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Exploring the Motivation and Experiences of Women in the Computer Science Major at Florida Research University

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EXPLORING THE MOTIVATION AND EXPERIENCES OF WOMEN IN THE COMPUTER SCIENCE MAJOR AT FLORIDA RESEARCH UNIVERSITY

By

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This dissertation is dedicated to my late parents-in-law, Mariam Khaïdama Sidibé and Cheick Alpha Cissé, two great minds and hearts who lived through the African transformation and independence movement. They knew that the future and success of our societies depended on gender equity and justice in education. Their legacy and lessons live on through the work of their children, grandchildren, and the African/Mali diaspora. *Ay go bani.*

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ABSTRACT

Universities are reflections of our societies and are tasked with educating the next generation of experts. The computer science (CS) phenomenon, with its high-paying jobs, attracts more students than ever to the CS undergraduate major. One may wonder why women are underrepresented in the CS major if they constitute half of university enrollment and technological consumers. For this reason, the underrepresentation of women in CS demands further investigation and understanding. The underrepresentation of women in CS can affect the next generation of researchers, industry professionals, and role models. If this underrepresentation in education persists, there is a risk of widespread gender-biased technology lacking women's valuable inputs and contributions in all sectors of society (Sax et al., 2017, p. 259).

The literature review revealed that the gender gap in CS has not always been a problem, but that societies and institutions have impacted women's successes and representation (Ehrlinger et al., 2018). The challenges they face are present in all aspects of university culture once they enter higher education and the CS major (Varma, 2016; Steele, 2010). This qualitative research study explored the motivations and experiences affecting whether women chose to persist in or leave the CS major. The findings in this study provided valuable insights for educational policy reforms and intervention strategies to help prospective students complete their degrees and make CS gender-balanced in universities and, ultimately, the workforce, research, and innovation (National Center for Science and Engineering Statistics [NCSES], 2021; National Science Foundation [NSF], 2021).

Keywords: Computer Science (CS), Education, Gender Equity, Women, Minorities, Hispanic/Latinx, Black, Science, Math, Engineering, Physics, STEM, Public University

CHAPTER 1

INTRODUCTION

Problem of Practice

Computers have become ubiquitous in modern-day life, keeping the world digitally connected, breaking down social barriers, and creating fascinating new economic opportunities. The field of computer science (CS) has been instrumental in shaping society's modes of communication, transportation, and daily transactions by implementing innovative technologies in all sectors of society (Berg, 2014). As the world's reliance on computers and advanced technologies increases, the workforce's demand for skilled CS professionals increases. In the United States, data have indicated a surge in demand for CS-related jobs in nearly every major industry, including automotive, healthcare, energy, financial services, manufacturing, and retail (BLS, 2021; The Global Risk Report [GRR] 2022, 2022). These are well-paying jobs with a median salary of $110,140 and a career outlook that projects a growth of 22% over the next ten years, making CS one of the fastest-growing industries in the United States (U.S. Bureau of Labor Statistics [BLS], 2021).

In the words of Apple's chief executive officer, Tim Cook, during a commencement speech at the Massachusetts Institute of Technology, the United States will not stay in the lead in technology unless the gender and diversity gaps are closed, because there are not enough trained Americans to fill the industry's strong projected growth. Since this speech in 2017, there has been nationwide improvement in technology education, but the ripple effects have not been fully transformative (Holmberg-Wright & Wright, 2018; NSF, 2018; MIT, 2017). Despite the compelling market dynamics of solid growth and lucrative salaries straining universities to produce more skilled graduates to fill the demand, women are still underrepresented—not only in

the professional space, where they make up less than a quarter of the science, technology, engineering, and math (STEM) workforce, but also more alarmingly in the CS academic setting where their numbers are flat at 22% (BLS, 2021; NCSES, 2021).

The national data show high demand for CS graduates in the marketplace, and this has translated into an equally high increase in undergraduate enrollment across U.S. universities. CS is now the second most popular major after biology (NSCES, 2021). For Fall 2021, the Florida Research University (FRU) reported over 45% of its incoming students had declared an interest in the CS major (FRU, 2022).

