place. An application for exemption was submitted for review to IRB for approval prior to any steps that involved recruitment, and the approval was granted. Additionally, the application included informed consent and recruitment forms (see Appendix C; Appendix D).

Once potential participants were identified through a database search, an initial recruitment email was sent to them. Once they confirmed that they were indeed first or second-year college students studying computer science full-time, the forms were given to those who voluntarily agreed to take part in the study for their review. Once an agreement was reached with their signed approval and an understanding of confidentiality, Zoom video conferences were scheduled with participants over a two-week period.

### *Confidentiality*

All participants were guaranteed confidentiality by the researcher through the use of aliases for the participants' names and colleges. The identities of participants were kept confidential as they were identified as female computer science student number 1, 2, 3, etc. However, participants were not guaranteed anonymity and the identities of the participants were not incorporated in the dissertation's final version. Participants were notified during initial outreach that there were no risks related to their participation in the study and that they could withdraw at any time without penalty. Participants also did not receive remuneration for their participation.

### *Security of Data*

Participants were notified during initial emails contacting them about the study that interview data would be retained for three years after the dissertation's acceptance date. After three years, data could be deleted and destroyed. The participants' materials were secured properly as digital data that was saved on a password-protected computer account that only the researcher can access. The process of data collection assured minimal risk to participants.

**Data Collection**

For this study, data were collected utilizing procedures that included boundaries for the research study, the collection of data through participant interviews, and through creating steps to record the data. The data collection process includes selecting participants, selecting the number of participants, and what data would be obtained from them. Data collection involved a qualitative research design approach that involved open-ended and semi-structured questions used to intentionally gather the opinions and perspectives of the participants (Creswell & Creswell, 2021). As such, interviews were utilized as a research tool to gather data through the use of verbal communication. Semi-structured and open-ended questions allowed for interviews to provide some objective information while the researcher gained an understanding of the participants' opinions and perspectives (Creswell & Creswell, 2021). Gray (2018) stated that these types of interviews align well with a phenomenological approach in which the researcher examines the subjective meanings from the responses of participants based on their experiences.

To obtain 15 participants for the study, information was obtained from High School X, a pseudonym for an all-girls high school in Los Angeles, California, that included the names, e-mail addresses, and phone numbers of graduates from the past two years who planned to pursue a computer science-related major. Initial contact with school alumni was done via email using the approved IRB recruitment script, with follow-up emails to schedule interviews and the use of phone calls as needed. Participant selection was gauged from their willingness to participate in the study. During this process, participants were informed that comments from interviews would not be attributed to them and that any information they shared would be kept with strict confidentiality. As such, these participants were sent the Informed Consent form.

Once interview appointments were confirmed, participants were supplied with a copy of the interview questions and approval for their consent two weeks prior to their scheduled interview. The interview took place digitally over Zoom, allowing participants to choose their location. Once the interview was completed, a thank you email was sent to participants for accepting to take part in the study and assuring them how the results would be utilized to inform results and how the information gathered would be kept confidential. During their scheduled interview times, participants were asked if they could be digitally recorded using audio, and when they gave their approval, the recording and notetaking began. Before the interview began, opening questions were conducted to ask each participant how she was doing and to answer any questions she would have before starting. Each participant was then asked if she had read and understood the informed consent form and if she agreed to its terms. When she agreed, the participant was asked to acknowledge the risks and benefits of her participation in the study. All forms were secured both digitally on a password-protected computer account and by printing them and placing them in a locked desk drawer, with no outside access, to secure confidentiality. Interviews were transcribed verbatim. Given the semi-structured nature of the interviews, protocols were developed on how the interviews were to be conducted.

**Interview Protocol**

The research questions that inform this research study were as follows:

- RQ1.What challenges do female first and second-year college students face in pursuing computer science-related majors?
- RQ2. What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges?

- RQ3. How do first and second-year female college students measure success in pursuing computer science-related majors?
- RQ4. What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science?

To ensure that the interviews were consistent, the interview protocol was utilized for each interview so that all interviews could be synchronized. The protocol also allowed for the researcher and participants to delve into the phenomenon to gain meaningful insights. Then, the researcher asked participants to answer the questions as truthfully as possible. Participants were informed of the semi-structured nature of the interview, and that follow-up questions may be asked for clarity or a deeper understanding of their responses. While there was no limit on time set for the interview, participants were notified that the interview would last about one hour. Participants were then informed that their participation in the qualitative study and their responses would be used to provide data in a doctoral dissertation that focuses on informing the best practices for female first and second-year college students majoring in a computer science-related field. Furthermore, the information could be used to inform best practices in K-12 education as well as the computer science industry to address gender gaps in the field.

The data from the interviews were collected using the same qualitative instrument. The instrument consisted of ten open-ended interview questions that were used to correspondingly answer the study's research questions, specifically as they related to female computer science college students. The instrument was developed based on the responses from members of the dissertation committee and those from the peer review panel.

### *Interview Questions*

The following interview questions were asked to address the research questions of this study:

- IQ 1: Think of the single most difficult challenge you have faced in pursuing a computer science-related major.
  - What was that challenge and
  - How did you experience it?
- IQ 2: What are other similar challenges you have experienced pursuing a computer science-related major?
- IQ 3: Are you personally aware of similar challenges that other woman may have faced in pursuing a computer science-related major?
- IQ 4: What strategies and best practices did you employ or what resources did you seek to overcome this particular challenge?
- IQ 5: What strategies or best practices did you employ, or resources did you seek to overcome these challenges?
- IQ 6: Are you personally aware of strategies or best practices employed or resources sought by these women?
- IQ 7: What is your ultimate goal in pursuing a computer science-related major?
- IQ 8: How do you ensure you stay on track to that goal?
- IQ 9: What advice or recommendations do you have for aspiring women who want to pursue studies in computer science-related majors?
- IQ 10: If you could, what is the one thing you would do differently, if you were to start your studies over?

*Relationship Between Research and Interview Questions*

The following interview questions correspond to the named research questions:

- Interview Questions 1, 2, and 3 correspond to Research Question 1.
- Interview Questions 4, 5, and 6 correspond to Research Question 2.
- Interview Questions 7 and 8 correspond to Research Question 3.
- Interview Questions 9 and 10 correspond to Research Question 4.

The research questions were used to gain an understanding from participants of their academic experiences and females in a computer science-related major that allowed them to reflect on their academic and personal experiences from the beginning of their education to the present. Interview questions and corresponding research questions are stated in Table 1.

**Table 1**

*Research and Corresponding Interview Questions*

| Research Questions | Corresponding Interview Questions |
|---|---|
| RQ1: What challenges do female first and second-year college students face in pursuing computer science-related majors? | **What attracted you to study a computer science related major?**<br><br>IQ1: Think of the single most difficult challenge you have faced in pursuing a computer science-related major.<br>a. What was that challenge and<br>b. How did you experience it?<br><br>IQ 2: What are other similar challenges you have experienced pursuing a computer science-related major?<br>IQ 3: Are you personally aware of similar challenges that other woman may have faced in pursuing a computer science-related major?<br><br>FU: Was anything in your upbringing values and beliefs that presented challenges for you? |
| RQ2: What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges? | IQ 4: What strategies and best practices did you employ or what resources did you seek to overcome this particular challenge? |

| Research Questions | Corresponding Interview Questions |
|---|---|
| | IQ 5: What strategies or best practices did you employ, or resources did you seek to overcome these challenges?<br>IQ 6: Are you personally aware of strategies or best practices employed or resources sought by these women?<br><br>FU: How did you overcome those? |
| RQ3: How do first and second-year female college students measure success in pursuing computer science-related majors? | IQ 7: What is your ultimate goal in pursuing a computer science-related major?<br><br>IQ 8: How do you ensure you stay on track to that goal? |
| RQ4: What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science? | IQ 9: What advice or recommendations do you have for aspiring women who want to pursue studies in computer science-related majors?<br><br>IQ 10: If you could, what is the one thing you would do differently, if you were to start your studies over? |

## Validity and Reliability of the Study

*Validity* refers to an instrument being able to evaluate what it is intended to evaluate and measure (Gray, 2018). *Reliability* refers to the instrument used being consistent (Creswell & Creswell, 2021). The instrument's validity and reliability were evaluated to ensure that the questions in the interview protocol attended to the research questions. Such validity was determined by determined through prima facie validity, peer review validity, and expert review. If the findings were not found to be valid or reliable, then they would not be relevant to the study's readers and other researchers (Creswell & Creswell, 2021).

### *Prima Facie Validity*

After an extensive literature review, the researcher arrived at eight interview questions that were designed to correspond with the study's research questions. Table 1 demonstrates the relations between the research questions and their corresponding interview questions, which represent prima facie validity. The interview questions were designed to intentionally produce rich responses from the participants as they answered the respective research questions.

### ***Peer Review Validity***

To further establish the validity of the interview questions as they correspond to the research questions, a peer review was used to challenge any assumptions and biases the researcher could have. Research questions were shared with three peers with knowledge of qualitative research, and based on their feedback, questions were reviewed and edited to achieve clarity and minimize bias as shown in Table 2. Once edits were made and questions were refined, they were submitted to the dissertation committee, which consisted of the dissertation chairperson and three committee members, as feedback is shown in Appendix E.

**Table 2**

*Research and Corresponding Interview Questions (Revised from Peer-Review Feedback)*

| Research Questions | Corresponding Interview Questions (Revised) |
|---|---|
| RQ1: What challenges do female first and second-year college students face in pursuing computer science-related majors? | Icebreaker. Tell me about your journey as a student in your major.<br><br>IQ 1: What is unique about the academic culture as it relates to your computer science-related major?<br><br>IQ 2: What are some of the most challenging aspects you face as a female pursuing a computer science-related major? |
| RQ2: What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges? | IQ 3: What practices and strategies enable you to pursue a computer science-related major?<br><br>IQ 4: What factors do you believe contribute to you being successful in pursuing a computer science-related major? |
| RQ3: How do first and second-year female college students measure success in pursuing computer science-related majors? | IQ 5: How do you define success for yourself as it relates to your academic and career pursuits?<br><br>IQ 6: How do you measure that success? |
| RQ4: What recommendations do first and second-year female college students who | IQ 7: What advice or recommendations would you give students who are considering your major? |

| | |
|---|---|
| pursue computer science-related majors offer to those aspiring to major in computer science? | IQ 8: Is there anything else you would like to share about your computer science experience that you think would be relevant to this study? |

### *Expert Review Validity*

The results from feedback from the initial peer review panel were provided to the dissertation review committee as a final step for validity. Every member of the dissertation committee is a subject matter expert in excellence and innovative practices, and as such, they provided their experience and knowledge to further advance the study's research to determine best practices. The expertise of this committee allowed the researcher to examine all significant aspects of the study (Creswell & Creswell, 2021). After the committee's review, changes were recommended, which resulted in the final approved list of interview questions shown in Table 3.

**Table 3**

*Research and Corresponding Interview Questions (Revised from Expert Review Feedback)*

| Research Questions | Corresponding Interview Questions |
|---|---|
| RQ1: What challenges do female first and second-year college students face in pursuing computer science-related majors? | **What attracted you to study a computer science related major?**<br><br>IQ1: Think of the single most difficult challenge you have faced in pursuing a computer science related major.<br>a. What was that challenge and<br>b. How did you experience it?<br><br>IQ 2: What are other similar challenges you have experienced pursuing a computer science related major?<br>IQ 3: Are you personally aware of similar challenges that other woman may have faced in pursuing a computer-science related major?<br><br>FU: Was anything in your upbringing values and beliefs that presented challenges for you? |
| RQ2: What strategies do female first and second-year college students who pursue | IQ 4: What strategies and best practices did you employ or what resources did you seek to overcome this particular challenge? |

| Research Questions | Corresponding Interview Questions |
|---|---|
| computer science-related majors apply to overcome these challenges? | IQ 5: What strategies or best practices did you employ, or resources did you seek to overcome these challenges?<br><br>IQ 6: Are you personally aware of strategies or best practices employed or resources sought by these women?<br><br>FU: How did you overcome those? |
| RQ3: How do first and second-year female college students measure success in pursuing computer science-related majors? | IQ 7: What is your ultimate goal in pursuing a computer science related major?<br><br>IQ 8: How do you ensure you stay on track to that goal? |
| RQ4: What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science? | IQ 9: What advice or recommendations do you have for aspiring women who want to pursue studies in computer science related majors?<br><br>IQ 10: If you could, what is the one thing you would do differently, if you were to start your studies over? |

### ***Reliability and Pilot Testing***

The interview questions in Table 1 were evaluated by a preliminary panel, which consisted of three peer reviewers who are researchers with knowledge in K-12 education, higher education, school administration, and STEM subjects (see Appendix F). Each peer reviewer was in the Doctor of Education in Learning Technologies program at Pepperdine University as an enrolled student. Parallel to this study, these doctoral candidates also conducted comparable research methods for their dissertations during this time. In addition, each candidate completed all required coursework for their doctoral degree and was well-versed in case studies, qualitative research, quantitative research, and mixed methods. For the peer-review process, peers were provided with a thank you letter, a summary statement, a synopsis of this research study, and the research questions with corresponding interview questions. Two pilot interviews were conducted with female computer science majors who met the criteria for participation. Once the interviews were completed, the researcher asked for input on the questions regarding flow and understanding. Their feedback for modifications is demonstrated in Appendix E.

## Statement of Personal Bias

This qualitative research study was developed rooted in the researcher's own desire to decrease the gender gap in the computer science field. There is a lack of information regarding best practices for female students in their first and second years of college, which is close to a pivotal time in which several women, even those who have decided to major in computer science-related subjects, decide to leave the industry entirely. A sense of urgency and attention needs to be paid to the gender gap in computer science. If not, younger K-12 female students may not receive the mentorship or envision themselves in such roles in the future, which could leave the gender gap unchanged.

Even though multiple tasks in this study's completion were performed, it is presumed that the personal bias of the researcher should be highlighted (Creswell & Creswell, 2021). As such, the researcher has taught computer science for over a decade, most recently at an all-girls high school, where he is witness to the potential an increased female presence could have in the field. The researcher has a passion for the growth of women in the STEM field, particularly in computer science, to increase diversity and remove stereotypes of what a computer scientist may look like.

### *Bracketing and Epoché*

Bracketing, or epoché, refers to the technique a researcher uses to alleviate personal biases from a study (Creswell & Creswell, 2021). Bracketing is intended to shield and protect an individual from exposure to and the study of psychologically stimulating content and allows for balance so that the biases do not taint the research (Tufford & Newman, 2012). While methodological biases may present themselves in the data collection process due to the personal interests of the researcher, epoché allows the researcher to mitigate such biases (Tufford & Newman, 2012).

## Data Analysis

The interview data were analyzed and transcribed using software, storage of transcripts, and coding. Notes were written when insights from personal observations were made of the study's participants as they responded to the interview questions. Those notes were then transcribed to a digital word-processing document. All data were transcribed and then coded. After this, data were stored in a password-protected computer account and printed data were stored in a locked desk cabinet.

### *Coding*

In a qualitative study, coding is used when a word or phrase is symbolic of capturing the essence of a response (Saldaña, 2016). This allows for the summarizing of varied raw data, creating correlations between findings, and identifying underlying themes that stem from the data. As such, coding could include descriptive code, which is one word or phrase, as it summarizes the topics that correspond to a response.

While coding, the researcher should employ inferences from an analytic lens, all the while observing the data as a way to observe the phenomenon (Saldaña, 2016). As such, the following coding techniques were used for the interview responses:

- transcribing all digital interviews and notes taken by the researcher where they were placed in a double-spaced format;
- having clear line breaks whenever a theme or concept appears to shift in the responses;

- refrain from running long passages of data from the interviews together; and
- having right-side margins that are wide for writing notes and corresponding codes (Saldaña, 2016).

In the coding process, there is the use of tags to group words, phrases, and sentences together to capture an image of the interview protocol brings forth (Saldaña, 2016). Once all the data is compiled through coding, the researcher is then equipped to write the fourth chapter of the dissertation research study. A master list of codes was developed for all codes used in this dissertation.

**Inter-Rater Validity and Data Presentation**

Creswell and Creswell (2021) state that there is strength in findings that are determined by the interrater and intercoder validity process. To establish such validity, the following steps were taken in the data analysis process, which informed the presentation of the data:

- the researcher reviewed and coded three interviews;
- the researcher discussed the results of coding with three peers who made suggestions for any alterations to the coding process, and
- the researcher then coded the data for the other 12 interviews.

When the data analysis is finalized, then the next step is to report the findings. This includes presenting findings in charts that demonstrate and arrange the number of interviewees who were part of a general theme.

**Chapter Summary**

This chapter provided the qualitative methodology for this research study and its processes. This included research, data collection, data analysis, and the interpretation of the data. Furthermore, research questions informed the study and drove the method by which the researcher obtained information about the population through interviews. Through open-ended questions, it ensured that the researcher could obtain data that was rich in content. Considerations for human subjects were described, which included a review of the IRB protocol. Interview information was reviewed and examined for the refinement of the interview tool. Data analysis procedures, which included coding, were discussed. The analysis of the data will be discussed in chapter four.

# Chapter 4: Findings

While there has been an increase of women in the workforce who work in the technology sector, the gender gap when compared to their male counterparts is still a significant one (L. L. Wang et al., 2021). Research indicates a need to study the educational journey of undergraduate female students who are pursuing computer science-related majors during their undergraduate experiences as decisions in technology by women may not be made by women if this gender gap is not addressed (Yates & Plagnol, 2021). By addressing the challenge of the gender gap in computer science, this study looks to address this male-dominated field through data presented by first and second-year female college students enrolled in computer science-related majors. This phenomenological study asked four research questions, including 10 interview questions, that were developed to address the purpose of the study. In accordance with Creswell & Creswell (2021), descriptions and findings for this study captured the lived experiences of the participants who all share the lived phenomenon. In understanding the participants' lived experiences, the following research questions were asked:

- RQ1. What challenges do female first and second-year college students face in pursuing computer science-related majors?
- RQ2. What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges?
- RQ3. How do first and second-year female college students measure success in pursuing computer science-related majors?
- RQ4. What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science?

The study's 15 participants fielded the research questions by answering 10 open-ended corresponding interview questions. These open-ended questions were utilized to determine the best practices and strategies aimed at addressing challenges employed by these college students to continue to thrive in their computer science-related studies. Participants' responses were transcribed and from there, themes and concepts were coded for corresponding questions. Next, themes were described in detail in this chapter. The qualitative design of this study was created to have a thorough understanding of best practices as employed by female college students in computer science-related majors. As a result of determining participants' best practices, the findings look to provide data to the current literature in addressing closing the gender gap for the field and and offering an outline for future research.

**Participants**

Participants for this study were selected using purposive sampling as supported by Creswell & Creswell (2021) and Gray (2018). Purposive sampling allowed for the identification of participants and communities that were best suited to answer the study's research questions. All participants of the study have lived the same phenomenon and they have insights related to the study, can relate to the study's research problem, and have all agreed to participate with an understanding that their responses would remain confidential.

Prior to conducting each interview, participants were contacted via email. Emails included a request to participate letter, the informed consent document to be signed, and the interview protocol, which included the interviewer's questions. The sample pool included 25 participants who were first or second-year female college students in computer science-related majors. Two of the remaining 13 participants attend a community college, whereas the remaining

13 participants attend a four-year university. Nine of the participants were first-year college students while 6 of the participants were second-year college students.

***Participants' Majors and Class Standing***

The following breakdown has a percentage distribution of participants' enrolled computer science-related majors:

- Ten (66%) of participants were enrolled in a computer science major; and
- Five (33%) of participants were enrolled in an engineering program that required computer science skills.

The following breakdown has a percentage distribution of participants' class standing at their college:

- Nine (60%) of the participants were first-year college students; and
- Six (40%) of the participants were second-year college students.

***Participants' College Locations***

The study allowed for participants who met the criteria for inclusion to be studying at any degree-awarding college or university. While all schools represented by participants were in the US, the locations of their school varied. The following breakdown has a percentage distribution of states in which participants' schools were located:

- Eleven (73%) of the participants were in schools in California;
- Two (13%) of the participants were in schools in Indiana;
- One (6%) of the participants was in a school in Colorado
- One (6%) of the participants was in a school in Virginia; and
- One (6%) of the participants was in school in Missouri.

Interestingly, while schools in states outside of California were all private universities, there was a range in school types from the California schools that included community colleges, state universities, and private universities.

**Data Collection**

In relation to the four research questions that were utilized to inform the research study, 10 corresponding interview questions were developed and asked of the participants. The data collection for this study was initiated on February 6, 2024, and came to an end on February 28, 2024. Participants were identified based on access to databases from High School X of graduates who met the criteria for inclusion and exclusion. The master list of prospective first and second-year female students in computer science-related majors in this study consisted of 20 individuals who were vetted to meet the criteria for inclusion. This was then followed by the finalizing of the master list of possible particpants. From there, 15 participants were narrowed down for use in the study. This process allowed for the use of maximum variation with participants who were in computer science programs nationwide.

Next, after the 15 participants were contacted, they agreed to participate in the study. Given their schedules, and depending on the time of the quarter or semester of their term, some scheduling conflicts did arise. Some participants, particularly those studying in a quarter system, were partaking in midterm examinations and therefore had to schedule at a time that was convenient for them given their course load. Moreover, some participants replied within a day or two, while other participants replied after follow-up email reminders were sent to them. Fortunately, all participants kept their appointments with the researcher and were able to interview at an agreed-upon time for both them and the researcher.

While challenges in scheduling participant interviews mostly lay in responding to the recruitment email, once participants replied, participants were proactive in their responses to move forward with a finalized interview date and time. Furthermore, during the interview process, participants expressed eagerness to take part in the study given its implications for the recruitment and retention of female college students in computer science and STEM. Lastly, all participants presented descriptive, complete, and well-articulated responses, which were representative of their levels of education and the rigor of their college majors.