However, women only represented 22% of freshmen seeking CS as a major in the 2021–2022 academic year (Florida Department of Education [FLDOE], 2022). A steady attrition rate further trims down the low number of women in the CS major before they reach their junior and senior years. Between 2018–2021, women graduating with an undergraduate major in CS did not exceed 16% (FLDOE, 2021). For reference, the national completion rate for women in CS was 19.9% in 2018 and is expected to keep increasing to 25% by the end of 2024 (see Figure 1; NSF, 2021). One of the most intriguing facts about the gender gap in CS is that the story was much different just a few decades ago when computer programming was seen as a woman's job (Ensmenger, 2010). In the 1940s, women were recognized for programming the first computer at the University of Pennsylvania; at the time, men saw hardware components as a more masculine line of work because programming was complicated and detailed (Ensmenger, 2019). By the 1960s, an article in *Cosmopolitan Magazine* titled "Computer Girls" continued to recruit women by describing programming as demanding similar qualities to household duties (Ensmenger, 2010). During the Korean and Vietnam wars, when many men were out of the country and

workforce, the share of CS degrees in the United States awarded to women rapidly rose; by 1984, women enrollment reached over 37% of bachelor's degrees (see Figure 1; NCSES, 2016).

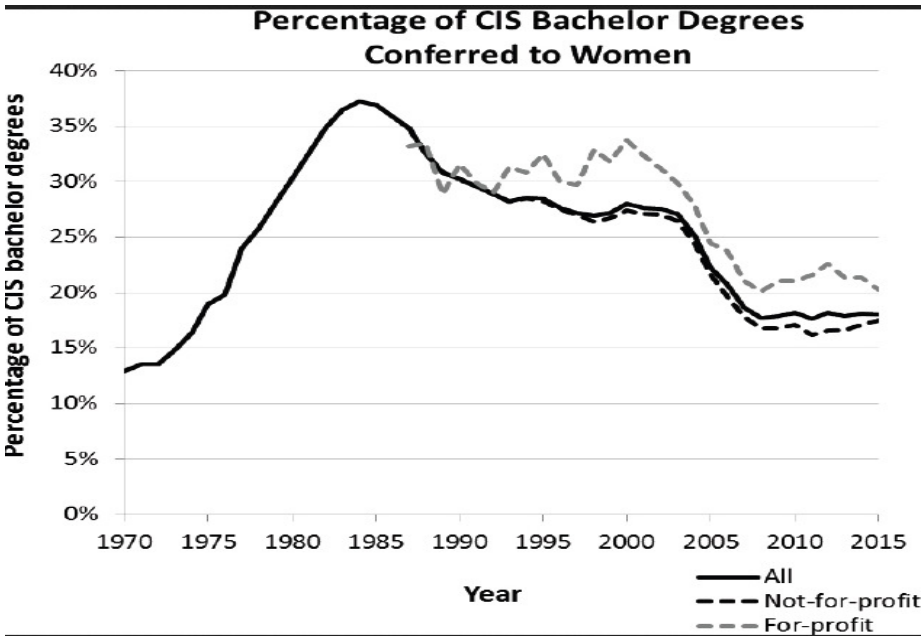

Figure 1

1970–2015 Bachelor's Degrees in Computer Science/Information Awarded to Women in the U.S.

Note. Reprinted from the National Center for Science and Engineering Statistics (NCSES, 2016). Used with permission.

As personal computers became more commonplace and CS jobs were in high demand, hiring practices became rigorous, requiring aptitude tests, mathematical puzzles, and personality tests that favored men in these roles (Ensmenger, 2010; Sax, 2017). The desire for more prestigious CS jobs supported by the employer's search for the ideal candidate translated into fewer women in the profession. (Ensmenger, 2010; Sax et al., 2017). The enrollment trends in universities declined in the 1990s, and the gender gap grew wider; in 1998, only 26.98% of CS

majors were women (see Table 1; FLDOE, 2020; Holmberg-Wright & Wright, 2018; NSF, 2018).

Table 1

Degrees Awarded to Women: Computer Sciences, 1998, 2008, 2018

Degree and year	Percentage of women	Number of women (thousands)
Bachelor's, 1998	26.98	7.58
Bachelor's, 2008	17.69	6.88
Bachelor's, 2018	19.93	16.00

Note. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, unrevised provisional release data, accessed 14 January 2020.

Many researchers believe students' pre-collegiate experience, ethnicity, and exposure to technology education contribute to their college major selection. Such factors are crucial in addressing the root causes of gender imbalance in the CS workforce. The achievement and success of underrepresented minorities in college gateway courses call for more disciplines, particularly mathematics and science, to improve their curriculum in these formative stages where power dynamics shape future computer scientists (Sonnert et al., 2007). Strong role models among professors are essential, and academic support services have been shown to reduce women's attrition (Ellis et al., 2016; Sax, 2017; Varma, 2016).

Boosting women's enrollment numbers in the CS major requires a robust economic investment and strategies to attract and retain women in the undergraduate pipeline (Sax et al.,

2017). Greater participation in CS would open more opportunities for women—since women earn significantly less than men in almost all professional fields in the United States (BLS, 2021), it is crucial to understand what causes the attrition rates and, in the long term, help narrow the long-lasting gender pay gap in the U.S. labor market. A woman who earns a bachelor's degree in CS can make 40% more in her lifetime than other college graduates (Brookings, 2020; Corbett et al., 2015).

Modern society's computerization was not an inevitable process driven by technological advances or economic interests but rather a creative, continuous, and fundamental human creation (Ensmenger et al., 2012). There is an ethical argument for a balanced, more gender-inclusive CS field because the tech revolution has turned nearly every economic sector into a potential computing field. Artificial intelligence (AI) and robotics computing are rapidly gaining a stronghold in many industries, progressively replacing human inputs in employment screening, police identification, and autonomous vehicles/weaponry. Women's participation is crucially needed in developing these technologies that would shape the lives of men and women alike (UN, 2021; Dave, 2018). The status quo presents a potentially riskier alternative in the form of a pervasive but biased tech industry, filling the marketplace with products and services that lack women's valuable inputs and contributions (Google, 2021; Sax et al., 2017).

Finally, from a broad demographic perspective, educating women in computing may be part of the solution to the skilled labor shortage in CS in the United States, especially given women represent roughly 51% of the U.S. population and this majority is projected to grow through midcentury (U.S. Census Bureau, 2020).

The gender imbalance in CS is a dangerous trap this study aimed to break by advocating for policy solutions at the university level. From the start, it is partly rooted in women's high

attrition rate throughout their curriculum (Holmberg-Wright & Wright, 2018). The lower undergraduate completion rate reduces women's access to the tech industry's highest-earning sectors and income (Hill et al., 2010). It restricts the pool of eligible candidates who would become next-generation researchers and members of academia. This, in turn, adversely impacts a women's ability to identify with industry role models, undermines her self-confidence, and undercuts her efforts to remain in the CS program through graduation. The cycle then self-perpetuates as it further amplifies the attrition rate of women at the top of the chain due to these factors.

In reality, the gender disparity in CS is an open secret that industry insiders acknowledge and participate in through embedded personality tests and hiring practices (Dave, 2018; Ensmenger, 2010; Williams, 2014). Leading technology companies in Silicon Valley have started to roll out gender-inclusive initiatives to address professional and development imbalances (Dave, 2018; Shaban, 2018).

In 2018, Google designed a program to foster a more gender-neutral software development process that sets up production teams of men and women (Shaban, 2018; Google, 2021). In the Google teams, women became the final reviewers for most specialized software and applications products (Google, 2021). This model provides a diverse perspective inspired by a unique body of social, professional, and educational reformers to benefit society and industry (Dave, 2018; Williams, 2014).

Purpose of Research

This qualitative research study explored the factors and motivations contributing to women's decisions to stay in or leave the CS major. Florida is unique in the educational and organizational landscape as it has the second-largest system of student enrollment, with over

300,000 enrolled students in the nation (FLDOE, 2021). According to the Florida Department of Education, there are three preeminent research universities, and this case study took place in one of them (FLDOE, 2022; Florida Legislature, 2020).

Specifically, I examined a sample of the participants who successfully entered the Engineering College as freshmen or transfer students and their experience in the CS major. A critical part of that experience was discovering how students navigated the introductory CS courses in the rigid course sequence, also known as gateway courses, students need to enter the major and then progress into their junior and senior years of study.

The first phase of this study consisted of a questionnaire guide for the collection of biographical data of the participants. The second phase was the twenty in-depth individual interviews using Zoom: ten women in the CS major (stayers) and ten women who left CS before reaching their senior year in the major (leavers). The participants chosen represented FRU's first time in college (FTIC) students and transfer students who successfully entered the Engineering College to pursue the CS major. In the third and last phase, I held two focus groups: one with the stayers group and another with the leavers group. A critical part of this phase was discovering how the women navigated the prerequisite and gateway courses, and how they progressed or changed majors to ultimately reach their senior year at FRU.

The literature on women in science has documented the issue of Calculus I, which is required for all science and engineering majors and is a prerequisite to the CS major. Calculus I builds the skills students need to complete more advanced mathematics courses such as Calculus II and III, Differential Equations, Linear Algebra, and Physics with Calculus (Ellis et al., 2016, p. 8). Calculus I is particularly interesting to this study because many students struggle with it, especially if they were not exposed to the concepts in high school (Ellis et al., 2016, p. 8). In a

study examining Calculus I, the researchers found that "it was the culprit for the loss of self-confidence in students and hindered their progression in STEM majors" (Ellis et al., 2016, p. 8), adding that women students were 1.5 times more likely to leave STEM majors after taking Calculus I. They concluded if women continued at the same rate as men in Calculus I, they would make up as much as 37% of the STEM workforce rather than the current 22%, as shown in Figure 2.