The protocols used for the research study's sampling frame were as follows through the list servers and information management systems of High School X.:

- High School X, an all-girls high school, allows for a larger selection for the goal of 15 participants for the study, provided site permission to access its list servers and information management systems, which included those of graduates now regarded as alumnae (see Appendix A);
- Based on information provided through the servers and systems, that gave insight into the graduates' intended majors and colleges they are attending;
- Information in the server lists also provided their graduation year, informing the researcher of the alumnae being a first or second-year college student;
- A letter about the research study was sent to prospective participants, informing them about the study's purpose and their role in being a participant in the study;
- Data about the participants was reviewed by the researcher to ensure they fit the inclusion criteria, which provided the study's participants;
- After the participants were identified, they were contacted using the IRB approved recruitment script shared via email for the purpose of scheduling their interviews.;

- Once meetings were scheduled with participants, interviews were audio recorded by the researcher on a password-protected computer;
- The researcher wrote copious notes at the moment of each interview to document both responses and anecdotal data to ensure there were no missed replies;
- The researcher transcribed audio recordings using OtterAI software; and
- The researcher valued the enthusiasm of participants wanting to take part in the study and its purpose.

Given the participants' varying geographical locations, online interviews were the best fit for this study. As such, when scheduling interviews, the researcher ensured that they took place at a time that was fitting for both the participants and researcher while ensuring there wasn't confusion for those in other time zones. See Table 4 for the dates/times of participant interviews.

**Table 4**

*Dates of the Participant Interviews*

| Interview Date | Participant |
|---|---|
| February 13, 2024 | P1 |
| February 13, 2024 | P2 |
| February 14, 2024 | P3 |
| February 15, 2024 | P4 |
| February 18, 2024 | P5 |
| February 19, 2024 | P6 |
| February 20, 2024 | P7 |
| February 20, 2024 | P8 |
| February 23, 2024 | P9 |
| February 27, 2024 | P10 |
| February 27, 2024 | P11 |
| February 27, 2024 | P12 |
| February 28, 2024 | P13 |
| February 28, 2024 | P14 |
| February 28, 2024 | P15 |

In addressing the study's four research questions, 10 corresponding interview questions were developed and were asked of participants to answer. Once interview meeting dates and times were confirmed with participants, signed informed consent and interview protocol sheets were collected from them. On the day of the interview, before any of the interview questions were asked, participants were asked if they understood the documents and if they had any questions prior to their start. The researcher employed reliability and validity procedures and asked participants the approved interview questions. As such, the following questions were asked of every participant included in this study:

- IQ 1: Think of the single most difficult challenge you have faced in pursuing a computer science-related major.
    - What was that challenge and
    - How did you experience it?
- IQ 2: What are other similar challenges you have experienced pursuing a computer science-related major?
- IQ 3: Are you personally aware of similar challenges that other women may have faced in pursuing a computer science-related major?
- IQ 4: What strategies and best practices did you employ or what resources did you seek to overcome this particular challenge?
- IQ 5: What strategies or best practices did you employ, or resources did you seek to overcome these challenges?
- IQ 6: Are you personally aware of strategies or best practices employed or resources sought by these women?
- IQ 7: What is your ultimate goal in pursuing a computer science-related major?

- IQ 8: How do you ensure you stay on track to that goal?
- IQ 9: What advice or recommendations do you have for aspiring women who want to pursue studies in computer science-related majors?
- IQ 10: If you could, what is the one thing you would do differently, if you were to start your studies over?

The participants of this study were instructed to respond to the 10 open-ended interview questions through insights and information from their lived experiences. These responses to the 10 interview questions added to the gathering of raw data to gain an in-depth understanding of the best practices utilized by first and second-year female college students in computer science-related majors. Therefore, this chapter includes data derived from participants' responses and the steps taken for this collection of data. Furthermore, findings from the data analyzed were also incorporated in this study.

Participant interviews conducted were successful and went well. Responses articulated by the participants allowed for insightful data about their experiences in their undergraduate studies. The interviews also allowed the researcher to gauge the emotions behind their responses through participants' expressions of frustration, hope, and laughter. All in all, participants were positive about their experience in this study as they looked forward to the possibility of affecting change for the future of women in computer science and STEM.

**Data Analysis**

A qualitative study has a phenomenon that is explored through the use of a theoretical framework that analyzes a problem which is based on the lived experiences of participants who experience the phenomenon and have familiarity with the problem (Creswell & Creswell, 2021). Data were collected from the participants with the use of qualitative design and inquiry based on their lived experiences. The researcher in this study coded the data through the use of two cycles that allowed for categorization of the data from participants' interview responses and then coding that data into common themes.

The problem framed in this study was explored through the use of analysis of data, coding of themes, categorizing, and interpretation of the participants' responses to the interview questions. Coding is subject to interpretation and therefore is not precise (Saldaña, 2016). As such, coding is known to be the capturing of essential components of responses by the grouping of similarities and regularities for the analysis of connection in telling the research's story (Saldaña, 2016). Additionally, coding allows the researcher to organize codes with similarities into themes that have shared traits (Saldaña, 2016). Saldaña (2016) defines a theme as the categorization of codes, as codes reflect larger themes or support themes.

The researcher looked for possible relationships through a first and second-level coding process for the development of presenting findings (Harding, 2013). Through this process, themes derived from narratives allow for the telling of the data's story through both similarities and by telling different stories (Harding, 2013). This process was captured through the audio recording of each participant's interview alongside the researcher taking copious notes during the interview. Epoché, also known as bracketing, was then used by the researcher to remove bias, minimize judgment, and remove the researcher's experiences from those of the participants and their responses (Creswell & Creswell, 2021). Through epoché, the researcher removed any preconceived opinions and thoughts as they related to the experiences of female students in computer science.

The researcher maintained professionalism with both verbal and nonverbal communication with each of the participants. Each interview was audio recorded and transcribed, and any information identifying the participants was removed and were assigned reference numbers. Participants' responses were analyzed and then coded, allowing the researcher to establish similarities in their responses as first and second-year female college students in computer science-related majors. After coding, codes were then clustered into themes and then sorted and ranked based on the frequency of responses, with the highest being first. Once the clustering process was complete, a validation protocol was distributed to three peers to complete the interrater review so that they could validate the data. As such, themes were coded based on feedback from the interrater review process.

**Inter-Rater Review Process**

An inter-rater review process was conducted by the researcher to ensure the data's validity. The researcher enlisted three doctoral candidates enrolled program for a Doctorate of Education in Learning Technologies at Pepperdine University. The enlisted doctoral candidates for the interrater review process have similar experience to the research in research methodology, use of qualitative data and methods, and data analysis. Every one of the three doctoral candidates was provided with a spreadsheet document that included the researcher's codes for the study's first three participants who were interviewed. Additionally, the three doctoral candidates were provided transcriptions of the interviews and themes derived from the data. The researcher provided context to the doctoral candidates with an introduction to the codes completed after the first three interviews. The doctoral candidates then reviewed the codes in the spreadsheet compared to the transcripts and themes the researcher identified and then provided feedback to the researcher. The researcher provided the inter-raters with a table to record their feedback. The researcher then discussed the recorded feedback with the inter-raters for any needed clarifications. Recommendations from inter-raters are shown in Table 5.

**Table 5**

*Inter-Rater Coding Feedback*

| Inter-Rater (3) | Interview Questions (IQ) | Item | Inter-Rater Recommendation | Modifications Made |
|---|---|---|---|---|
| Interrater 1 | IQ 1 | Themes: Imposter syndrome and Academic Uncertainty | Make 'Imposter syndrome' its own code. There are enough participants responding to this to make it its own theme and it supports that code. | [Yes] 'Imposter syndrome' and 'Academic Uncertainty' were made into two separate codes |
| Interrater 1 | IQ 7 | Theme: Define Passion | There are enough participants speaking about finding their path or passion, that could be its own code/theme. | [Yes] 'Finding Passion' was made into its own theme. |
| Interrater 2 | IQ 6 | Theme: Study Groups | P3 listed 'joining friends to do the work with' in code, which could be added to the theme 'Study Groups'. | [Yes] P3s 'peer-led team learning' was added to the 'Study Groups' theme. |
| Interrater 3 | IQ 2 | Theme: Lack of Women | P2 mentioned 'observing gender dynamic' and it was listed as a code. That could be added to the 'Lack of Women' theme given the context. | [Yes] P2's 'observing gender dynamic' was added to the theme "Lack of Women". |
| Interrater 3 | IQ 2 | Theme: Interactions with Other Students | P1 listed 'being ignored in groups' and it was listed as a code. That could be added to the 'Interactions with Other Students' theme. | [Yes] P1's 'being ignored in groups' was added to the theme "Interactions with Other Students". |

## Data Display

Data were displayed by framing research questions parallel to their corresponding interview questions. Once the data were coded, it was reviewed for common themes and concepts that emerged from the codes. To ensure the confidentiality of the study's participants, each participant was issued a reference number (e.g. Participant 1, Participant 2, etc.). As such, the data gathered on best practices and strategies of first and second-year female college students in computer science-related majors was collected during semi-structured interviews, which were integral to this research study.

Frequency charts emerged from the themes that were identified from participant interviews. Common themes were formed and identified only using the data collected from participant interviews for each of the interview questions. In support of the themes, each one was supplemented by a quote from each participant that was extracted from the interview transcription.

In wanting to maintain the integrity of the data, the researcher used quotes from participants as expressed verbatim to provide authenticity and clarity to any response that could be deemed ambiguous. The college students interviewed provided findings that provide best practices for computer science-related programs and their female student population. Data from their responses was coded, organized into themes, analyzed, and interpreted to address the study's four research questions.

## Research Questions

### *Research Question 1*

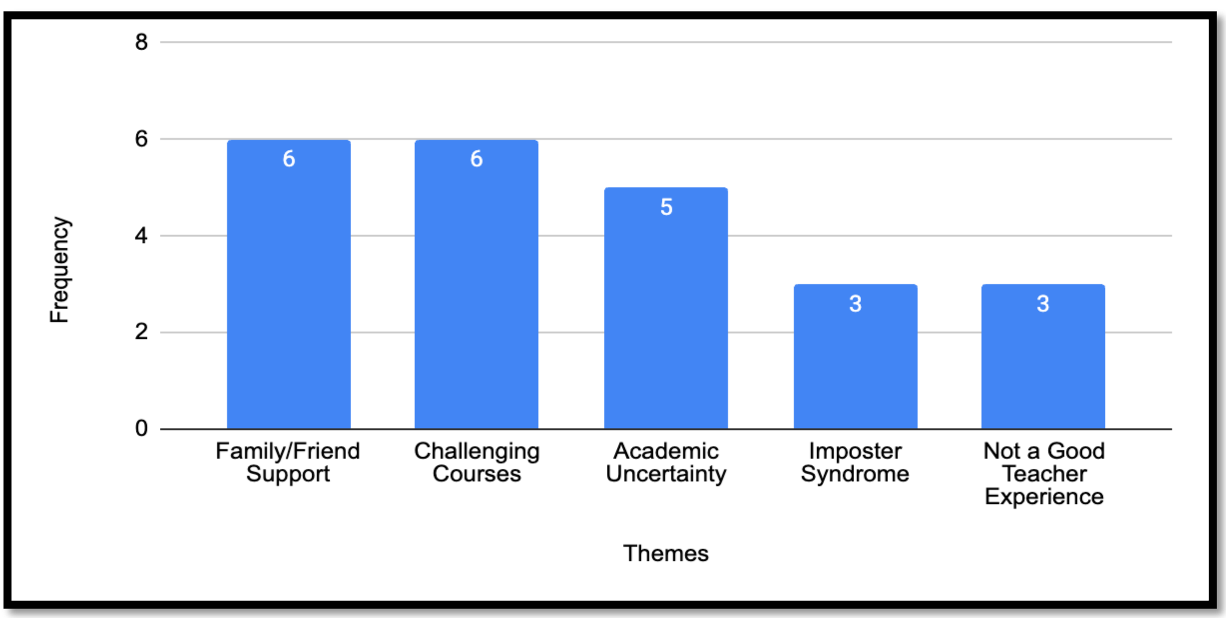
The first research question looked to determine the challenges female first and second-year college students face in pursuing their computer science-related majors. Responses to the corresponding interview questions informed themes that emerged from their corresponding interview questions. Responses to each question were analyzed separately and then collectively analyzed.

- IQ 1: Think of the single most difficult challenge you have faced in pursuing a computer science-related major.
    - What was that challenge and
    - How did you experience it?
- IQ 2: What are other similar challenges you have experienced pursuing a computer science-related major?

**Interview Question 1**. "Think of the single most difficult challenge you have faced in pursuing a computer science-related major.  What was that challenge and how did you experience it?" (see Figure 5).

**Figure 5**

*IQ 1: Challenges in Pursuing a Computer Science-Related Major*




*Note*. $n = 15$

***Family and Friends Support***. While this was not a challenge, 6 of the 15 (40%) participants expressed that what has helped them face or overcome their challenges has been support from their families and friends. According to Participant 11, "My friends have been encouraging me to do better when I am not doing well." Similarly, Participant 12 stated, "I seek out my friends for support when things get tough." A stable and reliable support system was important to students when faced with challenges. Fitzsimmons (2021) found that when female computer science students feel supported, it allows them to implement a growth mindset in their experiences.

***Challenging Courses***. When it came to speaking about challenges, 6 of the 15 (40%) participants stated that their coursework created challenges for them as they pursued their majors. When expressing specifically what courses have been the most challenging, 3 of the 15 (20%) participants shared that it was their mathematics courses they found the most difficult. Participants 1 and 11 shared that they had to retake a mathematics course based on the grade they earned the first time they took the course. With this particular challenge, Participant 2 shared that, "there is a lot of self-studying and self-learning when it comes to computer science courses." Challenges like these could be attributed to what Hagedorn and Purnamasari (2012) have found to be a lack of technical skill sets that are especially present in underrepresented groups, such as women, due to not being taught a proper STEM background during their K-12 education.

***Academic Uncertainty***. Five of the 15 (33%) participants noted that academic uncertainty was a challenge for them. This was expressed in a few ways; for example, Participant 5 stated, "Sometimes I don't feel like I'm good enough when I'm in a certain class." Similarly, Participant 10 expressed, "I am still trying to figure out my place in the program." From responses within this theme, academic uncertainty also demonstrated itself through feelings of unpreparedness and debating pursuits of wanting to obtain a computer science-related degree at all. Such academic insecurity is part of the daily experience female computer science students deal with during their daily interactions with the subject (Silva et al., 2022).

***Imposter Syndrome***. Related to the theme of academic uncertainty, 3 of the 15 (20%) participants explicitly stated that imposter syndrome was a challenge for them. Participant 6 shared an insight that related her imposter syndrome to the gender gap in computer science when she said, "I came from an all-girls high school experience, so my imposter syndrome came from seeing only five or six women in a STEM class of 25 when I got to college. You can feel the difference." Two of the participants who named imposter syndrome as a challenge also expressed the challenge of academic uncertainty. Diekman et al. (2011) state that imposter syndrome could be combated with the confidence that is built via mentorships if they are available to female computer science students.

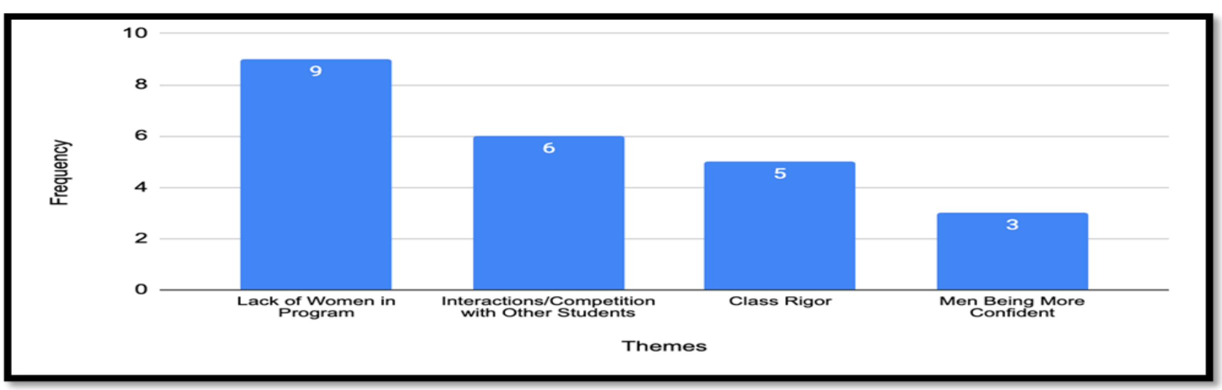
***Not a Good Teacher Experience***. Three of the 15 (20%) participants expressed that a challenge of theirs in their studies was not having a good experience with a professor during their time in college. Furthermore, the three participants who expressed this are all first-year college students, and given the time of the interview, they had only experienced one semester or at most two-quarters of college courses. As such, having a challenging instructor so early in their academic career has the implication to inform their attitudes toward STEM as they continue their collegiate pursuits. Participant 5, who had also shared that her mathematics course was a challenge said, "My pre-calculus professor was too fast-paced and others in the class agreed that his teaching style was not okay. I even got a recommendation to drop the course from the professor." When asked how the participant got through the challenge, Participant 5 shared, "I went to tutoring and that was more helpful than the professor was." Like Participant 5's responses, the other two participants whose responses were categorized in this theme similarly shared that the teacher they found challenging has a reputation shared by others. Female computer science students do better in environments where they can collaborate in their learning environments and feel that they are a part of something greater (Yates & Plagnol, 2021).

**Interview Question 1 Summary.** Challenges for first and second-year female college students in computer science-related majors stem from the academic experiences they are going through during their time in college. When it comes to challenges felt by students on the inside, these include feelings of academic insecurity and imposter syndrome. Specifically, when it comes to their coursework, participants have felt the rigor can be challenging, and that is highlighted through negative learning experiences from teachers. However, on a positive note, a large number of participants stated that they get through their challenges by having a support system of friends and family.

**Interview Question 2**. "What are other similar challenges you have experienced pursuing a computer science-related major?" (see Figure 6).

**Figure 6**

*IQ 2: Similar Challenges in Pursuing a Computer Science-Related Major*




*Note*. $n = 15$

***Lack of Women in Program***. Given the data behind the gender gap in computer science and STEM, there was a connection when the majority of participants, 9 out of the 15 (60%), listed the lack of women in computer science-related programs was an additional challenge for them. Participant 7 shared that only 20% of the computer science students in her school were women. Participant 9 said, “In some classes, I am the only female.” Additionally, participant 9 shared the insight, “As you get further into your studies, you see not many women make it. It makes you think if they are being pushed out.” Similar responses were present across all the participants who shared the theme. As such, program environments that combine awareness of the gender gaps and provide female-to-female empowerment assist in addressing the sense of belonging (Yates & Plagnol, 2021).

***Interactions/Competition With Other Students***. An additional challenge 6 of the 15 (40%) participants shared had to do with their interactions, often in the form of competition, with their classmates. Participants 8 and 11 shared how their interaction left them working on assignments on their own at times. When it comes to competition Participants 2, 4, and 8 expressed that they feel they are competing with students who have more computer science and STEM experience. Similarly, Participants 4, 9, and 10 shared that such interactions make it harder to be in study groups. For example, Participant 9 said, “I’ve been ignored in small groups before.” These classmate interactions the participants expressed have created resentment and hostility in their learning environments. Instead of having competitive environments, computer science programs should be places of collaborative learning, as it has been attributed as a large contributor to computer science achievement (Prince, 2004).

***Class Rigor***. The next challenge 5 of the 15 (33%) participants expressed was related to the rigor in their classes, particularly as they move forward in their coursework. Two of the participants whose responses fell into this theme expressed that their STEM courses are extremely fast-paced. In relation to the theme of the lack of women in their programs, Participant 7 said, “As the courses get more difficult, you see more women drop off the computer science program.” The five participants all expressed that the rigor is evident to them, with three of them being first-year college students. To improve self-efficacy in female students when learning skills related to computer science, a rigorous curriculum can be supplemented with project-based learning (Baker, 2013).

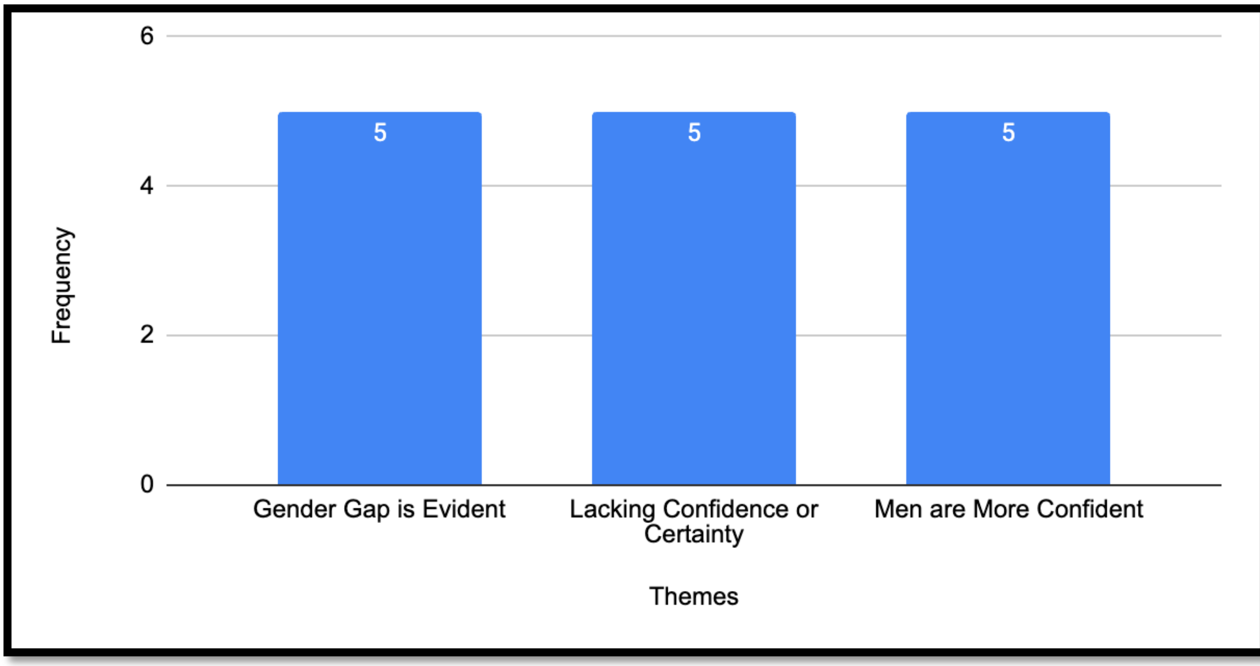
***Men Being More Confident***. In connection to the lack of women in computer science-related programs, 3 of the 15 (20%) participants shared that the men in their programs demonstrate more confidence in the subject of computer science. On the topic, Participant 12 expressed, “The men in computer science dominate the class. They’re the first to jump to answer questions before giving anyone else a chance.” Given that the majority of participants have noticed that the most of students in their programs are men, there is insight on classroom behavior as it relates to men’s confidence that can be attributed to their presence in such programs. Fitzsimmons (2021) and the work of Yates and Plagnol (2021) state that male dominance tends to lead to females feeling less technologically confident and less motivated than their male counterparts, even when they are equally or more capable.