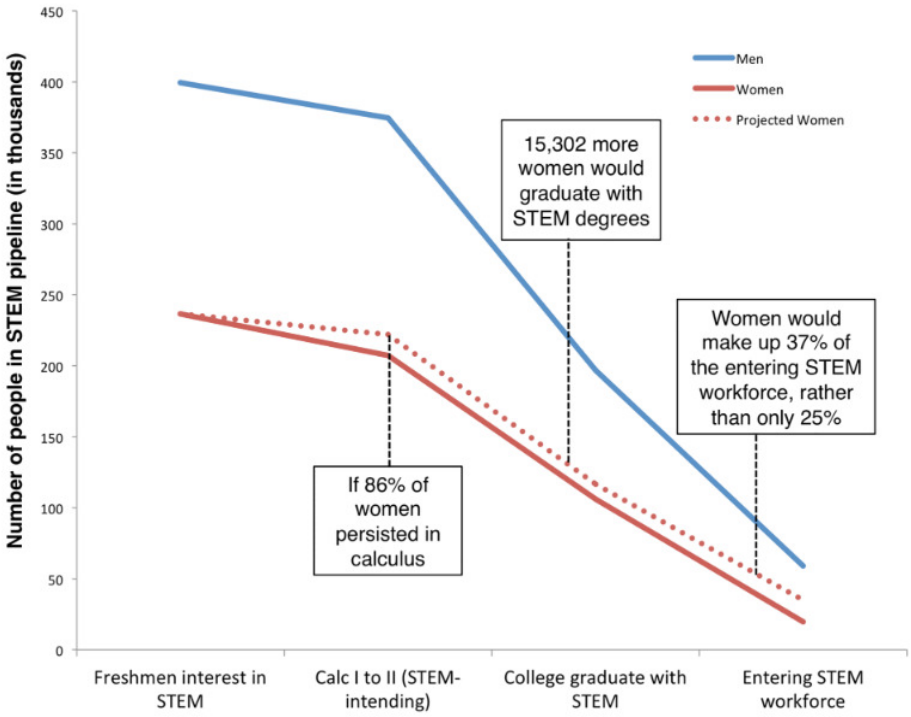

Figure 2

Interest and Participation in STEM Pipeline Over Time with Projected Equality

Note. Source: Women and Men's Participation in STEM majors after Calculus I (Ellis et al., 2016).

Underlying factors further affecting women's persistence before and within the CS major are social stigmas and bias through stereotype threats and microaggressions, which include a

pattern of being overlooked or passed by the majority (Steele, 2010). The stereotype threats are associated with typical CS students (i.e., nerdy, White males lacking interpersonal skills; Holmberg-Wright & Wright, 2018), and can also manifest through microaggressions and threaten women's image by suggesting their sexual orientation preference and compromising their self-esteem (Holmberg-Wright, 2018; Steele, 2010). These stereotype threats and gender biases, and society's views of such dynamics, can influence a student's desire to leave.

Study Design Overview

I used a single-site case study to analyze the bounded system of the CS undergraduate major (Merriam & Tisdell, 2019). The case study was an intensive, holistic description and "analysis of a phenomenon such as a program, an institution, a person, a process, or a social unit" (Merriam, 1998, p. xiii). The research was an exploratory study aimed at understanding the causes of the low entrance and graduation rates among women at the undergraduate level in the CS major at FRU despite the program's increasing popularity. The research targeted women who gained admission into the CS major, had reached their senior year, and had stayed in (i.e., stayed) or left the CS major. The design specifically used interviews to gain insights into the underlying issues to offer specific policy recommendations that may progressively improve the underrepresentation of women in the CS major (Carnegie Mellon Core Values, 2019, Section 3).

The rationale for using the exploratory model was due to the investigation needed in the local setting to determine the root causes of the problem. The university's CS department has fewer women than the national average of 22% in this major (NSF, 2021). A qualitative research study was needed on the underrepresentation of women to bring light to the women's perspectives in the CS major. The exploratory model was well suited to this end because little was known about a local context phenomenon. At best, the information available seemed

inconclusive, if not conflicting. The problem needed to be better understood for broader policy considerations. This design allowed for a deep dive into my problem of practice based on a needs assessment in my local setting.