**Interview Question 2 Summary**. While not their biggest challenge, a majority of the participants found that noticing the gender gap in their coursework has proven to be an additional challenge. Related to this, a fifth of the participants found that the men came across as more confident, but in a negative way as it appeared to add hostility to their environments. Additional challenges included interactions with classmates, which included a feeling of competitiveness, and the rigor of their classes.

**Interview Question 3**. Are you personally aware of similar challenges that other women may have faced in pursuing a computer science-related major? (see Figure 7).

**Figure 7**

*IQ 3: Challenges Experienced by Other Women in Pursuing A Computer Science-Related Major*




*Note*. $n$ = 15

***Gender Gap is Evident***. When it came to expressing challenges on behalf of other women in computer science-related majors, 5 of the 15 (33%) participants shared that other women notice the gender gap in their classes. An insight Participant 4 shared that had to do specifically with computer science and female students was when she responded, "My school is 70% women, and even so only 3 or 4 other women in my cohort are computer science majors." When thinking of what other women may experience in their programs, the lack of female students is something participants expressed would also be felt as a challenge by other women. While the gender is evident to these female computer science students, it is an awareness by the education institution that a social change needs to occur that will ignite motivation to affect the gap (Ruiz, 2017).

***Lacking Confidence or Certainty***. Unlike the theme of imposter syndrome that was captured in the responses of IQ 1, imposter syndrome was not explicitly named once by any of the participants as a challenge faced by other women studying computer science. However, a lack of confidence or certainty women in computer science face was named by 5 of the 15 (33%) participants. Participant 9 connected this with the theme of a lack of women by saying, “When you’re the only girl in a class, it makes you feel inferior and inadequate.” Participant 15 shared regarding going to class that “even when you are prepared, you doubt yourself that you are unprepared.” This lack of confidence can derive from the perception that women are viewed as outsiders in such fields and must continuously work toward being viewed as competent (Silva et al., 2022).

***Men Are More Confident***. Five of the 15 (33%) participants shared that a challenge for women in computer science-related coursework is that the male students appear to be more confident than the female ones. When speaking to the corresponding four participants, they all shared that the self-assuredness of men came across in a negative manner. For example, when speaking about other women pursuing the field, Participant 10 shared, “My friend who is in a STEM program at another school had to deal with men who are misogynistic” while Participant 15 said, “The men can sometimes come across as ‘know-it-alls.’” Participant 7 expressed a similar frustration when she said, “The men will double or triple check the work women share in class, but don’t do that for other men.” As such, while men appear to be more confident than the corresponding 5 participants, that confidence has come across as a notable challenge. Criado-

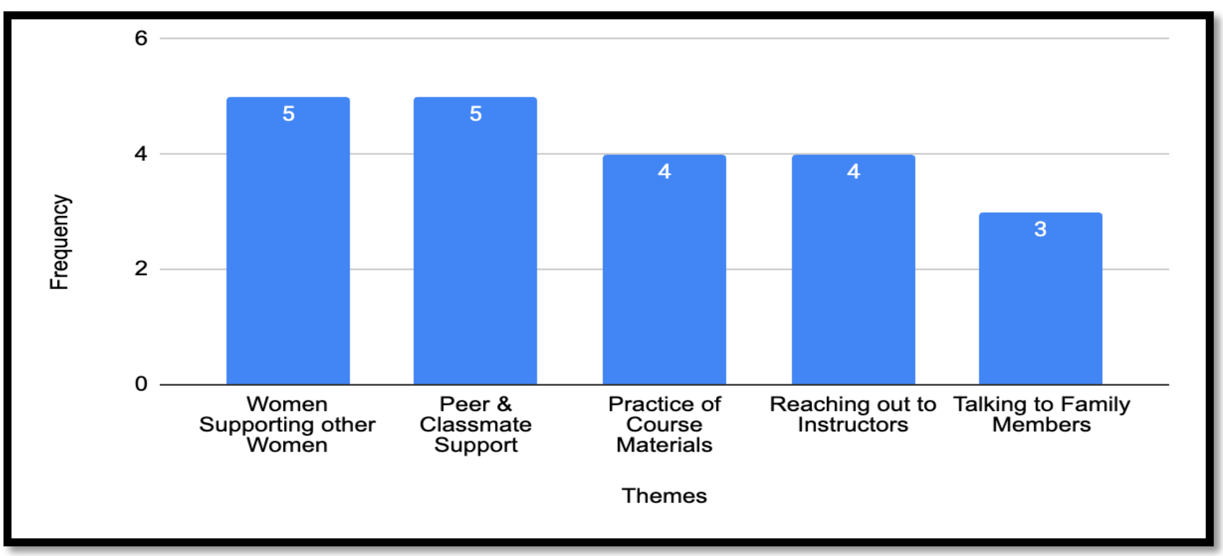
Perez (2020) states that men tend to be deemed with more genius-related traits, which could also add to men being viewed as more confident than their female counterparts.

**Interview Question 3 Summary**. When asked about challenges other women in computer science-related majors are faced with, themes from participants' responses demonstrated that the gender gap of there being fewer women in those STEM classes, lack of confidence or certainty women in those classes feel and men being more confident as those challenges. The lack of confidence or certainty expressed as a challenge for women in computer science derived from the lack of other women in the class. Additionally, the confidence men demonstrate in those courses lands negatively among the women in the course with men making misogynistic comments or men correcting or questioning women's work in courses.

**Interview Question 4**. What strategies and best practices did you employ or what resources did you seek to overcome this particular challenge? (see Figure 8).

**Figure 8**

*IQ 4: Best Practices for the First Challenge*




*Note*. *n* = 15

***Women Supporting Other Women***. When responding to the initial challenge expressed in Interview Question 1, 5 of the 15 participants (33%) expressed that the best practice they had in overcoming the challenge was by having other women support them. Three of the five participants whose responses were categorized in this theme said that they would look specifically to women in their computer science-related courses. Regarding this, Participant 7 said, "The women in my computer science classes look out for one another; we want to make sure we're not leaving a girl out." This practice of female-to-female empowerment allows women to feel a sense of belonging, especially in male-dominated fields like computer science (Yates & Plagnol, 2021).

***Peer and Classmate Support***. When it came to identifying best practices for their biggest challenge, 5 of the 15 (33%) participants stated that they looked to their peers and classmates for support. The differentiator between this theme and the one prior is that these five participants did not specify a gender in their responses. Additionally, these five participants did not limit these supports to only their computer science or STEM courses. Regarding this theme not being gender-specific, Participant 9 said, "I also looked to talk to the men in the class, it helps me to get to know everyone." Ambrose and Sternberg (2016) support that collaboration among students allows for a sense of belonging and also allows them to gain insight into how to work in teams when they reach the workforce.

***Practice of Course Materials***. Four of the 15 (26%) participants shared that one of their best practices was doing work for their courses. Participant 12 said, "I just keep practicing and doing the work." This best practice was shared by Participant 2 who said, "Get the hands-on experience and just practice." This also came in the form of reviewing course materials, as shared by Participants 8 and 9. This finding is supported by the work of White (1992) and Swiss

(1996) who state that women must continuously work so that they are perceived as skilled in their field.

***Reaching Out to Instructors***. When asked about best practices for what participants considered their largest challenge, 4 of the 15 (26%) participants shared that it came to reaching out to their instructors helped them succeed. Participant 9 shared, “At first I wouldn’t stay to talk to the professors, but I ask questions now.” Participant 15 said, “I now stay after class to talk to the professors, especially when I have questions.” For Participants 5 & 11, this best practice came in the form of visiting their professors during office hours. As such, educators play a crucial role in female students wanting to remain interested in STEM subjects like computer science (Guzdial & Bruckman, 2018).

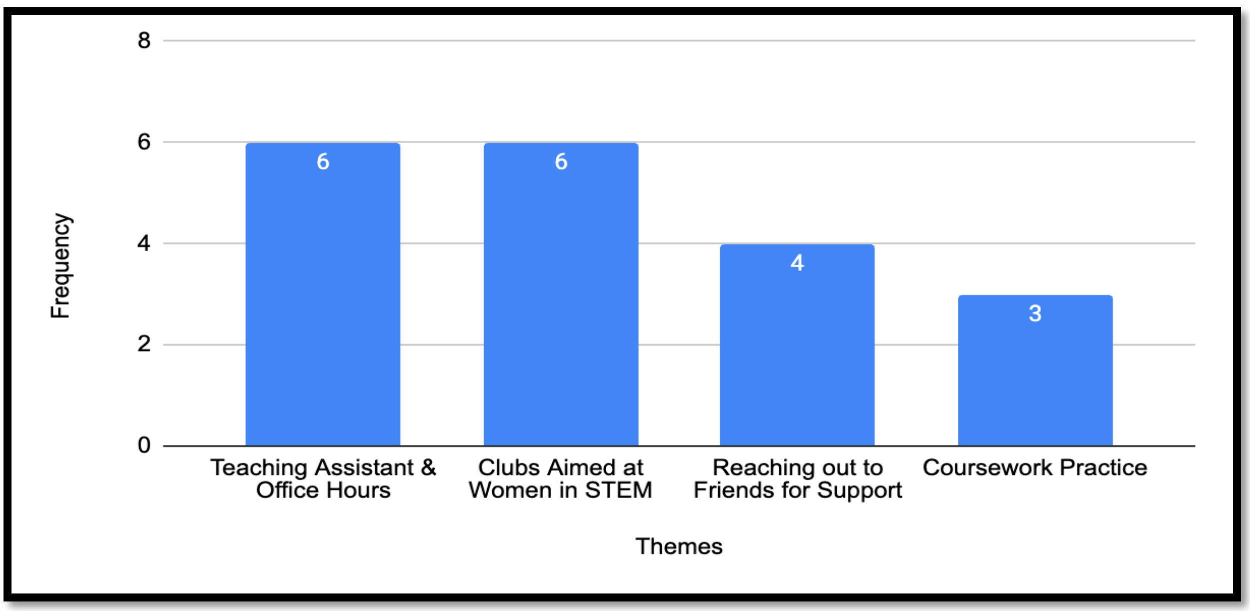
***Talking to Family Members***. A final theme that emerged from IQ 4 was that of participants talking to family members as their best practice for overcoming their largest challenge, as shared by 3 of the 15 (20%) participants. Participant 4 said, “I talk to my family and they keep me going. I like getting a pep talk from my mom.” Participant 13 said, “Even if they don’t know about the subject I’m studying, it’s nice to talk to my parents about my challenges. It’s comforting.” Female students look to feel supported as it allows them to envision themselves growing in their chosen field of computer science (Fitzsimmons, 2021).

**Interview Question 4 Summary**. When thinking about what their largest challenge was and what best practices they sought out, participants shared a variety of resources and strategies they employed. The most common best practice was seeking out classmate support, some participants specifically remarked that other women provided that support, but the same number also did not specify a gender for classmates they seek for that support. Other best practices employed included practicing course materials, reaching out to course instructors, and talking to their family members for support.

**Interview Question 5**. What strategies or best practices did you employ, or resources did you seek to overcome these challenges? (see Figure 9)

**Figure 9**

*IQ 5: Best Practices for Additional Challenges*




*Note*. *n* = 15

***Teaching Assistant and Office Hours***. When participants were asked what best practices they employ to overcome other challenges they face, 6 of the 15 (40%) participants stated that they reach out to the teaching assistant (TA) of the course or attend office hours. Under the context of office hours, teaching assistants were specifically named by 3 of the participants. For example, Participant 8 said, "I work with the TA, mostly during office hours, when I need extra help. Office hours were explicitly stated by all 6 participants, like Participant 9, who said, "I go to office hours and let the professors know about any challenges I'm facing. They've been very understanding." These resources could instill a sense of belonging in female computer science students, as Karlin (2019) has found that spaces that allow for a sense of belonging can be influential to these students' growth.

***Clubs Aimed at Women in STEM***. Six of the 15 (40%) participants expressed that a best practice was joining a club that was aimed at women in STEM. Participant 10 stated, "My school has the Society of Women Engineers." Similarly, Participant 7 said, "At my school, there is a Women in Engineering club." Other clubs named fell into the category of STEM, with two of the participants sharing that they have joined a club specifically for women in computer science. Ruiz (2017) has found that spaces like intentional clubs allow female STEM students to flourish in their chosen majors.

***Reaching Out to Friends for Support***. As a best practice for their challenges, 4 of the 15 (26%) participants shared that they reach out to their friends for support. Participant 15 said, "I feel that the best way for me to do well in class is to study with friends." Additionally, Participant 5 said, "When allowed, I like to collaborate with friends on projects." Participants' responses categorized in this theme did not specify the gender of friends they look to for such support. Such support could foster a sense of belonging for female students, who look for inclusivity in these programs (Yates & Plagnol, 2021).

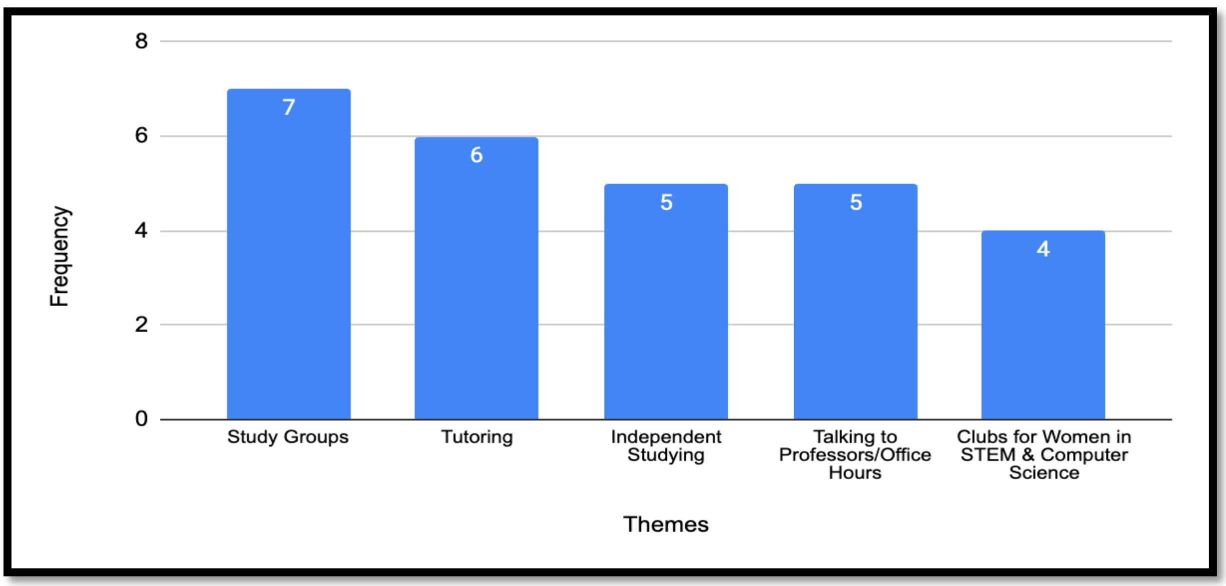
***Coursework Practice***. Three of the 15 (20%) participants expressed that doing practice for their classes is how they overcome additional challenges. Participant 9 shared, "I like to stay after class and finish up any notes I need to complete." Participant 2 stated, "I look through the textbook and see if there is any additional practice that will help me understand the material better." This student preparedness supports that women learning the content is not a problem that contributes to the gender gap in computer science.

**Interview Question 5 Summary**. When expressing the best practices participants employ in overcoming any additional challenges the most responses were themed in reaching out to teaching assistants, attending office hours, and participating in clubs aimed at women in STEM. Another resource participants brought up included reaching out to friends. Lastly, participants said they would practice their course materials to overcome their challenges.

**Interview Question 6**. Are you personally aware of strategies or best practices employed or resources sought by these women? (see Figure 10).

**Figure 10**

*IQ 6: Best Practices Sought Out by Women*




*Note*. $n$ = 15

***Study Groups***. When participants were asked what best practices other women in computer science-related majors employ, 7 of the 15 (46%) participants named study groups as a best practice. Participant 1 said, "I see people who write and rewrite notes with their friends." Additionally, Participant 10 said, "We have peer-led team learning that happens. Challenges are presented to groups and we work them out together. This helps everyone in the group understand the material." As such, Koca (2016) states that environments where students can learn from their peers can assist those students in appreciating the strengths of diversity in subjects like computer science.

***Tutoring***. Six of the 15 (40%) participants responded that other women in computer science-related majors seek out tutoring as a resource. Participant 4 said, "My school has a tutoring center, and I know other women to go to that for help." Participant 14 shared, "You see a lot of people who go to tutoring, especially if they got a score on a test they weren't happy with." Maltese and Tai (2011) state female students must have different types of learning experiences to build and foster STEM interest.

***Independent Studying***. In contrast to the theme of study groups, 5 of the 15 (33%) participants said that a best practice was women studying independently. As such, Participant 11 shared, "I know study groups work for some people, but I know a lot of people who would much rather do their schoolwork by themselves. I get that because sometimes I feel the same way." Similarly, Participant 1 said, "People like to study independently because the other people can be distracting."

***Talking to Professors & Office Hours***. Five of the 15 (33%) participants shared that a best practice for women in computer science-related majors employ is that of talking to their professors and visiting them during office hours. Participant 10 shared, "I go to office hours and have even asked professors for extra time on projects, and I know other women who've done the same." Participant 9 similarly said, "Sometimes going to office hours and just talking to the professors is the best thing." Time with faculty members is essential in engaging female computer science students, but it will need to be strengthened with training in inclusivity to affect female retention in the major (Killpack & Melón, 2016).

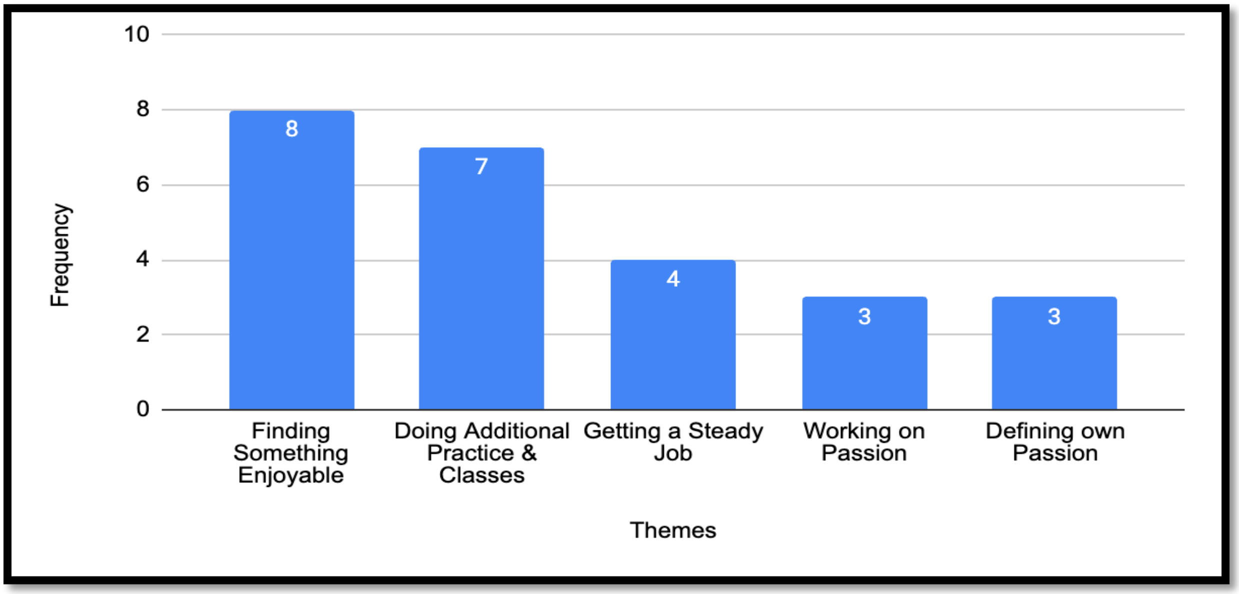
***Clubs for Women in STEM and Computer Science***. As an identified theme in IQ 5, clubs for women in STEM and computer science were expressed by 4 of the 15 (26%) participants as a resource. Participant 3 expressed, "There are tech clubs, and my school has a Women in Tech club I know some of my friends have joined." Parallel to that, Participant 13 said, "There are programs for women in computer science that I know my classmates and I have found helpful. You get to meet upper-class students who understand what you're going through." Spaces like these that can allow for collaboration and mentorship are important for the retention of female STEM students (Estapa & Tank , 2017).

**Interview Question 6 Summary**. Among the best practices that women in computer science-related majors seek out, participants shared that the most popular resource is that of study groups. Additionally, tutoring was also a named resource for women in computer science-related courses. However, studying independently was also identified as a theme. As such, resources sought out by women could include involving others or could be work done solo. Other themes that emerged from the responses were those of seeking help from professors during office hours and joining clubs for women in STEM and computer science.

**Interview Question 7**. What is your ultimate goal in pursuing a computer science-related major? (see Figure 11).

**Figure 11**

*IQ 7: Ultimate Goal of Participants*




*Note*. $n = 15$

***Finding Something Enjoyable***. When participants were asked about their ultimate goal in pursuing their computer science-related major, 8 of the 15 (53%) participants stated that they would like to find something they enjoy. Of those eight participants who responded within this theme, five of them responded by naming a specific company or industry in which they would like to work. Participant 4 said, "I would love to work for NASA or do something in cybersecurity." In also naming something specific, Participant 10 shared, "A dream would be to work on a mission to Mars in some capacity." In keeping with the theme, Participant 11 shared, "Wherever I decide to work, I just want to love what I do." For the retention of female employees in STEM-related industries once they enter the workforce, there is also a responsibility companies have to make sure to utilize a finding like this to affect the gender gap (Buse et al., 2013).

***Doing Additional Practice and Classes***. When asked about their ultimate goal in their major, 7 of the 15 (46%) participants expressed that they would like to do additional practice in their fields and to keep taking classes. Participant 4 said, "I would love to keep learning more coding languages so I could be better when it comes to cybersecurity." Participant 9 shared, "I want to keep taking classes so that I find my specialty. I still don't know what that is." Practice is important in universities ensuring they grant female students access to computer science-related courses to keep them engaged with the subject (Silva et al., 2022).

***Getting a Steady Job***. Four of the 15 (26%) participants in this study said their ultimate goal in pursuing their majors would be to obtain a steady job. Participant 3 said, "I would like to get the most out of the job market by getting something that is reliable. The tech industry has had a lot of layoffs lately, so that worries me, and I want to find something that will be stable." Participant 8 had a more direct answer and said, "I just want to get a steady job." In order to retain female employees, companies must also routinely reflect on their practices to allow for these types of steady opportunities (Smith, 2012).

***Working on Passion***. Passion was a word expressed in several responses in IQ 7. When asked about their ultimate goal, 3 of the 15 (20%) participants shared that they would like to work in a field that is their passion. Participant 1 said, "I want to work in something I'm passionate about and be successful in it." Similarly, Participant 11 said, "I want to be passionate about whatever it is I decide to do in my career." Allowing female computer scientists to pursue their passions lets technology companies promote their diversity efforts, which will also be beneficial for companies to drive up their profitability with their perspective of women making technology decisions for women being known from the outside (Nishii & Mayer, 2009).

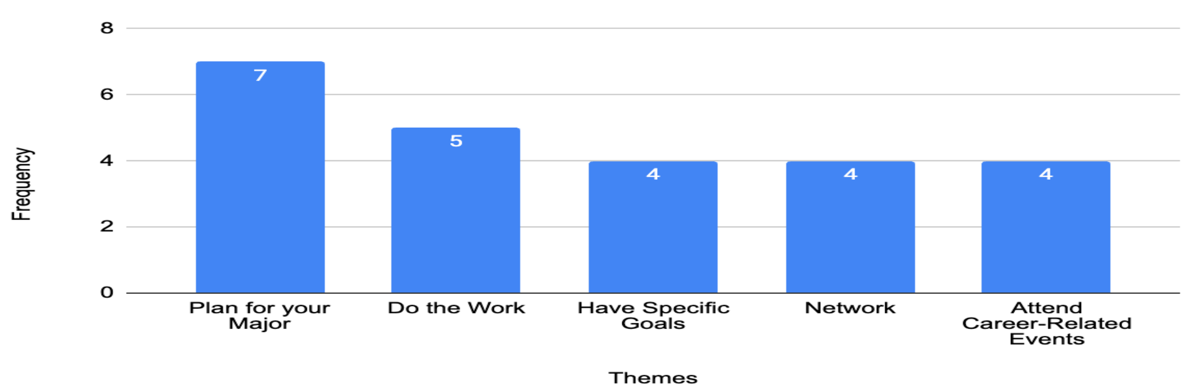
***Defining Own Passion***. Similar to the previous theme, passion was expressed when three of the 15 (20%) participants responded that they would like to define their passion as an ultimate goal. Participant 10 said, “I’m still trying to figure out what my passion is. I’m still not sure what that is.” Parallel to Participant 10, Participant 11 expressed, “I’m still trying to figure out my ultimate goal.” Allowing female computer scientists to define their passions could improve their morale in the workforce, which is beneficial to all employees (Avery et al., 2007).

**Interview Question 7 Summary**. Most participants expressed that their ultimate goal in pursuing their computer science-related majors lay in finding something they would enjoy. On a similar note, three participants said that they hope the job they find is a steady one. Several of those responses included naming specific industries or companies. Several participants also shared that they would like to continue learning content in their fields, like additional coding courses. The word passion was expressed by participants as they shared they would like to work on something they are passionate about or continue to define what their passion is.

**Interview Question 8**. How do you ensure you stay on track to that goal? (see Figure 12).

**Figure 12**

*IQ 8: How Participants Stay on Track With Goals*




*Note*. $n = 15$

***Plan for Your Major***. When participants were asked how they would ensure they stay on track with their ultimate goal, 7 of the 15 (46%) participants shared that they would do so by planning for their major. Four of those participants shared that they would specifically plan out the courses they are taking. Participant 11 said, "I plan what classes I am going to take each year and each semester. That helps me stay on top of my goals" Participant 8 shared, "I want to make sure I fulfill the requirements for my major." University supports for female STEM students are key to them remaining in their planned majors (Savaria & Monteiro, 2017).

***Do the Work***. Five of the 15 (33%) participants shared that they ensure they are on track with their goal by doing the work for it. Participant 11 stated, "I have a flow chart of what I need to do and that helps me make sure that it gets done." Participant 7 said, "I just make sure I am getting through the work." Doing such work could be further strengthened by allowing female computer science students to collaborate on their work in their learning environments (Yates & Plagnol, 2021).

***Have Specific Goals***. Participants shared that having specific goals is how they make sure they are keeping track of their goals, with 4 of the 15 (26%) of them saying as such. Participant 2 said, "I make sure I'm on track by having smaller specific goals and completing them at specific times." Participant 13 also shared, "I like having smaller attainable goals, it helps me reach the bigger ones." Such a finding is supported by Eagan et al. (2014) as they state female students tend to keep their interest in their STEM subject once they have decided to major in it, which allows for specific goals to keep them on track with their majors.

***Network***. Four of the 15 (26%) participants shared that they network to ensure they are staying on track with their ultimate goal. Participant 9 said, "I make sure I network. Then every three months I touch base with them to look for new opportunities and to make sure they remember I am still interested in being involved with them." Similarly, Participant 14 stated, "I like working on building a network, that way I can make sure I can take advantage of it, especially when I graduate." With participants wanting to network, corporations could benefit from this by creating bridge programs that allow women be successful in the technology sector (Gerhart & Carpenter, 2014).

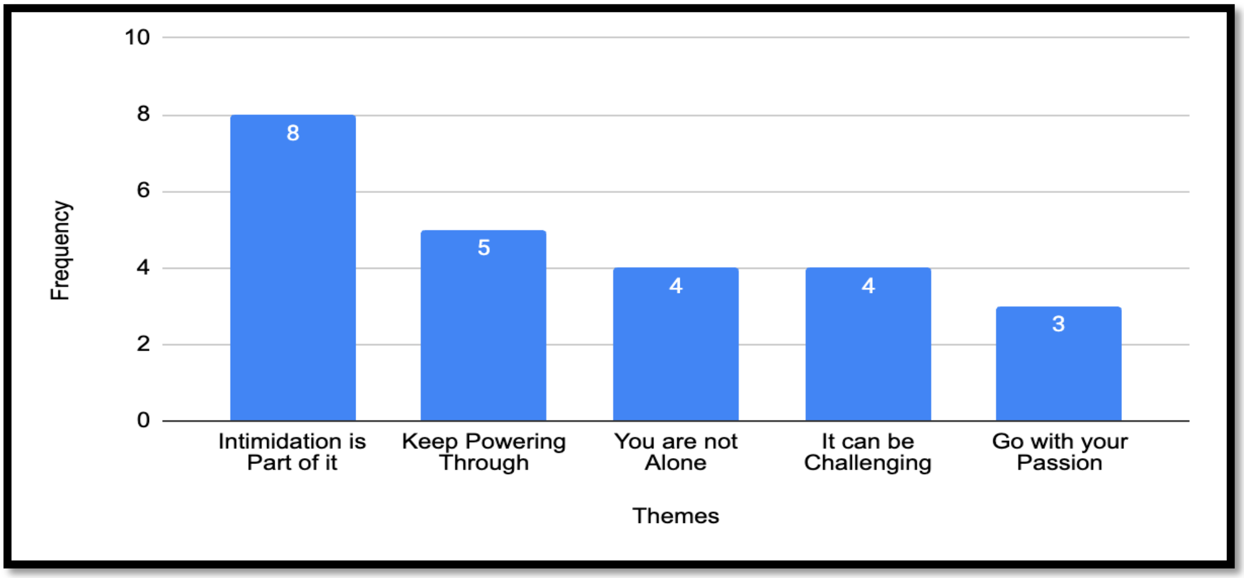
***Attend Career-Related Events***. A final identified theme related to how participants ensure they stay on track with their ultimate goal is related to the previous theme as 4 of the 15 (26%) participants said that they attend career-related events. Participant 9 said, "I make sure I go to events that involve alumni, conferences, and job fairs." Job fairs were also named by Participants 4 and 14. Participant 3 expressed, "I like visiting my school's career center for new opportunities." Companies should also be proactive in their efforts for outreach to prospective female employees as it would demonstrate that they are dispelling stereotypes of men being seen as more innovative than women (Hathaway & Kallerman, 2012).

**Interview Question 8 Summary**. Participants in this research study shared how they ensure they stay on track with their goals. Seven participants shared that they prepare for their major, by planning their classes and keeping track of what they need to complete to graduate. Participants also shared that they make sure they get their coursework done and making sure they stay on top of their assignments. Insights from participants' responses also demonstrated that having smaller specific goals, networking, and attending career-related events, like job fairs, allow them to keep track of their goals.

**Interview Question 9**. What advice or recommendations do you have for aspiring women who want to pursue studies in computer science-related majors? (see Figure 13).

**Figure 13**

*IQ 9: Advice and Recommendations for Aspiring Women*




*Note*. $n = 15$

***Intimidation is Part Of It***. The majority of participants shared that they would tell other aspiring women looking to pursue computer science-related majors that intimidation is part of it, with 8 of the 15 (53%) participants saying as such. Participant 5's response connected to the earlier theme of imposter syndrome, by saying, "It's okay to have imposter syndrome because it is easy to think you don't have the skills to do it." Participants 1 and 9 shared that aspiring women will have doubts and hesitations, but that they should not doubt themselves. Intimidation can come from stereotypes that women are less suited for jobs in computer science than men (Yates & Plagnol, 2021).

***Keep Powering Through***. Five of the 15 (33%) participants in this research study shared that they would tell aspiring women in computer science-related majors to keep powering through. Participant 10 stated, "As expressed by Nike, just do it. You just have to do the work and take it one step at a time." Participant 6 said, "You need to tell yourself that you can do it and keep doing the work." By powering through, female computer science students could contribute to dispelling that men are more capable than women in STEM (Silva et al., 2022).

***You Are Not Alone***. Participants also shared that they would tell aspiring women that they are not alone, with 4 of 15 (26%) expressing as such. Participant 10 shared this through her advice by saying, "Talk to women who have been through it, it's very helpful." Similarly, Participant 13 said, "Know that there are others who have been 'in the same boat' and that you are not alone in this." Empowerment among female computer science students is key to providing a sense of belonging (Yates & Plagnol, 2021).

***It Can Be Challenging***. Four of the 15 (26%) participants acknowledged that being in a computer science-related major as a woman comes with its challenges. Participant 7 advised, "Be prepared for the challenge. It can be difficult and discouraging at times." Additionally, Participant 9 said, "There is a stigma of women in STEM. That stigma presents its own challenges." While one root cause for the gender gap in computer science cannot be pinpointed, it can be challenges like societal stigmas and lack of encouragement that can contribute to the gap (Silva et al., 2022).

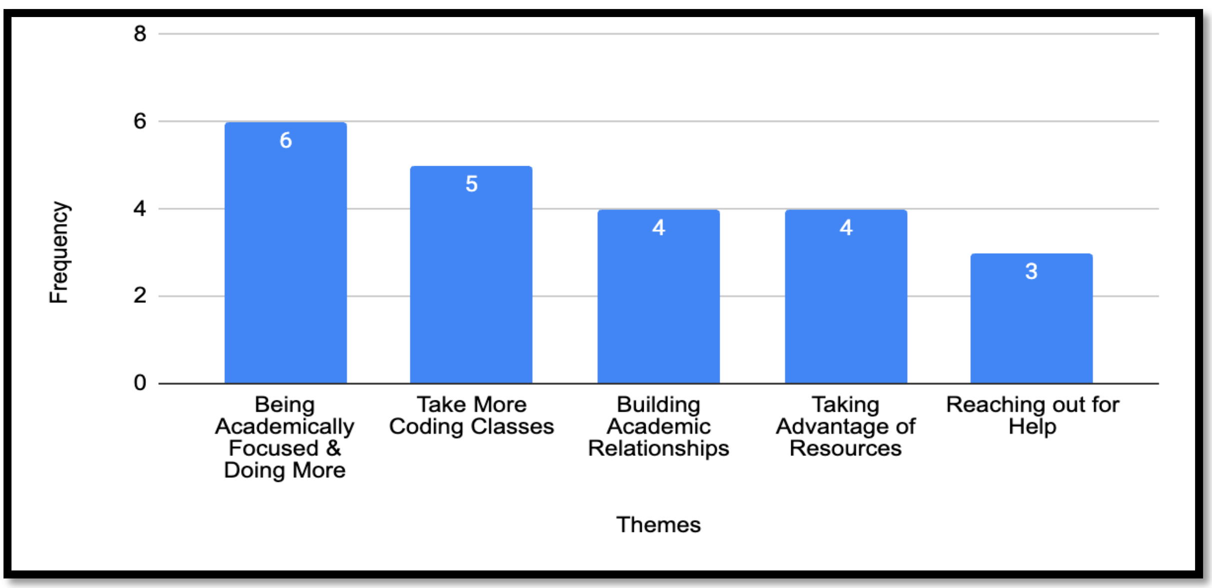
***Go With Your Passion***. A final theme to IQ 9 that 3 of the 15 (20%) participants shared they would tell aspiring women in computer science-related majors was for them to go with the passion. Passion, which made up two themes for IQ 7, came up again for this question. Participant 1 said, "I would tell other women to let your passion drive you. Apply what you're learning and learn to make it personal." Companies could also allow their female employees to go with their passions so that employees with new talents and skills could be onboarded (Forsyth, 2010).

**Interview Question 9 Summary**. When participants were asked what advice or recommendations they would give to women aspiring to pursue computer science-related majors, several responses had to do with obstacles, with the majority of the participants stating that intimidation is part of the academic journey and an acknowledgment that the major can be challenging. Specifically for advice, participants would tell aspiring women to keep powering through, remind them they are not alone, and to go about their academics with their passions in mind.

**Interview Question 10**. If you could, what is the one thing you would do differently if you were to start your studies over? (see Figure 14).

**Figure 14**

*IQ 10: One Thing Participants Would do Differently*




*Note*. $n = 15$

***Being Academically Focused and Doing More***. For their last interview question, participants were asked to look back on their experiences and what they would do differently. Six of the 15 (40%) participants expressed that they would be more focused on their academics and would have done more during their studies. Participant 1 said, "I wish I would have been more focused my senior year of high school, especially towards the end. I was just trying to get by and I should've paid more attention." Similarly, Participant 9 said, "I would have put in extra effort like I should've done some extra studying earlier in school." This type of preparedness is shown to be important, especially to young girls, as they begin to learn computer science skills early on that will set them up for long-term success in the subject (Froschl & Sprung, 2014).

***Taking More Coding Classes***. Five of the 15 (33%) participants in this research study shared that one thing they would do differently is they would have taken more coding classes. Participant 7 said, "I would learn more code, not just do what was conveniently offered to me. I would've also liked to have joined hackathons." Parallel to that response, Participant 3 said, "I would have taken coding classes earlier, like in the summer, so that I would've had more experience before going to college." Allowing female students to have various types of STEM experiences could strengthen their mindset with subjects like computer science (Maltese & Tai, 2011).

***Building Academic Relationships***. Four of the 15 (26%) participants expressed that they would have built academic relationships earlier in their academic careers. Participant 5 shared in her response, "I should've reached out for help earlier. I wish I had talked to professors and TAs when I first started having questions or didn't understand something. Now it's not a problem, but I think I would be in a better place and more comfortable if I had done that when I first started college." This type of relationship-building is important for universities to take note of as faculty-to-student experiences can be quite effective in closing the gender gap when there is a positive rapport present (Komarraju & Nadler, 2013).

***Taking Advantage of Resources***. Related to the previous theme, 4 of the 15 (26%) participants in this research study shared that they would have liked to take advantage of resources earlier during their studies. Participant 7 said, "I wish I had sought out opportunities, especially in computer science earlier, like in high school." Additionally, Participant 11 said, "I wish I would have gone to tutoring when I had my first challenges." Making resources that also allow for collaboration and mentorship available to female computer science students further motivates them to continue their studies in the subject (Eagan et al., 2014).

***Reaching Out For Help***. A final theme shared by participants for IQ 10 was 3 of 15 (20%) of them expressed that they wished they had reached out for help as something they would go back and change if they could. Participant 6 said, "Now that I'm in my second year of college, I wish I had reached out to classmates sooner for help, especially my freshman year." Similarly, Participant 15 said, "I would've liked to ask for help earlier in whatever way that would've helped me, especially that first semester of college." Faculty members must also make themselves available to their female students so students build their self-efficacy and confidence in computer science (Litzler et al., 2014).

**Interview Question 10 Summary**. Participants were asked to look back on their experiences and share one thing they would do differently if they were to start their studies over again. The most common theme was that participants wished they had been more academically focused or put more work into their studies. Comparably, participants also shared they wish they had taken more coding classes, which ties into their computer science-related majors. Looking for outward support, participants shared that they would have liked to build academic relations, take advantage of resources, and reach out for help earlier in their academic careers.

## Chapter Summary

Responses were collected from 15 female first and second-year college students in computer science-related majors through in-depth interviews based on 10 interview questions. The raw data gave insight into participants' experiences with their academics as they pursued their STEM goals. Most participants were first-year undergraduate students with some second-year students. While most participants are college students in California, a third of them are enrolled in schools in other US states.

Participant interviews captured the lived experience of these female college students as they pursued a major in a male-dominated field. Their responses were insightful and valuable in understanding their academic journeys. Furthermore, participants offered advice for women aspiring to pursue computer science-related majors. While there were challenges participants identified for themselves and other women pursuing STEM careers, participants additionally shared their best practices for overcoming those challenges.

Out of all of the question responses, the theme with the highest yield demonstrated that the gender gap in computer science-related courses is evident to the majority of the participants. Findings revealed that women in these courses also look for the support of other women, through friends and through college clubs aimed at supporting women in STEM and computer science. In reflecting on their experiences, participants shared that they wish they would have done more to be academically prepared at an earlier time in their computer science-related studies. Additionally, participants want other women aspiring to pursue computer science-related majors to know that there are challenges and obstacles but for them not to doubt themselves as they keep doing the work moving forward in their college career. A summary of the themes and findings from participant responses is listed in Table 6.

**Table 6**

*Summary of Common Themes by Research Question*

| RQ1. What challenges do female first and second-year college students face in pursuing computer science-related majors? | RQ2. What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges? | RQ3. How do first and second-year female college students measure success in pursuing computer science-related majors? | RQ4. What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science? |
|---|---|---|---|
| Challenging Courses and Class Rigor | Women Supporting Other Women | Finding Something Enjoyable | Intimidation is Part of Studying Major |
| Academic Insecurity | Peer and Classmate Support | Getting a Steady Job | Keep Powering Through |
| Imposter Syndrome | Practicing Course Materials | Wanting to take Additional Classes | You are not Alone |
| Not Having a Good Teacher Experience | Reaching out to Instructors, TAs, and Attending Office Hours | Working on Passion | It can be Challenging |
| Lack of Women in Program | Clubs Aimed at Women in STEM | Defining own Passion | Go with your Passion |
| Interactions & Competition with Other Students | Study Groups | Planning for Major | Be Academically Focused and do more |
| Men Being More Confident | Tutoring | Doing the Work | Take More Coding Classes |
| Friends & Family Support (in experiencing challenge) | Studying Independently | Networking | Build Academic Relationships |
| | | Having Specific Goals | Take Advantage of Resources |
| | | | Reach out for Help |

*Note*. Table 6 displays a summary of themes derived from data in participant responses through an analysis process.

The researcher appreciated the insights shared by participants in the raw data and the revelations their responses showcased. Given the themes extracted from the interviews, the researcher will make recommendations in Chapter 5, particularly for college-level computer science-related academic programs. In Chapter 5, the researcher presents a narrative of the study, the study's results, and a discussion for each question. Additionally, the research will share implications for the study, the conclusions from this study, recommendations for future research, and the final thoughts derived from the study.