The research questions that guided the study were:

1. Why do some women decide to stay in the CS major until graduation?
2. Why do some women decide to change majors or leave the CS major?

Study Site Overview

The FRU was established in the 1950s in Florida. In the 2000s, the university received preeminent status from the Florida Legislature and Board Governors and was placed in an elite category among the state's 12 public universities (FLDOE, 2020). The university has over 14 colleges, and Engineering College houses the CS majors. The CS department was founded in 1980 (FRU, 2022). The CS major serves over 2,500 students each year at the undergraduate level and has been ranked top among public universities for best CS programs (FLDOE, 2021; FRU, 2020; U.S. News & World Report, 2020).

The university's students who enter the Engineering College are among the highest achieving upon admission into the CS major. A student must complete a set of prerequisites determined by the CS Department to progress into the major, including scoring an average of 3.5–3.9 overall GPA in Calculus I and II and Physics I and II with labs. This GPA requirement is the highest among all other engineering majors and is the highest at the university. The CS major requires calculus and physics knowledge, and may take up to five years on average to complete (FRU, 2022).

Most students at the university have not taken the advanced placement (AP) CS course; in turn, the majority of students begin the first programming sequence courses only after

completing Calculus I; some are in their 3rd or 4th semester when first starting the three gateway courses: Introduction to Programming, Program Design (i.e., software design), and Computer Organization (i.e., hardware components). They must obtain a minimum grade of B in all three courses. After these classes, students have fully progressed and reached an upper-level status, usually toward the end of their sophomore year (FRU, 2020). As mentioned previously, according to the FRU's university admissions office, the university's Engineering College admission's criteria is one of the highest for entry, as students must be precalculus-ready before entering as first-year students (FRU, 2020).

The university's CS department is aware of the underrepresentation of women and, in turn, reached out for support from the National Center for Women in Information Technology (NCWIT), a 501I(3) nonprofit created by the National Science Foundation in 2004 to support women working in technology. Today, NCWIT makes a far more significant impact than if institutions acted alone, and they strive to improve gender equity in all education sectors and the workforce (NCWIT, 2022; FRU, 2021).

NCWIT paired FRU in a learning circle with the University of Maryland, College Park, and Case-Western Reserve University to structure and implement a broadening participation plan (FRU, 2021). The learning circle offered membership and guidance for increased access and participation to underrepresented students in computing, such as women, minorities (i.e., Black, Hispanic, and Native American), and students with disabilities (NSF, 2021).

After one year of participation in the learning circle, women's growth and retention rates had not improved, as the program had the same 16% average (FLDOE, 2021). This study aimed to investigate the efforts of the CS department and collect data from the women in the department.

Feasibility of the Study

As universities aim to retain their first-year college students, there is also hope to increase the number of students in underrepresented groups, such as women in STEM majors. My admissions, advising, testing, and social science background were assets to this qualitative case study. My role as the program advisor allowed me access to women students who declared CS as their major in the last five years. First, I created a list of women participants admitted as first time in college (FTIC). Then, I researched their academic standing to determine if they had completed at least 90 credits and the CS programming major. I drew on the CS broadening participation and engineering student services' current procedures to conduct this research in 2021 and 2022.

Significance

Local and national stakeholders are affected by women's underrepresentation in the CS major at the FRU. These stakeholders include the CS department, women in the CS program, the Florida community (i.e., Metropolitan City), the tech industry in the surrounding areas, businesses, investors, the scientific and research field, and society. Ultimately, they are all stakeholders in the broader effort for gender diversity. Many factors and experiences influence a women's motivation to pursue a CS major in college, and education professionals can innovate practical solutions to the problem as industries, and local employers have difficulty obtaining a gender-balanced workforce in the technology field (BSL, 2021; Google, 2021; NSF, 2021). Nationally and locally, the market demand for CS majors is at an all-time high. The CS field is attractive to young professionals (both men and women) because it provides many opportunities for (a) participation in life-changing innovations, (b) excellent salaries, (c) flexible work

schedules, and (d) remote work opportunities outside the confines of a traditional office building (U.S. News & World Report, 2021).

Conclusion

Current salary trends in the United States have revealed CS, and higher education degrees in the STEM fields tend to have more positive economic outcomes for women, such as higher median earnings, than those with degrees in non-STEM fields (Corbett et al., 2015; Muro et al., 2018; Snyder et al., 2020). As more U.S. jobs become automated and high-paying jobs move to the technology sector, it is critical to narrow the gender gap in the industry by first understanding the root causes upstream in the educational pipeline. This study examined the motives and experiences influencing women's decisions to either persist in the major or leave the major prematurely. At the end of the study, I offer findings based on my increased knowledge of women's experiences to progressively improve their representation in the CS major and other educational settings.

CHAPTER 2

BACKGROUND ANALYSIS

Introduction

As enrollment increases in the undergraduate computer science (CS) major at the Florida Research University (FRU), one intriguing fact remains clear: the number of women is still low and not increasing. The underrepresentation of women in CS is not a new problem at the university; it has been lingering since the late 1980s when the CS major received its first accreditation from the Accreditation Board of Engineering and Technology (ABET, 2022). Then, women made up roughly 10–20% of the CS students pursuing the CS major; today, 30 years later, that metric has risen but still lags at a low rate of 18.2% (FLDOE, 2021; FRU, 2021). For context, women make up 22% of students pursuing an undergraduate degree in CS nationally (NSF, 2021); therefore, the underrepresentation of women in CS is a national issue not unique to this university (NSF, 2021).

Although it is difficult, if not impossible, to attribute the weakness in women's enrollment to a single factor, this case study provided a baseline understanding of the complexity and interaction of the key factors underlying the gender gap issue in CS. A substantial body of research has grouped these factors into two broad categories: pre-enrollment and post-enrollment. The first set of factors come into play early enough in a young woman's academic life to ultimately influence her initial decision to enroll in the CS major; they include freshman characteristics such as participation in math and science courses, exposure to programming or coding, student's sense of achievement/self-confidence (Steele, 2010), and admission standards into the program itself—such as the first-year gateway math course (Calculus I), other CS gateway courses, and attrition rates. The second group of factors applies once students are

admitted to the CS major, including classroom biases, stereotype threats, and identification with role models (Steele, 2010). These factors are influential because they can either inspire students or wear them down in their academic journey.

A third and important factor associated with the underrepresentation of women in the CS major is a lack of support systems during their early schooling, both for their initial pursuit of the CS major and in continuing to navigate the challenging higher levels of the program (Varma, 2006). This factor indicates the university's broader culture regarding the collective engagement of faculty, staff, and teaching assistants contributing to student success (Varma, 2006).

Understanding these drivers collectively bears significance as they play a crucial role in shaping the psychological context of young women and girls. Therefore, this exploratory study thoroughly investigated factors underlying women's enrollment and the graduation gap in the CS major. Later, this study is informed by women's selection of the CS major in college and their perceptions and motivations to continue in the CS program until completion. An exploratory approach was best suited for this type of research as little was known about the problem's origin in the university's local context. The problem has remained because it needs to be better understood at the root-cause level (Merriam, 1998). At that time, the problem could be adequately addressed with policy recommendations and interventions needed to make equitable improvements to the CS major at FRU and other similar institutions (Merriam, 1998).

The study used a qualitative research design to explore the experiences of target students that had reached their senior years and remained in the CS program, compared to those who had left the major prematurely. Specifically, through targeted interviews and focus groups, I explored the following questions:

1. Why do some women decide to stay in the CS major until graduation?

2. Why do some women decide to change majors or leave the CS major?

Orientation in the Larger Educational Landscape

Across the state of Florida, The University of Central Florida (UCF) has the best record for graduating women in CS undergraduate major in Florida, at 23%, followed by Florida International (FIU) with 22%, and the University of Florida (UF) with 30% (Florida University Systems, 2021). These figures suggest the problem at FRU is not as pronounced compared to the other similarly ranked Florida universities or compared to national averages; however, it is worth noting these state peers have all instituted various diversity and inclusion programs such as The Building, Recruiting, and Inclusion for Diversity (BRAID) initiative to help attract and retain underrepresented groups, including women. Still, the gender gap in CS enrollment is too significant to ignore locally, regionally, or nationally.

Women's enrollment and completion metrics in CS have not always been as low as 22% nationwide (NSF, 2021). In the mid-1980s, the CS field peaked in popularity when women earned about 35% of bachelor's degrees (Lehman et al., 2017; National Center for Educational Statistics, 2014). Fueled by the personal computer's early success, many corporations built their computing infrastructure, and hiring was plentiful. Slowly, employers left out women's characteristics as the desired personality type (Ensmenger, 2010). As "computer experts" rose to power in modern society, the prestige associated with the profession also resulted in overlooking the "Computer Girls" of the past (Ensmenger, 2010, p. X). By the 1990s, a decline began in both industries and universities; the trend bottomed out by 2011 when only 18% of CS degrees were awarded to women (Lehman et al., 2017), with a relative rebound to the current level of 22% (NSF, 2021).