# Chapter 5: Summary, Implications, Conclusions, and Recommendations

## Introduction to the Study

There is an urgency that needs emphasis to close the gender gap in the computer science industries and its related fields (L. L. Wang et al, 2021). This gap can be affected by findings of from first and second-year female undergraduate students as they pursue majors in these fields. Best practices derived from participant interviews, as they reflect their lived experiences, have the potential to grow interest and retention of women in these majors, which could ultimately affect their retention in the industry once they enter the workforce.

### *Intent of the Study*

There is a gender gap in computer science with men dominating the field (L. L. Wang et al, 2021). While the number of women in computer science has increased, there was a need to study why so few women pursue computer science as a major during their undergraduate studies (Yates & Plagnol, 2021). This study intended to gain insights into the success factors, challenges, and best practices of female college students in computer science-related majors, specifically during their first or second year of college.

Only 20% of computer science majors are women, therefore, capturing these best practices from the study's participants allows for college computer science programs to also gain significant insights into the recruitment and retention of female students (Master et al., 2021). According to Florentine (2018), women are 45% more likely than men to exit the field. As such, responses from this research study's interviews would allow for these computer science programs to inform how they shape their programs.

### *Purpose of the Study*

The purpose of this study was to understand student issues causing the gender gap in the technology field. Yates and Plagnol (2021) express the concern behind this purpose by stating that without leveling out the women in computer science and in the technology field, decisions affecting women's technology use may not be made by women. This is especially concerning since computer science continues to be dominated by men with men being 80% of those professionals (National Center for Education Statistics, 2023).

The purpose of this study was to inform readers of the issues students face that contribute to this gender gap, and by sharing data from first and second-year female college students in computer science-related majors, that information can be used in college programs to assist in closing the gender gap in the field. Increasing the number of female computer science majors or in related STEM majors could increase the number of women who work in the technology sector and decide to stay in the industry. At the college level, not unlike the professional field, women only make up 21% of computer science majors, a population that this study looks to increase (National Girls Collaborative Project, 2023).

## Summary of the Study

This study looked to affect change to level out the gender gap in the field of computer science so that technology decisions for women are made by women. Parallel to companies, the timeliness of college can be founded in the vision of its learners, flexibility, and ability to collaborate (Gomez-Mejia et al., 2018). Therefore, colleges must look to their visions and flexibility to ensure female students looking to major in computer science both increase and numbers and that those women stay to pursue careers in STEM industries.

As such, this study enlisted 15 participants from various colleges who were identified as female first and second-year college students in computer science-related majors. Those 15 participants were interviewed and findings and common themes were pulled from their interview responses. Additionally, the study's findings were compared to data found in the literature that could support, continue, or nullify the existing body of research.

After reviewing the academic literature, four research questions were formed, with 10 corresponding open-ended interview questions to gain qualitative data. The research questions this study looks to answer are the following:

- RQ1. What challenges do female first and second-year college students face in pursuing computer science-related majors?
- RQ2. What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges?
- RQ3. How do first and second-year female college students measure success in pursuing computer science-related majors?
- RQ4. What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science?

The interview questions were then asked of the 15 participants that were used to inform this phenomenological research study. Per Creswell and Creswell (2021), this approach captures the participants' lived experiences as they relate to the phenomenon.

Chapter 1 of this phenomenological research study provided an introduction, while Chapter 2 provided a literature review that discussed information regarding the purpose of the study. Chapters 3 and 4 included the structure for conducting the study and demonstrated how the data were gathered as well as the results from the data. After forming that basis, data were collected from the 15 participants in semi-structured interviews that were validated via prima facie validity, peer reviews, and expert reviews from the dissertation committee members. Responses from the participants were documented through audio recorded and then transcribed, with information being kept in a password-protected computer.

Data from responses were then coded into common themes. After the first three coded interviews concluded, inter-rater reviews took place, which provided the researcher with feedback taken into consideration as the remaining interviews continued. From there, data from all 15 interviews was coded into themes, and those themes were displayed with bar graphs and summaries of interview responses. The collection of themes was then used to inform discussions of findings, implications for the study, applications, conclusions, and recommendations for future research.

**Discussion of Findings**

This study looked to identify best practices for first and second-year female college students in computer science-related majors. As such, findings from this qualitative research study may help inform the practices of college computer science-related programs to increase female student enrollment and retention in such programs. Similarly, other college-level STEM programs could utilize the data for female student enrollment and retention as well.

As such, this study sought to identify the challenges and success factors of first and second-year female college students in computer science-related majors through themes identified from interviews with participants who share the phenomenon. From the research, 45 themes were identified that emerged from participant responses.

***Results for Research Question 1***

Research Question 1 looked to determine what challenges first and second-year female college students in computer science-related majors have faced in their studies. From an analysis of participant responses, eight common themes emerged: challenging courses and class rigor, academic insecurity, imposter syndrome, not having a good teacher experience, lack of women in the program, interactions and competition with other students, men being more confident than women, and friends and family support.

Participants shared that the rigor of their STEM courses presented a challenge, including the pace of their coursework. This included participants needing to balance out those challenges to keep up with their assignments and assessments. This also included the pace of the courses given the amount of content they needed to learn within each term. Furthermore, when it came to challenges, six participants shared that one of those challenges was academic insecurity. On the topic, those participants shared that they have experienced feelings of not being good enough, stress, and unpreparedness. Academic insecurity also came in the form of two of the participants debating whether or not they wanted to continue to pursue a computer science major. Additionally, three of the participants specifically named imposter syndrome as a challenge they have experienced. Participants tied this theme to that of men being more confident than women. One participant stated she felt imposter syndrome as soon as she started her university studies.

Participants also shared that they had not had a good experience in a class because of their teacher. Three of the participants whose responses informed this theme had a connection to the theme of class rigor, specifically in mathematics courses. Two participants also shared that those experiences led them to retake those mathematics courses. Moreover, most participants shared that they noticed the lack of women in their computer science-related programs, adding that the gender gap is noticeable. The literature indicates that closing the larger issue of the gender gap will take strides in moving national efforts forward to increase female enrollment in computer science (Gould, 2015). One participant shared that in some of her courses, she has been the sole woman there.

Six participants indicated that a challenge for them came down to their interactions and competitiveness with other students. This type of competitiveness did not specify competition of one gender with another, but rather the feelings of overall competitiveness in STEM courses. These types of interactions also contributed to participants finding it a challenge to form supports such as study groups. As such, participants shared that men in their classes are seemingly more confident, but oftentimes it comes off negatively. This included men correcting and double-checking the work of their female classmates. This also included feelings of men dominating the class.

While not a challenge, several responses indicated that participants looked to their friends and family members when facing those challenges. Some of these supports came in the form of comfort, help in the classes, and encouragement for one another. These supports continue to allow participants to face the aforementioned challenges.

***Discussion of Research Question 1***

According to results, first and second-year female college students pursuing computer science-related majors face challenges, mainly connected to their learning environments, which aligns with findings in the literature. This includes noticing the majority of men in those classes, but also the hostility that stems from men's attitudes and behaviors in the classroom. These themes could conflate with the literature in that Silva et al. (2022) describe that female students tend to think less of their capabilities in computer science classes, and as such, could find those courses more challenging. Yates and Plagnol (2021) support this by adding that women tend to downplay their competencies in computer science, which could add to the perception that those courses are a challenge. To address this, N. J. Kim (2017) states that STEM-related courses should include experiential learning to create stronger learning environments. Additionally, Prince (2004) added that collaborative learning could strengthen STEM classroom environments. While it has been shown that women tend to underestimate their technical abilities, this connects to data from Yates and Plagnol (2021) in that men tend to overestimate theirs. Attitudes like these can discourage female students from pursuing computer science (Silva et al., 2022).

When it came to the theme of imposter syndrome, the finding could have a connection with women tending to rate their technical skills at a lower level than men, even when they perform equally or better than men in computer science (Yates & Plagnol, 2021). Fitzsimmons (2021) adds that a sense of belonging could support a growth mindset of female students in computer science, which could address the issues brought forth by feelings of imposter syndrome. Academic insecurity has the implication its presence could affect the retention of female students in these majors. However, research shows that female students are often equal to or outperform male students in STEM subject assessments Larson, 2021). Therefore, the internal feelings of academic insecurity may not reflect the class performance of female students. These challenges are further demonstrated by participants sharing that they've had negative experiences with teachers and that their coursework could be quite rigorous.

Closing the gender gap will also take efforts to implement early exposure to STEM that provides learning opportunities for students of all genders (Seepersad, 2016). This could be addressed by implementing best practices in the classroom that allow for the inclusivity of all students in STEM-based subjects through professional development for instructors (Estapa & Tank, 2017). Female students in particular need to feel a sense of belonging in their learning environments as opposed to feelings of competition with their classmates (Sap et al., 2016). Additionally, interactions have been identified as a challenge as Powell and Graves (2003) indicated that accessing networks for mentorships and support and their availability has been a barrier for women in STEM. However, on a positive note, participants also shared that they can turn to their friends and family for support in pursuing their computer science-related goals.

***Results for Research Question 2***

Research Question 2 looked to determine the strategies first and second-year female college students in computer science-related majors employ when overcoming their challenges. From an analysis of participant responses, eight common themes emerged: women supporting other women, peer and classmate support, practicing course materials, reaching out to instructors, TAs, and attending office hours, clubs aimed at women in STEM, study groups, tutoring, and studying independently.

Participants found that women supporting other women in their courses has been a strategy they have employed to overcome challenges. One participant indicated how in her courses women look out for one another ensuring they don't leave a woman out. Participants also find comfort and support with women when it specifically comes to their computer science-related courses. Furthermore, gathered by the responses from the interview questions that corresponded to RQ 1, support from peers and classmates was found as a way for participants to overcome their challenges. Unlike the previous theme, responses coded in this theme were not specific to any one gender. Additionally, a participant shared that talking to the men and getting to know everyone in the courses was a strategy employed.

In one of the more practical strategies that emerged from participant responses, derived the common theme of doing and practicing the coursework. This included participants reviewing, previewing, and asking questions about their coursework materials. One participant noted that the best strategy was to keep practicing and doing the work for the courses. Several participants indicated that going beyond the class and reaching out to educational faculty, including during available office hours, was a way they overcame classroom challenges. Participants also stated that this practice was something that did not come to them initially and that it is now a practice that is more routine. Several participants also shared that they would have reached out to academic faculty sooner if they were to start their journey over again.

Colleges having available clubs aimed at women in STEM was a strategy participants highlighted in their responses. Six of the study's participants indicated that their school had such programs to support women. Additionally, two other participants indicating joining parallel clubs, but that those clubs were not geared toward a specific gender, but that they have been helpful during their time in college. Parallel to this, seven of the research study's participants indicated that study groups allow them to overcome their challenges. Participants indicated that study groups allow them to rewrite notes with friends and collaborate on challenges. Responses pertaining to study groups were not indicative of any one gender making up the majority of those study groups.

Six participants specifically indicated in their responses that tutoring was a best practice employed by women to overcome their computer science-related challenges. These responses indicated that most of them knew of another woman who sought out tutoring, with only two indicating that they went to tutoring themselves. Therefore, colleges having services like tutoring centers could greatly affect the success of female computer science students. However, in contrast to study groups, five of the participants indicated that they study independently to overcome their challenges in computer sciences. One participant indicated that while she looks to study groups for some lessons, studying on her own allows her to focus on the tasks at hand. Another participant indicated that independent studying allows her to get ahead in lessons when compared to studying with a group.

### *Discussion of Research Question 2*

Female undergraduates in their first years of computer science-related studies look to others for support when addressing their challenges, challenges that were supported by the literature. Several women look to other women for female-to-female empowerment. According to Yates and Plagnol (2021), environments that allow for female-to-female empowerment create a sense of belonging for women in computer science but reaching out to other classmates, regardless of gender, is also helpful. Reaching out outside of class to academic resources has also been a strategy participants employ. Engagement like this, as discussed by Munoz-Boudet (2017), can be telling of interest in computer science down the line for female students.

That includes being involved in clubs aimed at women in STEM and reaching out to educational faculty outside of class, including office hours. Ruiz (2017) states that having spaces for female mentorship, including that from more experienced students, allows female students to flourish and enhance their learning experiences. This is parallel to Yates and Plagnol's (2021) of addressing the gender gap in computer science by providing female-to-female empowerment. Lastly, doing the work needed for classes, whether in a study group, through tutoring, or working independently allows female computer science students to overcome their challenges. This is supported by Ambrose and Sternberg (2016), who state that learning to work in teams allows for the optimization of contributions in companies, although the practice in university settings for students lacks literature to support this for women in computer science studies

### *Results for Research Question 3*

Research Question 3 looked to determine how first and second-year female college students in computer science-related majors go about measuring success. From an analysis of participant responses to corresponding interview questions, six themes emerged: finding something enjoyable, getting a steady job, wanting to take additional classes, working in and defining passion, planning for major, and networking.

The majority of the research study's participants indicated finding something enjoyable was a measure of success to them. Several of these participants also indicated specific fields or industries they would like to be involved in with their careers, including aerospace engineering, cybersecurity, and NASA launches. Ultimately, these participants shared that those are fields and industries that would bring them joy, while the remaining participants will feel successful if they love what they do. Related to the previous theme, but on a more practical note, participants indicated that a measure of success would be getting a steady job. One participant shared that she would like to get the most out of the job market given concerns about layoffs in the technology industry that had taken place around the time of her interview.

When asked about their goals, seven of the participants indicated that they would like to take additional classes. This was mainly for their want of improving their computer science skills, specifically having to do with them wanting to learn more coding languages. One participant shared that she would like to take classes to find out what her specialty will be, which she has not figured out yet. This can be connected to the aforementioned theme of getting a steady job, as acquiring skills could indicate greater job security. Additionally, six of the research study's participants specifically named that a success factor had to do with their passion. Three of the respondents shared that they would like to work in something they are passionate about, while the other three will know success once they have defined what that passion is. If women can see themselves in different branches of computer science, then they could see themselves pursuing their passions in the field.

Planning for more immediate milestones is a measure of success for most participants. Seven of the participants indicated that see success as planning for and continuing their studies within their majors. Additionally, four participants shared that they like having specific goals that are attainable. This measurement of success can be highlighted as a response to the challenging courses and rigor as indicated in RQ1 responses, which indicated its importance to participants. Furthermore, networking was seen as a measure of success for participants as they looked to build their connections to ensure job placement and satisfaction throughout their careers. Four participants indicated that they attend networking events such as job fairs and alumni mixers. Staying on the radar of their network connections has also been expressed as an important factor in ensuring industry success. This could further inform their measurement of success being that they have a steady job.

***Discussion of Research Question 3***

Measures of success for first and second-year female college students in computer science-related majors are mostly associated with how they envision their careers. Participants want to build their networks while they are in college to ensure they find a steady job that they enjoy. However, the retention of women technologists will be indicative of whether companies offer mentorship for their female employees, which Koch and Gorges (2016) have found to be a best practice that supports Ruiz's (2017) findings that women need a sense of belonging. Gerhart and Carpenter's (2014) work supports this in indicating that bridging recent graduates to industry skills could benefit both employees and the industry.

Additionally, participants are looking to do work in which their passions lie. Finding a passion comes from belonging in STEM, which means that women see their place in the field by imagining what a computer scientist looks like, mainly a White male (Sap et al., 2016). To look ahead at their careers, and as supported by the literature, participants are ensuring that they complete smaller attainable goals, but that also includes making sure they fulfill their graduation requirements by taking and planning for corresponding courses.

### *Results for Research Question 4*

Research Question 4 looked to identify recommendations first and second-year female college students pursuing computer science-related majors would offer to other women aspiring to pursue those majors. From an analysis of participant responses to corresponding interview questions, seven themes emerged: intimidation is part of studying the major, keep powering through, you are not alone, go with your passion, be academically focused and do more, build academic relationships, and take advantage of resources.

Several participants shared that they would tell women aspiring to pursue computer science-related majors that they will feel intimidated and that is part of the program. According to participants, this can stem from feelings of inadequacy, interactions with classmates, and the course content. As expressed by participants, aspiring women in the field should accept that it is part of this educational pursuit. But without addressing issues like intimidation, Killpack and Melón (2016) indicate that resources for allowing groups, such as women, to have a sense of belonging are key to retention in technology programs.

When it comes to the common theme of powering through as a recommendation, participant responses were fairly short with comments that included just doing the work and going for it. One participant shared that she would tell aspiring women to just let themselves know that they can do it and to find what works for them. One participant shared that she checks in with herself to make sure she is indeed completing the work she needs to get done at that given time.

Four of the research study's participants stated they would like to let women aspiring to pursue computer science-related majors that they are not alone. Two of those participants wanted to remind those women that there are others who have gone through it and to reach out to those women. This ties to the earlier theme of women supporting other women, as they are ensuring no woman is left behind. Furthermore, participants would like to share with women aspiring to pursue computer science-related majors to go with their passion. One participant advised that women aspiring to pursue the field to love what they do. Similar to responses to RQ 3, working with passion came up within the recurring themes among participants.

Eleven participants shared responses categorized into the theme of them having done more or having been more academically focused if they were to start their studies again. Five of the participants said they would have liked to have taken coding classes earlier in their studies or to have learned more code once they decided to pursue computer science. Those participants expressed that through earlier exposure to coding, they feel they would have a stronger foundation in college. Additionally, participants recommend that women aspiring to pursue computer science-related majors start building their academic relationships early. This coincides with their best practice theme and participants sharing that they would have reached out to professors and TAs earlier than they did if they could start again. As such, participants want future female computer science students to know that they should take advantage of the availability of academic faculty.

Keeping in mind the strategies shared by participants, they similarly shared that they would advise female computer science students to take advantage of resources. These resources include tutoring, course materials, and looking for ways to be involved in computer science. This also tied into the theme of participants utilizing time with academic faculty.

***Discussion of Research Question 4***

When participants were asked questions corresponding to what they would share with women looking to pursue computer science-related majors, they acknowledged that there would be challenges present. Challenges include intimidation and feelings of being alone. As indicated by Prince (2004), having this type of reaching out could be significant to women staying in computer science as mentorship for women by women has been indicative of both success and retention in the field. Yates and Plagnol (2021) state that a challenge for women in computer science is being in environments with inadequate resources for them, and as such, participants shared that if those resources are available, they should be utilized.

One best practice identified in the literature is for educational faculty to have professional development aimed at inclusivity of diverse groups of learners and allow for a sense of belonging for everyone (Killpack & Melón, 2016). Additionally, to address this, participants would advise female students to keep powering through, to keep their passions in mind, to do the work, and to seek out resources. Especially for early college students, this time could be pivotal for women to decide to no longer pursue computer science if they feel they cannot continue with their studies in the field (Fitzsimmons, 2021). Participants also advise female students to start acquiring computer science skills as early as possible with additional courses, specifically those in coding. Early exposure to computer science and STEM is highly indicative of the long-term interest held by female students when considering college majors (Lin & Chan, 2018).

**Implications of the Study**

This research study's purpose was to identify best practices and strategies employed by first and second-year female college students in computer science-related majors. As students look ahead at their careers in a male-dominated field, participants are mindful of the gender gap in their majors. Therefore, findings in this study could inform colleges, educational faculty, and educational staff, particularly those in STEM and computer science programs, how they could best support this student population to ensure an increase in female enrollment and retention in such programs.

Additionally, findings from this study could support environments involved in K-12 education. Research indicates the importance of early recruitment and interest in STEM for young girls, and as such, if they lose their interest over time, the issue of the gender gap will continue to persist. Looking into their future graduates, K-12 institutions can gain insight from this study into what best practices can be employed early on by both their female students and the faculty who teach them. Participants indicated that they wish they had taken their K-12 studies more seriously or would have taken more computer science-related courses, and that is information institutions could use to affect the gender gap for future generations.

Similarly, the study has implications for informing best practices for corporations. The technology industry is a large indicator of the gender gap. Through best practices found in this research study, companies can begin looking at how they can affect the gender gap for both recent graduates and college students who are looking to take advantage of the professional networks they are building during their collegiate pursuits.

**Application**

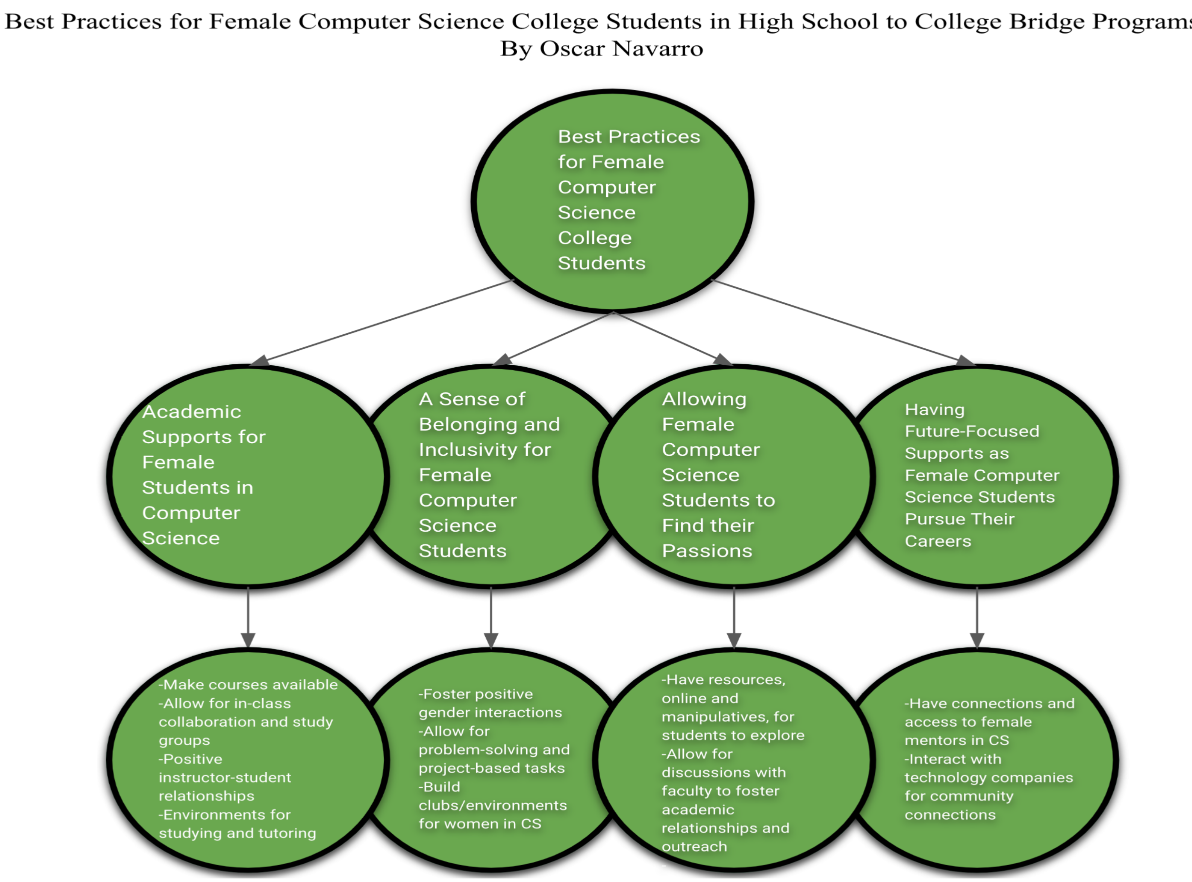
To address the gender gap in computer science, keeping in mind the population of first and second-year female college students in computer science-related majors, an application model was created by the researcher. This application model was created so that colleges could address four best practices when structuring their computer science and related STEM programs. This model identifies four key areas the research identified to be areas of growth for these college programs for the recruitment and retention of female students into their available computer science-related majors.

The model, as shown in Figure 15, demonstrates four identified areas colleges should include in their training and professional development programs regarding computer science. This model is the basis for a bridge program for recent high school graduates entering college as computer science majors. Bridge programs allow students to be better-prepared post-college with the skills their industries will require of them, further setting female computer science students up for success in the long term and affecting the gender gap in the industry (President's Council of Advisors on Science and Technology, 2012). Additionally, bridge programs allow students to see that there is a real demand for their careers, which could allow them to stay on track with their studies (New York University, 2018).

The first key area is for universities to have academic support for their female computer science students. This includes support such as tutoring and making educational faculty available for office hours. Additionally, female students should have additional courses available to them to expand their computer science knowledge in topics such as coding.

**Figure 15**

*Best Practices for Female Computer Science Students*




*Note*. By Oscar Navarro

The second application college programs could implement is the best practice of creating a sense of belonging and inclusivity for female computer science students. Analysis of the data found that several female students notice the gender gap and are also affected by their interactions with their male counterparts. As such, professional development geared toward academic faculty making their learning environment more inclusive so that women feel they have a place in the course could be imperative to their retention in such programs.

The third application as a best practice is to allow female computer science students to find their passions. Passion was a term used in several responses to the interview questions and was a recurring theme for two of the research questions. As such, female computer science students need to be allowed the space to explore STEM through various types of experiences, including those proven to resonate with them. Additionally, by allowing a space for discussion with academic faculty, conversations could lead to exploring and defining passions related to computer science.

A final application of the model for best practices that can be employed by colleges is that colleges should have future-focused support for their female computer science students. This support is with a future focus on the careers these students will embark on once they graduate. The data indicates that students want to build their network to find jobs they enjoy, allow them to work in their passion, and provide them with stability. Given the gender gaps in corporations, this is beneficial for technology companies to engage with as they could affect change in this male-dominated industry. Furthermore, mentorships connecting students with female technology professionals allow students to see themselves in such positions in the future, which could affect the gender gap when they enter the workforce.

**Study Conclusions**

If women are not represented in the technology industry, decisions for the technology use by women will not be made by women. This is concerning as women only make up 20% of the technology industry (Master et al., 2021). As such, the the low numbers of women in this male-dominated field are from results stemming from learning environments from early childhood to collegiate studies and beyond.

How children interact with toys, including those that deal with technology, affects how different genders see their future roles in society (Heim, 2005). Without a sense of belonging, women may not decide to major in computer science when they enter college, further contributing to the workforce gender gap. By middle school, most female students have lost interest in STEM subjects, and this disinterest can stay with them when they enter high school (Fox, 2021). As such, computer science programs at all levels must engage diverse populations of students, as it could inform future technology use.

The goal of this study was to identify the success factors, challenges, and best practices of first and second-year female college students in computer science-related majors, as the literature indicates that this could be a determinant time in their academic journeys on whether they decide to stay in their majors or not. As such, findings in this study indicated that female computer science students seek support when it comes to their academics, their interactions with classmates and their learning environments, finding their passions and looking at their next steps for when they step into the workforce.

The gender gap in computer science was evident to the participants at the time of their interviews and such observations are noted in the literature. In participating in this research study, participants were eager and enthusiastic that their responses could affect change in closing the gender gap in computer science and STEM both in schools and in the industry as a whole.

Ruiz (2017) supports this by stating that female students are more empowered to persevere in computer science when they feel they are part of something larger than themselves, especially when affecting social change. Therefore, this study has the potential to affect how colleges perceive the recruitment and retention of female computer science majors.

**Recommendations for Future Research**

From this research study, the researcher looks to continue and contribute to the body of literature on the topic of computer science by focusing on best practices that benefit female college students to allow them to succeed in this male-dominated field. However, there are still opportunities, as listed below, for future research:

- identifying female college students in computer science-related majors who identify as people of color, as data shows the number of women of color in technology is even smaller;
- identifying female students who only recently decided to major in computer science and why they decided to make the switch over to the major;
- conducting a longitudinal study that invites participants to this study back to reflect on their experiences once they are in the post-graduate workforce;
- conducting a study of computer science and STEM college faculty to determine their best practices for the benefit of female students; and
- allowing other underrepresented student groups in STEM to take part in a parallel study.

From this study, the researcher’s purpose is to inform college computer science on how they could affect change to address the gender gap. As such, there is the potential to close the gap for other groups, such as cultural groups, that are underrepresented in the field. Through a model made up of best practices, the researcher looks to college computer science programs to apply the model to affect these types of changes.

**Final Thoughts**

The researcher has been involved in the computer science education of female high school students for a large part of his career at an all-girls school. From this, the researcher sought to answer how he keeps the interest of female students in computer science after they graduate from high school. Moreover, as a recipient of accolades from the College Board that address the gender gap and the researcher's work in the field with female students, the gap in the industry was made more apparent with the need for such awards.

The researcher looks for a time when the technology decisions made for his students, future, current, and former, are made by fellow female programmers who understand the issues women face when using technology. This is especially true when it comes to the use of platforms such as social networking platforms and parallel interactions that could affect the mental health of its users. As such, the researcher is hopeful that all institutions, not just colleges, can engage with their female student populations as closing the gender gap could have a significant impact on the technology industry.

In conducting the interviews with the participants, the researcher was surprised to see how many of them used the word *passion* to describe their work. In working on a topic the researcher is passionate about through this dissertation research study, the researcher has hopes for the study's participants to pursue their passions in their future endeavors. It is a passion that could lead to positive changes in the industry.

REFERENCES

Aina, O. E., & Cameron, P. A. (2011). Why does gender matter? Counteracting stereotypes with young children. *Dimensions of Early Childhood, 39*(3), 11–20. http://southernearlychildhood.org/upload/pdf /Dimensions_of_Early_Childhood_ Volume_39_Number_3.pdf#page=13

Ambrose, D., & Sternberg, R. J. (Eds.). (2016). *Giftedness and talent in the 21st century: Adapting to the turbulence of globalization*. Sense.

Arinder, J. A., & Roe, M. F. (2020). Feminist theory. In J. Egbert (Ed.), *Theoretical models for teaching and research* (Chapter 8). Pressbooks.

Avery, D. R., McKay, P. F., Wilson, D. C., & Tonidandel, S. (2007). Unequal attendance: The relationships between race, organizational diversity cues, and absenteeism. *Personnel Psychology*, *60*, 875–902. https://doi.org/10.1111/j.1744-6570.2007.00094.x

Bahar, A. K., Kaya, E., & Zhang, X. (2022). Gender disparities in AP Computer Science Exams: Analysis of trends in participation and top achievement. *Journal of Advanced Academics, 33*(4), 574–603. https://doi.org/10.1177/1932202x221119499

Baker, D. (2013). What works: Using curriculum and pedagogy to increase girls’ interest and participation in science. *Theory into Practice*, *52*(1), 14–20. https://doi.org/10.1080/07351690.2013.743760

Barsh, J., & Yee, L. (2012). *Unlocking the full potential of women at work*. McKinsey & Company.

Bergagna, E., & Tartaglia, S. (2018). Self-esteem, social comparison, and Facebook use. *Europe’s Journal of Psychology*, *14*(4), 831–845. https://doi.org/10.5964/ejop.v14i4.1592

Bibeau, W. (2014). *Educators' perspectives on female students' enrollment in computer science and engineering* (Publication No. 3632402) [Doctoral dissertation, Walden University]. ProQuest Dissertations & Theses Global.

Blake-Beard, S., Shapiro, M., & Ingols, C. (2021). A model for strengthening mentors: Frames and practices. *International Journal of Environmental Research and Public Health*, *18*(12), 6465. https://doi.org/10.3390/ijerph18126465

Blau, F. D., & Kahn, L. M. (2007). The gender pay gap: Have women gone as far as they can? *Academy of Management Perspectives, 21*(1), 7–23. http://connection.ebscohost.com/c/articles/24286161/gender-pay-gap-have-women-gone-as-far-as-they-can

Blau, F. D., & Kahn, L. M. (2016). The gender swap: Extent, trends, and explanations. *Journal of Economic Literature, 55*(3), 789–865. https://doi.org/10.1257/jel.55.3.789

Borghans, L., Ter Weel, B., & Weinberg, B. A. (2014). People skills and the labor-market outcomes of underrepresented groups. *ILR Review*, *67*(2), 287–334. https://doi.org/10.1177/001979391406700202

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3–15. https://www.jstor.org/stable/3699979

Bowles, H., & McGinn, K. (2005). Claiming authority: Negotiating challenges for women leaders. In D. Messick & R. Kramer, *The psychology of leadership: New perspectives and research* (pp. 191–208). Lawrence Erlbaum.

Bozkurt, G. (2017). Social constructivism: Does it succeed in reconciling individual cognition with social teaching and learning practices in mathematics? *Journal of Education and Practice, 8*(3), 210–218. https://eric.ed.gov/?id=EJ1131532

Breault, L. (2006). Protecting human research subjects: The past defines the future. *The Ochsner Journal 6*(1), 15–20. https://www.ochsnerjournal.org/content/6/1/15.abstract

Buck Institute for Education. (2018). *What is PBL?* https://www.bie.org

Bureau of Labor Statistics. (2017). *Civilian labor force: Entrants and leavers, 2006, 2016, and projected 2026*. https://www.bls.gov/emp/ep_table_305.htm

Buse, K., Bilimoria, D., & Perelli, S. (2013). Why they stay: Women persisting in US engineering careers. *Career Development International, 18*(2), 139–154. https://doi.org/10.1108/CDI-11-2012-0108

Bushe, G. R. (2012). Foundations of appreciative inquiry: History, criticism and potential. *AI Practitioner*, *14*(1), 8–20. https://www.gervasebushe.ca/Foundations_AI.pdf

Campa, D., & Harrington, D. E. (2018). Earnings and occupational attainment: A quantile regression approach. *Social Science Research, 72*, 135–151.

Cao, J., & Xue, W. (2013). *What are the best practices to promote high-ranking female employees within organizations*? http://digitalcommons.ilr.cornell.edu/student/19/

Chen, J. A., Tutwiler, M. S., Metcalf, S. J., Kamarainen, A., Grotzer, T., & Dede, C. (2016). A multi-user virtual environment to support students' self-efficacy and interest in science: A latent growth model analysis. *Learning and Instruction*, *41*, 11–22. https://doi.org/10.1016/j.learninstruc.2015.09.007

Cheng, R. (2015, May 6). *Women in technology: The numbers don't add up*. http://www.cnet.com/news/women-in-tech-the-numbers-dont-add-up/

Code.org. (2023a). *Code.org's approach to Diversity & Equity in computer science*. https://code.org/diversity

Code.org. (2023b). *Computer science connections*. https://code.org/educate/csc

Code.org. (2023c). *Diversity of students using Code.org courses*. https://code.org/promote/diversitydata

College Board. (2022). *AP computer science female diversity award*. AP Central: College Board. https://apcentral.collegeboard.org/exam-administration-ordering-scores/scores/awards/ap-computer-science-female-diversity-award

Combs, G. M., & Luthans, F. (2007). Diversity training: Analysis of the impact of self- efficacy. *Human Resource Development Quarterly, 18*(1), 91–120. https://doi.org/10.1002/hrdq.1193

Cook-Sather, A., & Seay, K. (2021). 'I was involved as an equal member of the community': How pedagogical partnership can foster a sense of belonging in black, female students. *Cambridge Journal of Education*, *51*(6), 733–750. https://doi.org/10.1080/0305764x.2021.1926926

Corbett, C., & Hill, C. (2012). *Graduating to a pay gap: The earnings of women and men one year after college graduation*. American Association of University Women.

Cornell University. (n.d.). *Definition: College student from 15 USC § 1637(r)(1) | LII / Legal Information Institute*. Legal Information Institute. https://www.law.cornell.edu/definitions/

Creswell, J. W., & Creswell, J. D. (2021). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage.

Criado-Perez, C. (2020). *Invisible women: Exposing data bias in a world designed for men*. Vintage.

Davis, S. A. (2009). SHRM's international diversity and inclusion study reveals global trends and practices. *Profiles in Diversity Journal, 11*(3), 14, 56. http://www.diversityjournal.com

Dean, M., & Laidler, K. A. (2013). Leveling the playing field through Facebook: How females construct online playspaces. *Journal of Youth Studies*, *17*(1), 113–129. https://doi.org/10.1080/13676261.2013.793787

Dede, C. (2015). Virtual worlds as immersive playgrounds. *Educational Researcher*, *44*(2), 93–96. https://www.tandfonline.com/

Dennehy, T. C., & Dasgupta, N. (2017). Female peer mentors early in college increase women's positive academic experiences and retention in engineering. *Proceedings of the National Academy of Sciences*, *114*(23), 5964-5969.

Deulen, A. A. (2013). Social constructivism and online learning environments: toward a theological model Christian educators. *Christian Education Journal, 10*(1), 90–98. https://doi.org/10.1177/073989131301000107

Dhillon, S. (2009). Diversity vs. inclusion. *Profiles in Diversity Journal, 11*(6), 28. https://issuu.com/diversityjournal/docs/2009novdec

Diehl, A. B., Stephenson, A. L., Dzubinski, L. M., & Wang, D. C. (2020). Measuring the invisible: Development and multi-industry validation of the gender bias scale for women leaders. *Human Resource Development Quarterly*, *31*(3), 249–280. https://doi.org/10.1002/hrdq.21389

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2011). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science, 22*(8), 997–1003. https://doi.org/10.1177/0956797610377342

Dobbin, F., & Kalev, A. (2016, August 23). *Why diversity programs fail*. Harvard Business Review. https://hbr.org/2016/07/why-diversity-programs-fail

Duguid, M. M., & Thomas-Hunt, M. C. (2015). Condoning stereotyping? How awareness of stereotyping prevalence impacts expression of stereotypes. *Journal of Applied Psychology, 100*(2), 343–359. https://doi.org/10.1037/a0037908

Dweck, C. S. (2008). *Mindset: The new psychology of success: How we can learn to fulfill our potential*. Ballantine Books.

Eagan, K., Hurtado, S., Figueroa, T., & Hughes, B. (2014). *Examining STEM pathways among students who begin college at four-year Institutions* [Commissioned paper]. National Academy of Sciences.

Eagly, A., & Carli, L. (2007). *Through the labyrinth: The truth about how women become leaders*. Harvard Business School Press.

Elmuti, D., Jia, H., & Davis, H. H. (2009). Challenges women face in leadership positions and organizational effectiveness: An investigation. *Journal of Leadership Education, 8*(2), 167–186. https://doi.org/10.12806/V8/I2/RF4

Estapa, A. T., & Tank, K. M. (2017). Supporting integrated STEM in the elementary classroom: A professional development approach centered on an engineering design challenge. *International Journal of STEM Education, (4)*6, 2196–7822. https://doi.org/10.1186/s40594-017-0058-3

Evans, L. A. (2009). *Success strategies of high achieving women: A qualitative phenomenological investigation* (Publication No. 3387040) [Doctoral dissertation, Pepperdine University]. ProQuest Dissertation and Theses.

Farheen, S. (2021, August 9). *Women in STEM: 3 challenges we face–and how to overcome them*. CNBC. https://www.cnbc.com/2021/08/09/women-in-stem-3-challenges-we-face-and-how-to-overcome-them.html

Farndale, E., Biron, M., Briscoe, D. R., & Raghuram, S. (2015). A global perspective on diversity and inclusion in work organisations. *The International Journal of Human Resource Management, 26*(6), 677–687. https://doi.org/10.1080/09585192.2014.991511

Fountain, J. E. (2000). Constructing the information society: Women, information technology, and design. *Technology in Society, 22*(1), 45–62. https://doi.org/10.1016/S0160-791X(99)00036-6

Fitzsimmons, S. (2021). *A comparative study of male and female undergraduate computer science students' educational pathways* (Publication No. 28322950) [Doctoral dissertation, University of South Florida]. ProQuest Dissertations & Theses Global.

Florentine, S. (2018, November 16). *Why women leave tech*. CIO. https://www.cio.com/article/222541/why-women-leave-tech.html

Forsyth, D. (2010). *Group dynamics* (5th ed.). Wadsworth.

Forte, A., Szymanski, M. H., Adams, A., & Lam, S. (2018). When and why women and minorities leave computing. *ACM Transactions on Computer-Human Interaction (TOCHI), 25*(3), 17. https://dl.acm.org/doi/abs/10.1145/3193120

Fox, L. (2021). *Examining the factors which affect middle school male and female students' interest in computer science* (Publication No. 28491235) [Doctoral dissertation, University of Massachusetts Lowell]. ProQuest Dissertations & Theses Global.

Friebroon-Yesharim, M., & Ben-Ari, M. (2018). Teaching computer science concepts through robotics to elementary school children. *International Journal of Computer Science Education in Schools*, *2*(3). https://doi.org/10.21585/ijcses.v2i3.30

Froschl, M., & Sprung, B. (2014). The role of out-of-school time in encouraging girls in STEM. In J. Koch (Ed.), *Girls and women in STEM* (pp. 139–152). Information Age Publishing.

Gates, M. (2019). *The moment of lift: How empowering women changes the world*. Pan Macmillan Australia.

Gay, L. R., Mills, G. E., & Airasian, P. (2012). *Educational research: Competencies for analysis and applications* (10th ed.). Pearson.

George Washington University. (n.d.). *Diversity and inclusion defined*. https://diversity.gwu.edu/diversity-and-inclusion-defined

Gerhart, A. L., & Carpenter, D. D. (2014). Creativity, innovation, and ingenuity summer enrichment program: Collaborating with a cultural institution and preliminary assessment. IEEE Frontiers in Education Conference (FIE) *Proceedings, Madrid,* 1–5. https://doi.org/10.1109/FIE.2014.7044145

Gino, F., Wilmuth, C. A., & Brooks, A. W. (2015). Compared to men, women view professional advancement as equally attainable, but less desirable. *Proceedings of the National Academy of Sciences, 112*(40), 12354–12359. https://doi.org/10.1073/pnas.1502567112

Glynn, S. (2014). *Explaining the gender gap*. American Progress. https://www.americanprogress.org/issues/economy/report/2014/05/19/90039 explaining-the-gender-wage-gap/

Gomez-Mejia, L. R., Patel, P. C., & Zellweger, T. M. (2018). In the horns of the dilemma: Socioemotional wealth, financial wealth, and acquisitions in family firms. *Journal of Management*, *44*(4), 1369–1397. https://doi.org/10.1177/0149206315614375

González-Pérez, S., Mateos de Cabo, R., & Sáinz, M. (2020). Girls in STEM: Is it a female role-model thing? *Frontiers in psychology*, *11*, 2204. https://doi.org/10.3389/fpsyg.2020.02204

Gould, S. (2015). *Five "disruptive" women scientists who broke the mold*. Ms. Magazine. http://msmagazine.com/blog/2015/06/18/5-disruptive-women-scientists-who-broke-the-mold/

Gray, D. E. (2018). *Doing research in the real world* (4th ed.). Sage.

Green, T. (2017). *Discrimination laundering: The rise of organizational innocence and the crisis of equal opportunity law*. Cambridge University Press.

Grissom, A. R. (2018). Workplace diversity and inclusion. *Reference and User Services Quarterly, 57*(4), 242–247. https://www.researchgate.net/publication/326128885_Workplace_diversity_and_inclusion

Grossman, P. J., Eckel, C., Komai, M., & Zhan, W. (2019). It pays to be a man: Rewards for leaders in a coordination game. *Journal of Economic Behavior & Organization*, *161*, 197–215. https://doi.org/10.1016/j.jebo.2019.04.002

Gurian, M. (2010). *Leadership and the sexes: Using gender science to create success in business*. John Wiley & Sons.

Gurian, M., Daniels, P., & Stevens, K. (2009). *Successful single-sex classrooms: A practical guide to teaching boys and girls separately; Grades K-12*. Jossey-Bass.