It is noteworthy to state these national averages hide a wide degree of disparity among U.S. universities. Two schools stand out at the other end of the enrollment spectrum for early adopters of policy-driven changes to close the gender gap in their CS programs. The Massachusetts Institute of Technology, one of the most recognized and reputable educational institutions in the United States and the standard-bearer in tech education, currently boasts a 50% women enrollment rate in CS. Many years in the making, this gender parity was achieved through comprehensive structural changes, including a proactive approach to revamping the CS curriculum, non-gender-bias training for faculty, and a targeted recruitment effort toward women (MIT, 2020).

Harvey Mudd College, a small private university in Claremont, California, had 20% women enrollment in 2006, right on target with other CS trends. Since then, their president has implemented sweeping cultural changes to stop the decline of women in the school's CS major (Frieze, 2019). Some changes included changing the admission requirements, providing more support services, having more women in faculty positions serving as role models and mentors, and increasing women's representation on the board of directors (Frieze, 2019). Early acknowledgment and action in the institution's culture and CS departments contributed to the over 51% women enrollment in 2019 (Frieze, 2019). These two success stories partly inspired my study by focusing on the broader, all-encompassing cultural backdrop where all the other factors interact to shape the student's college experience.

In a recent study conducted by NSF's ADVANCES program (diversity section of NSF), they found women and minorities (i.e., Black, Hispanic, and Native American) represented only 9% of faculty in science, technology, engineering, and math (STEM) fields at four-year institutions, which silently contributed to the low representation of women and other minorities

(NSF, 2021). Their analysis concluded increasing women's representation in faculty positions could, in turn, drastically reduce the gender and achievement gap by 20% to 50% in gateway courses (NSF, 2021).

Literature Review

In the literature review for this study, I focused on understanding the influences that have contributed to women's motivations to pursue, stay in, or leave the CS major. Women's personal experiences in the undergraduate CS major are missing from the literature review and data. As Gillham (2000) suggested, it is essential to know what the literature suggests about the situation being studied, as it provides the researcher with a sense of what the field has done and where it may need further exploration by using a case study.

The current research literature contains comprehensive empirical studies and articles that provide valuable insights into women's challenges in CS. Much of the literature review centers on research studying how the stereotype threats in classrooms, role models, and student supports contribute to women's retention in male-dominated CS majors. "Although the micro-culture of classrooms shaped women and girls' attitudes, they are not isolated from broader, prevailing cultural messages" (Frieze et al., 2011, p. 12). The discussion in the literature highlights the topics that provide an understanding of the complexity of students' CS experiences, and add on the factors that influence women to leave the major.

Access and Equity in CS Education

Researchers cannot aim to understand the disparity in advanced placement (AP) CS exams without examining the high school systems available to women seeking the CS major. As background, only 45% of high schools in the United States teach any CS courses, and of test-takers, girls represent around 34% of those students exposed to early CS programming concepts.

Comparatively, in Florida, only 33% of AP exams taken by high school students are in the CS subject, with women accounting for 31% of those students (Florida Department of Education, 2020). Locally, at the research site university (FRU), there are much lower metrics: less than 20% of its incoming freshmen CS students, of which 10% are women, had prior credentials of CS credits (Code.org, 2020; College Board, 2020; Florida Department of Education, 2019).

The United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2015) released a new report discussing the need to increase the participation of women and girls in science because they consist of one-third of the researchers but are still underrepresented in the leading positions at top universities; consequently, women have a lower number of articles and publications. In turn, women and girls are less known, receive less recognition, and have less research funding. The UNESCO report was released in 2015 when they also established the International Day of Women and Girls in Science, now celebrated each February 11th.

The United Nations Secretary-General António Guterres (2021) recognized the importance of making technical education available to women and girls in high schools, and discussed the importance of adjusting to future technology education. The United Nations' definition of technical and vocational education is vital in increasing learning outcomes for women, as well as potential earnings and skill sets needed for our transglobal society.

Many U.S. states, including Florida, are trying to improve women's representation in CS. Florida approved new graduation substitutes and waivers that allow CS to satisfy a high school math credit (FLDOE, 2019). Improving access to CS courses is vital to ensuring women and girls enter high-paying technology jobs to drive innovation and creativity in the field (Microsoft, 2020). Research demonstrates women are more likely to pursue CS in college if they can explore it in high school (College Board, 2020). According to the College Board (2020), women and

girls who took the AP Computer Science Principals course and the continuing course, AP Computer Science A, in high school are five times more likely to select CS in college than those who did not take the CS AP courses (College Board, 2020). The study also found that minority groups such as Black and Hispanic students are nearly twice as likely to declare CS as their major. These AP courses are a route to the STEM fields for many underrepresented minorities that the CS major and, potentially, academia as a whole is missing (College Board, 2020).