Guzdial, M., & Bruckman, A. (2018). Providing equitable access to computing education. *Communications of the ACM*, *61*(8), 26–28. https://doi.org/10.1145/3232039

Hagedorn, L. S., & Purnamasari, A. V. (2012). A realistic look at STEM and the role of community colleges. *Community College Review, 40*(2), 145–164. https://doi.org/10.1177/0091552112443701

Harding, J. (2013). *Qualitative data analysis from start to finish.* Sage.

Harris, B. (2017, November 1). *What is the gender gap (and why is it getting wider)?*. World Economic Forum. https://www.weforum.org/agenda/2017/11/the-gender-gap-actually-got-worse-in-2017/

Harry, N., & Malepane, T. (2021). Gender and emotional intelligence as predictors of career adaptability in the Department of Water and sanitation in South Africa. *SA Journal of Industrial Psychology*, *47*. https://doi.org/10.4102/sajip.v47i0.1828

Hastings, R. R. (2009, June). Diversity and inclusion are priorities for top executives, SHRM research finds. *SHRM Newsletter*. https://www.shrm.org/resourcesandtools/hr-topics/behavioral- competencies/global-and-culturaleffectiveness/pages/diversityandinclusionaretop.aspx

Hathaway, I., & Kallerman, P. (2012). *Technology works: High-tech employment and wages in the United States*. Bay Area Council Economic Institute.

Hausmann, R., Tyson, L. D., & Zahidi, S. (2022). *Global gender gap report 2022: Insight report*. World Economic Forum. https://www3.weforum.org/docs/WEF_GGGR_2022.pdf

Heilman, M. E., & Caleo, S. (2018). Combatting gender discrimination: A lack of fit framework. *Group Processes & Intergroup Relations*, *21*(5), 725–744. https://doi.org/10.1177/1368430218761587

Heim, P. (2005). *Hardball for women: Winning at the game of business*. Penguin Books.

Hernandez, P. R., Patterson, M. S., Nyanamba, J. M., Adams, A. S., Barnes, R. T., Bloodhart, B., Burt, M., Clinton, S. M., Pollack, I. B., & Fischer, E. V. (2023). *Webs of science: Mentor networks influence women's integration into STEM fields*. Frontiers in Ecology and the Environment. https://doi.org/10.1002/fee.2666

Hewlett, S. (2014, March). What's holding women back in science and technology industries. *Harvard Business Review*. https://hbr.org/2014/03/whats-holding women-back-in science-and- technology-industries?utm_source=Socialflow

Hewlett, S., Luce, C., Servon, L. J., Sherbin, L., Shiller, P., Sosnovich, E., & Sumberg, K. (2008, June). The Athena factor: Reversing the brain drain in science, engineering, and technology. *Harvard Business Review.* https://hbr.org/product/the-athena-factor-reversing-the-brain-drain-in- science-engineering-and-technology/10094-PDF-ENG

Hiller, N. J., & Beauchesne, M. M. (2014). Executive leadership: CEOs, top management teams, and organizational level outcomes. In D. V. Day (Ed.), *The Oxford handbook of leadership and organizations* (pp. 556–588). Oxford University Press.

Houston, T. (2019). *STEM pathways: Factors that inspire women to pursue careers in science, technology, engineering, and mathematics* (Publication No. 22587272) [Doctoral dissertation, Pepperdine University]. ProQuest Dissertations & Theses Global.

Howard-Brown, B., & Martinez, D. (2013). *Engaging diverse learners through the provision of STEM education opportunities*. http://secc.sedl.org/resources/briefs/ diverse_learners_ST EM/

Hutchison, A., Colwell, J., Gutierrez, K., Evmenova, A., Offutt, J., & Taylor, V. (2021). Designing a model of computer science professional development for elementary educators in inclusive classrooms. *Journal of Technology and Teacher Education, 29*(2), 165–193. https://www.learntechlib.org/primary/p/218960/

Ingersoll, M. (2016, April 7). *Silicon Valley's gender gap problem is really a culture problem*. Quartz Online. http://qz.com/656436/silicon-valleys- gender-gap-problem-is-all-about-the-culture/

International Society for Technology in Education. (2012). *A constructivist approach to the national educational technology standards for teachers*. http://www.iste.org/docs/excerpts/CONNET-excerpt.pdf

Ireland, D. T., Freeman, K. E., Winston-Proctor, C. E., DeLaine, K. D., McDonald Lowe, S., & Woodson, K. M. (2018). (Un)Hidden figures: A synthesis of research examining the intersectional experiences of black women and girls in STEM education. *Review of Research in Education*, *42*(1), 226–254. https://doi.org/10.3102/0091732x18759072

Jazzar, M., & Algozzine, R. (2007). *Keys to successful twenty-first century educational leadership*. Allyn & Bacon.

Karlin, M. (2019). *Strategies for recruiting and retaining female students in secondary computer science* (Publication No. 27668748) [Doctoral dissertation, Indiana University]. ProQuest Dissertations & Theses Global.

Kemp, P. E., Wong, B., & Berry, M. G. (2019). Female performance and participation in \ computer science. *ACM Transactions on Computing Education*, *20*(1), 1–28. https://doi.org/10.1145/3366016

Khan Academy. (2023). *Welcome to Meet the professional!* Khan Academy. https://www.khanacademy.org/computing/computer-programming/meet-the-computing-professional-unit/meet-the-computing-professional/v/welcome-meet-the-computing-professional

Killpack, T. L., & Melón, L. C. (2016). Toward inclusive STEM classrooms: What personal role do faculty play? *Life Science Education, 15*(3), 1–7. https://www.lifescied.org/doi/pdf/10.1187/cbe.16-01-0020

Kim, D., & Starks, L. T. (2016). Gender diversity on corporate boards: Do women contribute unique skills? *The American Economic Review, 106*(5), 267–271. https://doi.org/10.1257/aer.p20161032

Kim, N. J. (2017). *Enhancing students' higher order thinking skills through computer-based scaffolding in problem-based learning*. https://digitalcommons.usu.edu/etd/5488

Koca, F. (2016). Motivation to learn and teacher–student relationship. *Journal of International Education and Leadership, (6)*2, 1-13. https://files.eric.ed.gov/fulltext/EJ1135209.pdf

Koch, M., & Gorges, T. (2016). Curricular influences on female afterschool facilitators' computer science interests and career choices. *Journal of Science Education and Technology*, *25*(5), 782–794. https://doi.org/10.1007/s10956-016-9636-2

Komarraju, M., & Nadler, D. (2013). Self-efficacy and academic achievement: Why do implicit beliefs, goals, and effort regulation matter? *Learning and Individual Differences, 25*, 67–72. https://eric.ed.gov/?id=EJ1008472

Korstjens, I., & Moser, A. (2017). Series: Practical guidance to qualitative research. Part 2: Context, research questions and designs. *European Journal of General Practice, 23*(1), 274–279. https://doi.org/10.1080/13814788.2017.1375090

Kulow, M. D. (2013). Beyond the Paycheck Fairness Act: Mandatory wage disclosure laws: A necessary tool for closing the residual gender wage gap. *Harvard Journal on Legislation, 50*, 385-386. http://harvardjol.com/wp-content/uploads/2013/09/Kulow1.pdf

Larson, R. C. (2021). *Teaching our students how to fly*. INFORMS. https://doi.org/10.1287/orms.2021.04.10

Lalier, A. (2018, January 23). *Navigating your career in a male-dominated industry*. UNC Kenan-Flagler Business School. https://www.kenan-flagler.unc.edu/news/ navigating-your-career-in-a-male-dominated-industry/

Lee, A. (2020). The association between female students' computer science education and STEM major selection: Multilevel structural equation modeling. *Computers in the Schools*, *37*(1), 17–39. https://doi.org/10.1080/07380569.2020.1720553

Lin, F., & Chan, C. K. (2018). Promoting elementary students' epistemology of science through computer-supported knowledge-building discourse and epistemic reflection. *International Journal of Science Education*, *40*(6), 668–687. https://doi.org/10.1080/09500693.2018.1435923

Litzler, E., Samuelson, C. C., & Lorah, J. A. (2014). Breaking it down: Engineering student STEM confidence at the intersection of race/ethnicity and gender. *Research in Higher Education, 55*, 810-832. https://link.springer.com/article/10.1007/s11162-014-9333-z

Livingston, R. W., Rosette, A. S., & Washington, E. F. (2012). Can an agentic black woman get ahead? The impact of race and interpersonal dominance on perceptions of female leaders. *Psychological Science, 23*(4), 354–358. https://doi.org/10.1177/0956797611428079

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education Policy, 95*(5), 877–907. https://doi.org/10.1002/sce.20441

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). *STEM: Country comparisons: International comparisons of science, technology, engineering and mathematics (STEM) education*. http://dro.deakin.edu.au/view/DU:30059041

Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2019). *Stuck in the shallow end: Education, race, and computing*. MIT Press.

Master, A., Meltzoff, A. N., & Cheryan, S. (2021). Gender stereotypes about interests start early and cause gender disparities in computer science and engineering. *Proceedings of the National Academy of Sciences*, *118*(48). https://doi.org/10.1073/pnas.2100030118

Maxwell, J. (2012). *Qualitative research design: An interactive approach*. J. A. Maxwell.

McConnell, C., Rush, D., & Gartland, M. (2016). Investigating MBA degrees earned by women: A decade of change. *Journal of Education for Business*, *91*(6), 318–326. https://doi.org/10.1080/08832323.2016.1201453

McMillan, J. H., & Schumacher, S. (2014). *Research in education: Evidence-based inquiry.* Pearson.

McNally, S. (2020). *Gender differences in tertiary education: what explains STEM participation?* (No. 165). IZA Policy Paper. https://www.econstor.eu/handle/10419/243451

Meuser, J. D., Gardner, W. L., Dinh, J. E., Hu, J., Liden, R. C., & Lord, R. G. (2016). A network analysis of leadership theory: The infancy of integration. *Journal of Management, 42*(5), 1374–1403. https://doi.org/10.1177/0149206316647099

Michigan Technological University. (2023, May 26). *What is computer science?* Michigan Technological University. https://www.mtu.edu/

Milkman, K. L., Akinola, M., & Chugh, D. (2015). Supplemental material for what happens before? A field experiment exploring how pay and representation differentially shape bias on the pathway into organizations. *Journal of Applied Psychology, 100*(6), 1678–1712. https://doi.org/10.1037/apl0000022.supp

MIT Registrar's Office. (2023). *Women's enrollment 2022-2023*. MIT Registrar. https://registrar.mit.edu/statistics-reports/womens-enrollment

Moody, J. W., Woszcynski, A. B., Beise, C. M., & Myers, M. E. (2003). Diversity and the IT Workforce: Barriers and opportunities. *Journal of Computer Information Systems, 43*(4), 63–71. https://doi.org/10.1080/08874417.2003.11647535

Mosatche, H. S., Matloff-Nieves, S., Kekelis, L., & Lawner, E. K. (2013). Effective STEM programs for adolescent girls: Three approaches and many lessons learned. *After-school Matters, Spring*, 18–25. https://files.eric.ed.gov/fulltext/EJ1003839.pdf

Munoz-Boudet, A. M. (2017, March 16). *STEM fields still have a gender imbalance. Here's what we can do about it*. World Economic Forum. https://www.weforum.org/agenda/2017/03/women-are-still-under-represented-in-science-maths-and-engineering-heres-what-we-can-do

National Academies Press. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. https://www.nap.edu/read/13165/chapter/1

National Center for Education Statistics. (2023). *Undergraduate degree fields*. *Condition of Education*. U.S. Department of Education, Institute of Education Sciences. https://nces.ed.gov/programs/coe/indicator/cta.

National Center for Information Technology. (2016). *Women in tech: The facts (2016 update)*. National Center for Information Technology. https://ncwit.org/resource/thefacts/

National Girls Collaborative Project. (2023, March). *State of girls and women in STEM*. State of Girls and Women in STEM. https://ngcproject.org/resources/state-girls-and-women-stem

National Science Board. (2016). *Science and engineering indicators* [NSB-2016-1]. National Science Foundation. https://files.eric.ed.gov/fulltext/ED571833.pdf

National Science Foundation. (2017). *Field of degree: Women*. *Women, minorities, and persons with disabilities in science and engineering*. https://www.nsf.gov/statistics/2017/nsf17310/digest/fod-women/computer-sciences.cfm

National Women's Law Center. (2018). *Workplace justice*. https://nwlc.org/resources/how-the-paycheck-fairness-act-will-strengthen-the-equal- pay-act/

Newman, T. (2023, March 31). *Sex and gender: Meanings, definition, identity, and expression*. Medical News Today. https://www.medicalnewstoday.com/articles/232363#summary

New York University. (2018). *Research innovation; K-12 STEM education*. https://engineering.nyu.edu

Nishii, L. H., & Mayer, D. M. (2009). Do inclusive leaders help to reduce turnover in diverse groups? The moderating role of leader-member exchange in the diversity to turnover relationship. *Journal of Applied Psychology, 94*, 1412–1426. https://doi.org/10.1037/a0017190

O'Brien, K. R., Scheffer, M., van Nes, E. H., & van der Lee, R. (2015). How to break the cycle of low workforce diversity: A model for change. *PloS one, 10*(7), e0133208. https://doi.org/10.1371/journal.pone.0133208

Ortiz, A. M., & Santos, S. J. (2010). Campus diversity and ethnic identity development. *Diversity and Democracy, 13* (2), 5–7. https://www.aacu.org/publications-archive/diversity-democracy-archive

Ozturk, Z., Dooley, C. M., & Welch, M. (2018). Finding the hook: Computer science education in elementary contexts. *Journal of Research on Technology in Education*, *50*(2), 149–163. https://doi.org/10.1080/15391523.2018.1431573

Parette, H. P., Hourcade, J. J., Blum, C., Watts, E. H., Stoner, J. B., Wojcik, B. W., & Chrismore, S. B. (2013). Technology user groups and early childhood education: A preliminary study. *Early Childhood Education Journal*, *41*(3), 171–179. https://doi.org/10.1007/s10643-012-0548-3

Patterson Hazley, M. (2016). *Successful female students in undergraduate computer science And computer engineering: Motivation, self-regulation, and qualitative characteristics.* (Publication No. 10106174) [Doctoral dissertation, University of Nebraska – Lincoln]. ProQuest Dissertations & Theses Global.

Peeters, R. L., Bonn, I., & Fichter, M. (2020). The impact of pay secrecy on individual performance and pay. *Journal of Organizational Behavior, 41*(5), 435–451.

Peterson, S. J., Walumbwa, F. O., Byron, K., & Myrowitz, J. (2009). CEO positive psychological traits, transformational leadership, and firm performance in high- technology start-up and established firms. *Journal of Management, 35*, 348–368. https://doi.org/10.1177/0149206307312512

Pew Research Center. (2021c, March 30). *Women remain underrepresented in Physical Sciences, computing and engineering jobs*. Pew Research Center Science & Society. https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/ps_2021-04-01_diversity-in-stem_00-03/

Pham, N. D., & Triantis, A. J. (2015, March 19). Reaching the full potential of stem for women and the U.S. economy. https://www.uschamberfoundation.org/

Powell, G., & Graves, L. (2003). *Women and men in management* (3rd ed.). Sage.

Prawat, R. S. (1999). Social constructivism and the process-content distinction as viewed by Vygotsky and the Pragmatists. *Mind, Culture, and Activity*, *6*(4), 255–273. https://doi.org/10.1080/10749039909524731

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. https://obamawhitehouse.archives.gov/ sites/default/files/microsites/ostp/pcast-engage- to-excel-final_2-25-12.pdf

Price, N. G. (2022). *Factors that contribute to lower enrollments of underrepresented minority and female graduate students in computer science and engineering (CSE) at Bay Area California State University campuses and mitigating factors from student perspectives*. https://doi.org/10.31979/etd.pdty-rk5r

Prince, M. (2004). Does active learning work?: A review of the research. *Journal of Engineering Education*, *93*(3), 223–231. http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/Prince_AL.pdf

Robbins, S. P., & Judge, T. A. (2015). *Organizational behavior* (16th ed.). Pearson.

Roy, J. M. (2014). *Underrepresentation of female computer science graduates in information technology: A phenomenological study* (Publication No. 3647305) [Doctoral dissertation, University of Phoenix]. ProQuest Dissertations & Theses Global.

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal, 24*(1), 92-96. https://doi.org/10.1080/10400419.2012.650092

Ruiz, P. A. (2017). *Female computer science and engineering undergraduates: Reflections on participation in the academic landscape* (Publication No. 10681233) [Doctoral dissertation, Pepperdine University. ProQuest Dissertations & Theses Global.

Sahin, A., Gulacar, O., & Stuessy, C. (2014). High school students' perceptions of the effects of international science Olympiad on their STEM career aspirations and twenty-first-century skill development. *Research in Science Education, 45*(6), 1–21. https://www.researchgate.net/publication/284837095_High_School_Students'_Perceptions_of_the_Effects_of_International_Science_Olympiad_on_Their_STEM_Career_Aspirations_and_Twenty-First_Century_Skill_Development

Saldaña, J. (2016). *The coding manual for qualitative research* (3rd ed.). Sage.

Sap, M., Card, D., Gabriel, S., Choi, Y., & Smith, N. A. (2016). The risk of racial bias in hate speech detection. Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing, 1668–1678. https://doi.org/10.18653/v1/P19-1163

Savaria, M., & Monteiro, K. (2017). A critical discourse analysis of engineering course syllabi and recommendations for increasing engagement among women in STEM. *Journal of STEM Education, 18*(1), 92-97. https://eric.ed.gov/EJ1141079

Science and Technology Committee, House of Commons. (2016). *Digital skills crisis: Second report of Session 2016–17*. http://dera.ioe.ac.uk/26605/1/270.pdf

Schneider, B., Broda, M., Judy, J., & Burkander, K. (2013). *Pathways to college and STEM careers: Enhancing the high school experience*. New Directions for Youth Development, 140, 9–29. https://doi.org/10.1002/yd.20076

Scott, K. A., & Brown, D. J. (2006). Female first, leader second? Gender bias in the encoding of leadership behavior. *Organizational Behavior and Human Decision Processes, 101*(2), 230–242. https://doi.org/10.1016/j.obhdp.2006.06.002

Seepersad, C. C. (2016). *How to involve more women and girls in engineering*. The Conversation. http://theconversation.com/how-to-involve-more-women-and-girls-in-engineering-55794

Seltzer, L. F. (2021, July 7). *How do you define success?*. Psychology Today. https://www.psychologytoday.com/us/blog/evolution-the-self/202107/how-do-you-define-success

Shetterly, M. L. (2016). *Hidden figures: The American Dream and the untold story of the Black women mathematicians who helped win the space race*. Harper Luxe.

Silva, U. F., Ferreira, D. J., Ambrósio, A. P., & Oliveira, J. L. (2022). Problems faced by female computer science undergraduates: A systematic review. *Educação e Pesquisa*, *48*. https://doi.org/10.1590/s1678-4634202248236643eng

Simon, B., et al. (2018). Building community in the computer science classroom: Strategies for managing group work and creating an inclusive environment. *ACM Transactions on Computing Education (TOCE), 18*(1), 4.

Simpson, R. (2006). Masculinity and management education: Feminizing the MBA. *Academy of Management Learning & Education, 5*(2), 182–193. https://doi.org/10.5465/AMLE.2006.21253782

Smith, M. (2012). Social regulation of the gender pay gap in the EU. *European Journal of Industrial Relations, 18*(4), 365–380. https://doi.org/10.1177/0959680112465931

Southern Illinois University. (2023, February 9). *STEM education defined: STEM Education Research Center: SIU*. STEM Education Research Center. https://stemedresearch.siu.edu/what-is-stem-education/

Stanberry, K., & Aven, F. (2013). Unequal pay for equal work: Why women still lag behind after the 50th anniversary of the U.S. Equal Pay Act. *Compensation & Benefits Review, 45*(4), 193-199. https://doi.org/10.1177/0886368713505991

Stewart-Williams, S., & Halsey, L. G. (2021). Men, women and STEM: Why the differences and what should be done? *European Journal of Personality*, *35*(1), 3–39. https://doi.org/10.1177/0890207020962326

Stout, J. G., et al. (2020). Mentoring undergraduate women in psychology: The role of mentoring source and impact on retention in the major. *Sex Roles, 82*(11-12), 713–726.

Subotnik, R. F., Olszewski-Kubilius, P., & Worrell, F. C. (2011). Rethinking giftedness and gifted education: A proposed direction forward based on psychological science. *Psychological Science in the Public Interest, 12*, 3–54. https://doi.org/10.1177/1529100611418056

Sutton, J., & Austin, Z. (2015). Qualitative research: Data collection, analysis, and management. *The Canadian Journal of Hospital Pharmacy, 68*(3), 226–231. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4485510/

Swiss, D. (1996). *Women breaking through: Overcoming the final 10 obstacles at work*. Peterson and Pacesetter Books.

Tan, E., Calabrese, A., Kang, B. H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Researching in Science Teaching, (50)*10, 1143–1179. https://doi.org/10.1002/tea.21123

The White House. (2017). *President Trump signs memorandum for STEM education funding*. www.whitehouse.gov

Toohey, M. (2022). *Not everyone has access: How elementary teachers' computer science goals and strategies relate to equity* (Publication No. 29215059) [Doctoral dissertation, University of California, Los Angeles]. ProQuest Dissertations & Theses Global.

Tufford, L., & Newman, P. (2012). Bracketing in qualitative research. *Qualitative Social Work, (11)*1, 80-96. https://doi.org/10.1177/1473325010368316

Tulsi, B. B. (2016). Women in STEM. *Lab manager*. http://www.labmanager.com/magazine/issue/2016/12/Women-in-STEM

UC Berkeley. (n.d.). *Causes of academic difficulty*. Causes of academic difficulty. L&S Advising. https://lsadvising.berkeley.edu/academic-difficulty/causes-academic-difficulty

United States Department of Education. (2015). *Science, technology, engineering, and math: Education for global leadership*. https://www.ed.gov/stem

United States Department of Justice. (n.d.). *Understanding bias: A resource guide*. https://www.justice.gov/file/1437326/download

Vilorio, D. (2014). STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly, Spring*, 3-11. https://www.bls.gov/careeroutlook/2014/spring/art01.pdf

Walker, C. L., & Shore, B. M. (2015). Understanding classroom roles in inquiry education. *SAGE Open*, *5*(4), 215824401560758. https://doi.org/10.1177/2158244015607584

Wang, L. L., Stanovsky, G., Weihs, L., & Etzioni, O. (2021). Gender trends in computer science authorship. *Communications of the ACM*, *64*(3), 78–84. https://doi.org/10.1145/3430803

Wang, M. T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review, 29*(1),119–140. https://doi.org/10.1007/s10648-015-9355-x

Warner, J. (2014). *Fact sheet: The women's leadership gap*. https://www.americanprogress.org/issues/women/report/2014/03/07/85457/factsheet-the-womens-leadership-gap/

Webster, J. (1996). *Shaping women's work: Gender, employment and information technology*. Longman.

White, J. (1992). *A few good women: Breaking the barriers to top management*. Prentice Hall.

Williams, M. M., & Casey, G. (2014). Using and doing science: Gender, self-efficacy, and science identity of undergraduate students in STEM. *Journal of Women and Minorities in Science and Engineering, 20*(2), 99–126. https://www.researchgate.net/publication/270468372_Using_and_doing_science_genderself-efficacy_and_science_identity_of_undergraduate_students_in_STEM

Wyatt, J., Feng, J., & Ewing, M. (2020, December). AP® computer science principles and the stem and computer science pipelines. https://apcentral.collegeboard.org/media/pdf/ap-csp-and-stem-cs-pipelines.pdf

Yates, J., & Plagnol, A. C. (2021). Female Computer Science Students: A qualitative exploration of women's experiences studying Computer Science at university in the UK. *Education and Information Technologies*, *27*(3), 3079–3105. https://doi.org/10.1007/s10639-021-10743-5

Young, D. M., Rudman, L. A., Buettner, H. M., & McLean, M. C. (2013). The influence of female role models on women's implicit science cognitions. *Psychology of Women Quarterly, 37*(3), 283–292. https://doi.org/10.1177/0361684313482109

Zeiden, N. (2016, August 31). *Tech culture must change to attract more women*. http://womenforhire.com/advice/tech-culture-must-change-to- attract more-women/

Zhu, M., & Kadirova, D. (2020). Self-directed learners' perceptions and experiences of learning computer science through MIT Open Courseware. *Open Learning: The Journal of Open, Distance and e-Learning*, *37*(4), 370–385. https://doi.org/10.1080/02680513.2020.1781606

APPENDIX A

Signed Site Permission

Site identifying information removed

[redacted]

To: Pepperdine University
From: [redacted]
Date: 9/18/23

Pepperdine University,

I am in full support of Oscar Navarro's dissertation research. I give him permission to access PowerSchool and our school databases and communications systems, to gather the necessary data and contact alumnae for interviews. PowerSchool and our systems are password-protected and include student and parent information (i.e. names, numbers, and email addresses).

Sincerely,

[redacted]

[redacted]

APPENDIX B

Pepperdine University IRB Approval Notice

eProtocol
24255 Pacific Coast Highway
Malibu, CA 90263
TEL: 310-506-4000

**NOTICE OF APPROVAL FOR HUMAN RESEARCH**

Date: February 06, 2024

Protocol Investigator Name: Oscar Navarro

Protocol #: 23-09-2254

Project Title: SUCCESS FACTORS AND CHALLENGES FACED BY FIRST AND SECOND-YEAR UNDERGRADUATE FEMALE STUDENTS IN COMPUTER SCIENCE-RELATED MAJORS

School: Graduate School of Education and Psychology

Dear Oscar Navarro:

Thank you for submitting your application for exempt review to Pepperdine University's Institutional Review Board (IRB). We appreciate the work you have done on your proposal. The IRB has reviewed your submitted IRB application and all ancillary materials. Upon review, the IRB has determined that the above entitled project meets the requirements for exemption under the federal regulations 45 CFR 46.101 that govern the protections of human subjects.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit an amendment to the IRB. Since your study falls under exemption, there is no requirement for continuing IRB review of your project. Please be aware that changes to your protocol may prevent the research from qualifying for exemption from 45 CFR 46.101 and require submission of a new IRB application or other materials to the IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite the best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the IRB as soon as possible. We will ask for a complete written explanation of the event and your written response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the IRB and documenting the adverse event can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* at community.pepperdine.edu/irb.

Please refer to the protocol number denoted above in all communication or correspondence related to your application and this approval. Should you have additional questions or require clarification of the contents of this letter, please contact the IRB Office. On behalf of the IRB, I wish you success in this scholarly pursuit.

Sincerely,

Judy Ho, Ph.D., IRB Chair

cc: Mrs. Katy Carr, Assistant Provost for Research

Page: 1

# APPENDIX C

## Interview Recruitment E-Mail Script

Dear [Name],

My name is Oscar Navarro, and I am a doctoral student in the Graduate School of Education and Psychology at Pepperdine University. I am conducting a research study examining the success strategies used by first and second-year female college students in computer science-related majors. You are invited to participate in the study.

The purpose of this study is to determine the success strategies that first and second-year female computer science students employ to make them successful in the field. This study consists of 10 open-ended interview questions that will focus on identifying the successes and challenges of current female computer science students to address the gender gap in the field. I am seeking out participants to help me in this qualitative research study. Based on specific qualifying criteria, I have determined that you would be an excellent participant in this study. The interview will take approximately 45-60 minutes and will be conducted online through audio recordings. Questions asked in the interview and an informed consent form will be sent to you before the interview.

If you have questions or want to participate, please contact me at oscar.navarro@pepperdine.edu.

Thank you for your participation, Oscar Navarro Doctoral Candidate Pepperdine University, GSEP oscar.navarro@pepperdine.edu

APPENDIX D

Informed Consent

IRB SOCIAL- BEHAVIORAL ADULT PARTICIPANT INFORMED CONSENT

**IRB #: 23-09-2254**

**Formal Study Title: SUCCESS FACTORS AND CHALLENGES FACED BY FIRST AND SECOND-YEAR UNDERGRADUATE FEMALE STUDENTS IN COMPUTER SCIENCE-RELATED MAJORS**

**Authorized Study Personnel:**

Principal Investigator: Student, Oscar Navarro
Student Number, 100883484
Student email. oscar.navarro@pepperdine.edu

**Key Information:**

**If you agree to participate in this study, the project will involve:**

- ☑ (Males and Females) between the ages of (18-80)
- ☑ Procedures will include (Contacting participants using the recruitment script, informed consent, data collection via structured interview, transcription of data, analysis of data, documentation of findings)
- ☑ One virtual visit is required
- ☑ This visit will take 60 minutes total
- ☑ There is minimal risk associated with this study
- ☑ You will not be paid any amount of money for your participation
- ☑ You will be provided a copy of this consent form

**Invitation**

You are invited to take part in this research study. The information in this form is meant to help you decide whether or not to participate. If you have any questions, please ask.

**Why are you being asked to be in this research study?**

You are being asked to be in this study because you are a female undergraduate student in the computer science industry. You must be 18 years of age or older to participate.

**What is the reason for doing this research study?**

The purpose of this phenomenological study is to determine the best practices employed by female university students with computer science-related majors that assist in inspiring them to persist and have the grit to do well and succeed in this male-dominated field.

**What will be done during this research study?**

You will be asked to complete a 60 minute semi-structured virtual interview. The PI will ask you a series of questions aimed at figuring out what strategies are used by undergraduate students in your field. While the research will take approximately 26 to 52 weeks, your interview will only take 60 minutes.

**How will my data be used?**

Your interview responses will be transcribed, analyzed, and aggregated in order to determine the findings to the established research questions.

**What are the possible risks of being in this research study?**

This research presents minimal risk of loss of confidentiality, emotional and/or psychological distress because the interview involves questions about your best practices. You may also experience fatigue, boredom, or anxiety as a result.

**What are the possible benefits to you?**

You are not expected to get any benefit from being in this study.

**What are the possible benefits to other people?**

The benefits to society may include better understanding of strategies used within your industry. Other emerging undergraduate female students might also benefit from any additional recommendations that are shared through this process.

**What are the alternatives to being in this research study?**

Participation in this study is voluntary. There are no alternatives to participating, other than deciding to not participate.

**What will participating in this research study cost you?**

There is no cost to you to be in this research study.

**Will you be compensated for being in this research study?**

There will be no compensation for participating in this study.

**What should you do if you have a problem during this research study?**

Your welfare is the major concern of every member of the research team. If you have a problem as a direct result of being in this study, you should immediately contact one of the people listed at the beginning of this consent form.

**How will information about you be protected?**

Reasonable steps will be taken to protect your privacy and the confidentiality of your study data. The data will be deidentified and stored electronically through a secure server and will only be seen by the research team during the study and until the study is complete.

The only persons who will have access to your research records are the study personnel, the Institutional Review Board (IRB), and any other person, agency, or sponsor as required by law. The information from this study may be published in scientific journals or presented at scientific meetings but the data will be reported as group or summarized data and your identity will be kept strictly confidential and audio recordings will be deleted right after final transcription is made. All data will be destroyed 3 years after publication in their prospective sections.

**What are your rights as a research subject?**

You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study.

***For study related questions, please contact the investigator(s) listed at the beginning of this form.***

For questions concerning your rights or complaints about the research contact the Institutional Review Board (IRB):
Phone: 1(310)568-2305
Email: gpsirb@pepperdine.edu

**What will happen if you decide not to be in this research study or decide to stop participating once you start?**

You can decide not to be in this research study, or you can stop being in this research study ("withdraw') at any time before, during, or after the research begins for any reason. Deciding not to be in this research study or deciding to withdraw will not affect your relationship with the investigator or with Pepperdine University.

You will not lose any benefits to which you are entitled.

**Documentation of informed consent**

You are voluntarily making a decision whether or not to be in this research study. Signing this form means that (1) you have read and understood this consent form, (2) you have had the consent form explained to you, (3) you have had your questions answered and (4) you have decided to be in the research study. You will be given a copy of this consent form to keep.

**Participant Name:** ______________________________________
(First, Last: Please Print)

**Participant Signature:** ______________________________________
Signature Date

**Interview Protocol**

- IQ 1: Think of the single most difficult challenge you have faced in pursuing a computer science related major.
    - What was that challenge and
    - How did you experience it?
- IQ 2: What are other similar challenges you have experienced pursuing a computer science related major?
- IQ 3: Are you personally aware of similar challenges that other woman may have faced in pursuing a computer-science related major?
- IQ 4: What strategies and best practices did you employ or what resources did you seek to overcome this particular challenge?
- IQ 5: What strategies or best practices did you employ, or resources did you seek to overcome these challenges?

- IQ 6: Are you personally aware of strategies or best practices employed or resources sought by these women?
- IQ 7: What is your ultimate goal in pursuing a computer science related major?
- IQ 8: How do you ensure you stay on track to that goal?
- IQ 9: What advice or recommendations do you have for aspiring women who want to pursue studies in computer science related majors?
- IQ 10: If you could, what is the one thing you would do differently, if you were to start your studies over?

APPENDIX E

Peer Review Feedback of Interview Questions

Peer Review 1

**Instructions for Reviewer:**

Thank you for reviewing my interview questions for my research study. If you haven't been prompted to do so, please make a copy of this document and share with me.

Please review each question and corresponding interview questions. There is a drop-down column in the middle of each section that will have you choose, "**keep as is**", "**modify**" or "**delete it**". If you are choosing to **modify**, please provide feedback and modifications. Thank you so much. Please return this via email to: oscar.navarro@pepperdine.edu.

| Research Questions | Corresponding Interview Questions |
|---|---|
| RQ1: What challenges do female first and second-year college students face in pursuing computer science-related majors? | Icebreaker. Tell me about your journey as a student in your major. Well done here!<br><br>IQ 1: What is unique about the academic culture as it relates to your computer science-related major?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>_____________________________________<br>I recommend adding the following interview questions:<br>_____________________________________<br>IQ 2: What are some of the most challenging aspects you face as a female pursuing a computer science-related major?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>_____________________________________<br>I recommend adding the following interview questions:<br>_____________________________________ |
| RQ2: What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges? | IQ 3: What practices enable you to pursue a computer science-related major?<br>a. The question is directly relevant to Research question - **Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>**c. The question should be modified as suggested: Attach the word "best" before practice**<br>I recommend adding the following interview questions:<br>_____________________________________ |

<table>
<tr><th>Research Questions</th><th>Corresponding Interview Questions</th></tr>
<tr><td></td><td>IQ 4: What factors do you believe contribute to you being successful in pursuing a computer science-related major?<br><br>a. The question is directly relevant to Research question - Keep as stated<br>b. The question is irrelevant to research question – Delete it<br>c. The question should be modified as suggested:<br>________________________________________<br>I recommend adding the following interview questions:<br>________________________________________</td></tr>
<tr><td>RQ3: How do first and second-year female college students measure success in pursuing computer science-related majors?</td><td>IQ 5: How do you define success for yourself as it relates to your academic and career pursuits?<br><br>a. The question is directly relevant to Research question - Keep as stated<br>b. The question is irrelevant to research question – Delete it<br>c. The question should be modified as suggested:<br>________________________________________<br>I recommend adding the following interview questions:<br>________________________________________<br><br>IQ 6: How do you measure that success?<br><br>a. The question is directly relevant to Research question - Keep as stated<br>b. The question is irrelevant to research question – Delete it<br>c. The question should be modified as suggested:<br>________________________________________<br><br>I recommend adding the following interview questions:<br>You may have to differentiate between “define” in the previous question and measure in this one. Just food for thought.</td></tr>
<tr><td>RQ4: What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science?</td><td>IQ 7: What advice or recommendations would you give students who are considering your major?<br><br>a. The question is directly relevant to Research question - Keep as stated<br>b. The question is irrelevant to research question – Delete it<br>c. The question should be modified as suggested:<br>________________________________________<br>I recommend adding the following interview questions:<br>________________________________________<br><br>IQ 8: Is there anything else you would like to share about your computer science experience that you think would be relevant to this study?<br><br>a. The question is directly relevant to Research question - Keep as stated<br>b. The question is irrelevant to research question – Delete it<br>c. The question should be modified as suggested:<br>________________________________________<br>I recommend adding the following interview questions: _______________</td></tr>
</table>

Peer Review 2

**Instructions for Reviewer:**

Thank you for reviewing my interview questions for my research study. If you haven't been prompted to do so, please make a copy of this document and share with me.

Please review each question and corresponding interview questions. There is a drop-down column in the middle of each section that will have you choose, "**keep as is**", "**modify**" or "**delete it**". If you are choosing to **modify**, please provide feedback and modifications. Thank you so much. Please return this via email to: oscar.navarro@pepperdine.edu.

| Research Questions | Corresponding Interview Questions |
|---|---|
| RQ1: What challenges do female first and second-year college students face in pursuing computer science-related majors? | Icebreaker. Tell me about your journey as a student in your major.<br><br>IQ 1: What is unique about the academic culture as it relates to your computer science-related major?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>____________________________________<br>I recommend adding the following interview questions:<br>____________________________________<br><br>IQ 2: What are some of the most challenging aspects you face as a female pursuing a computer science-related major?<br>a. The question is directly relevant to Research question - Keep as stated<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>____________________________________<br><br>**I recommend adding the following interview questions:**<br>**Maybe just challenges instead of most challenging aspects** |
| RQ2: What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges? | IQ 3: What practices enable you to pursue a computer science-related major?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>**c. The question should be modified as suggested:**<br>**Attach the word "best" before practice**<br>I recommend adding the following interview questions:<br>____________________________________ |

| Research Questions | Corresponding Interview Questions |
| --- | --- |
| | IQ 4: What factors do you believe contribute to you being successful in pursuing a computer science-related major?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>________________________________________<br>I recommend adding the following interview questions:<br>________________________________________ |
| RQ3: How do first and second-year female college students measure success in pursuing computer science-related majors? | IQ 5: How do you define success for yourself as it relates to your academic and career pursuits?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>________________________________________<br>I recommend adding the following interview questions:<br>________________________________________<br><br>IQ 6: How do you measure that success?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>________________________________________<br>I recommend adding the following interview questions:<br>________________________________________ |
| RQ4: What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science? | IQ 7: What advice or recommendations would you give students who are considering your major?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>**I like this question Oscar!**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>________________________________________<br>I recommend adding the following interview questions:<br>________________________________________<br><br>IQ 8: Is there anything else you would like to share about your computer science experience that you think would be relevant to this study?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it** |

| Research Questions | Corresponding Interview Questions |
|---|---|
| | c. The question should be **modified as suggested**:<br>___________________________________________<br>I recommend adding the following interview questions:<br>___________________________________________<br>___________________________________________ |

Peer Review 3

**<u>Instructions for Reviewer:</u>**

Thank you for reviewing my interview questions for my research study. If you haven't been prompted to do so, please make a copy of this document and share with me.

Please review each question and corresponding interview questions. There is a drop-down column in the middle of each section that will have you choose, "**keep as is**", "**modify**" or "**delete it**". If you are choosing to **modify**, please provide feedback and modifications. Thank you so much. Please return this via email to: oscar.navarro@pepperdine.edu.

| Research Questions | Corresponding Interview Questions |
|---|---|
| RQ1: What challenges do female first and second-year college students face in pursuing computer science-related majors? | Icebreaker. Tell me about your journey as a student in your major.<br><br>IQ 1: What is unique about the academic culture as it relates to your computer science-related major?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>___________________________________________<br>I recommend adding the following interview questions:<br>___________________________________________<br><br>IQ 2: What are some of the most challenging aspects you face as a female pursuing a computer science-related major?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>___________________________________________<br>I recommend adding the following interview questions:<br>___________________________________________<br>___________________________________________ |
| RQ2: What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges? | IQ 3: What practices enable you to pursue a computer science-related major?<br>a. The question is directly relevant to Research question - **Keep as stated**<br>b. The question is irrelevant to research question – **Delete** |

| Research Questions | Corresponding Interview Questions |
| --- | --- |
| | **it**<br>**c. The question should be modified as suggested:**<br><br>I recommend adding the following interview questions:<br>**Add the word strategy if that's the RQ**<br><br>IQ 4: What factors do you believe contribute to you being successful in pursuing a computer science-related major?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>______________________________________________<br>I recommend adding the following interview questions:<br>______________________________________________ |
| RQ3: How do first and second-year female college students measure success in pursuing computer science-related majors? | IQ 5: How do you define success for yourself as it relates to your academic and career pursuits?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>______________________________________________<br>I recommend adding the following interview questions:<br>______________________________________________<br><br>IQ 6: How do you measure that success?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>______________________________________________<br>I recommend adding the following interview questions: |
| RQ4: What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science? | IQ 7: What advice or recommendations would you give students who are considering your major?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>**I think this question will make them feel like real contributors to the solution**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>______________________________________________<br>I recommend adding the following interview questions:<br>______________________________________________ |

| Research Questions | Corresponding Interview Questions |
|---|---|
| | IQ 8: Is there anything else you would like to share about your computer science experience that you think would be relevant to this study?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>____________________________________________<br>I recommend adding the following interview questions:<br>____________________________________________<br>____________________________________________ |

APPENDIX F

Feedback from Pilot Testing

| Research Questions | Corresponding Interview Questions |
| --- | --- |
| RQ1: What challenges do female first and second-year college students face in pursuing computer science-related majors? | Icebreaker. Tell me about your journey as a student in your major.<br><br>IQ 1: What is unique about the academic culture as it relates to your computer science-related major?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>_____________________________ _<br>I recommend adding the following interview questions:<br>_____________________________<br><br>IQ 2: What are some of the most challenging aspects you face as a female pursuing a computer science-related major?<br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>_____________________________<br>I recommend adding the following interview questions:<br>_____________________________ |
| RQ2: What strategies do female first and second-year college students who pursue computer science-related majors apply to overcome these challenges? | IQ 3: What practices enable you to pursue a computer science-related major?<br><br>a. The question is directly relevant to Research question - **Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>**c. The question should be modified as suggested: PRACTICES alone was unclear**<br><br>I recommend adding the following interview questions:<br><br>IQ 4: What factors do you believe contribute to you being successful in pursuing a computer science-related major?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>_____________________________<br>I recommend adding the following interview questions:<br>_____________________________<br>__________ |
| RQ3: How do first and second-year female college students measure success in pursuing computer science-related majors? | IQ 5: How do you define success for yourself as it relates to your academic and career pursuits?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>**In both instances, pilot testers believed this was the strongest question**<br>b. The question is irrelevant to research question – **Delete it** |

| | |
|---|---|
| | c. The question should be **modified as suggested**:<br>___________________________________________<br>I recommend adding the following interview questions:<br>___________________________________________ __<br><br>IQ 6: How do you measure that success?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>**Note: They took the longest to answer this one**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>___________________________________________<br>I recommend adding the following interview questions: |
| RQ4: What recommendations do first and second-year female college students who pursue computer science-related majors offer to those aspiring to major in computer science? | IQ 7: What advice or recommendations would you give students who are considering your major?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>___________________________________________<br>I recommend adding the following interview questions:<br>___________________________________________<br><br>IQ 8: Is there anything else you would like to share about your computer science experience that you think would be relevant to this study?<br><br>**a. The question is directly relevant to Research question - Keep as stated**<br>b. The question is irrelevant to research question – **Delete it**<br>c. The question should be **modified as suggested**:<br>___________________________________________<br>I recommend adding the following interview questions:<br>___________________________________________<br>___________________________________________ |