The CS major at FRU has three gateway courses. The Introduction to Programming course for only CS majors requires completion of Calculus I; this prerequisite already places many women at a disadvantage if they do not receive calculus preparation at their high school. Consequently, it can take an average of three to four semesters for women who start as first-time-in-college (FTIC) students below the calculus level that might be placed in college algebra or precalculus to gain access to the first programming course.

Achievement and Self-Confidence

Academic self-confidence is considered a reliable predictor of academic achievement, regardless of a student's age and gender. For young women in STEM fields, Lehman et al. (2017) found that self-confidence correlates to the students' liking for mathematics and science. They based their findings on an analysis of data from the Cooperative Institutional Research Program (CIRP) relative to the demographic backgrounds, career aspirations, and self-perceptions of a large sample of first-year CS women in the United States as compared to both their male CS counterparts and a broader subset of women in other STEM subfields. The study revealed that in CS, men earned higher SAT math scores than women, although women earned higher SAT verbal scores (Lehman et al., 2017).

Surprisingly, the CS women self-rated their math skills lower than women in the other STEM majors even though, in most cases, they scored higher than women in other sciences; they also rated themselves lower than both men in CS and women in other STEM fields on measures of academic and leadership ability (Lehman et al., 2017). In summary, although young women graduate from high school performing equally to boys on standardized tests and possessing math and science skills useful for STEM careers, many choose not to pursue a CS degree because they lack self-confidence (Lehman et al., 2017). For these reasons, the study concluded women in CS are more likely to be undecided in their career plans than students in the other two reference groups.

Women's underrepresentation is partly due to their lack of exposure to technology and coding. CS courses are challenging in nature, as they are essential in narrowing down the pool of students in the CS major. For most students, introductory CS gateway courses are some of their most stressful classes (Holland, 2019). The communal problem seemed to be that encountering STEM content was much harder—"whether intrinsically or situationally"—for students without prior technology and programming access (Holland, 2019, p. 285). The struggles and challenges women face, and their view of their competence, causes them to doubt their belonging in CS and STEM majors as "they are also shaped by classroom and program climates, most especially by interactions with instructors and peers" (Holland, 2019, p. 285).

Moreover, a comparative case study by Frieze et al. (2019) further expanded on the latent importance of self-confidence by exploring the correlation between gained experience and increased self-confidence among women in CS classrooms. The study found that gender-balanced classrooms correlated with women's higher levels of self-confidence compared to less gender-balanced classrooms (Frieze et al., 2019). The study also noted that it was less

appropriate in the United States for women to express a sense of confidence than men compared to other countries such as Malaysia.

The literature has also revealed how several aspects of self-identification associated with building self-confidence provide women with higher collegial grades and persistence levels in CS college majors (Frieze et al., 2019). Interestingly, Orr et al. (2011) found women in science and engineering earned higher grades than men; their desire to overperform stemmed from proving to themselves that they belonged. The CS classroom transition and the impact of stereotype threats were also manifested in the CS college classrooms (Sax, 2017).

Stereotype Threats in the Classrooms

As a field of study, CS has male stereotype threats associated with it, creating identity threats that undermine women's sense of belonging and their interest in pursuing the major. Popularized in the current media landscape, these stereotype threats include being White, male, a hacker, a gamer, nerdy, and a social misfit. The latter three characteristics have negative connotations from a women's perspective (Cheryan et al., 2016, p. 65).

In a study examining gateway courses in the CS major, Benbow et al. (2016) reported women participants were asked to describe male students' typical profiles and faculty in CS. Many participants saw CS students as "brogrammers," which describes a "male that loves to play video games, and this also creates them using programming." They described the CS faculty member as "very macho and smart" (Benbo et al., 2016, p. 25). This double stereotype threat often makes for a lonely experience in the classroom for women, as highlighted by one of the participants who said, "When you are surrounded by men who seem like they have it all together, you feel a little out of place" (Benbow et al., 2016, p. 25).

Meyer and Marx (2014) led a qualitative study to determine why undergraduates leave engineering. These authors found one of the common reasons was trouble fitting in. The study found that women and other underrepresented minorities (i.e., Black, Hispanic, and Native American) would feel more comfortable interacting with peers like them and have better learning outcomes (McGee, 2017; Varma, 2006). For Varma (2006), the isolation created by the stereotype threats was crucial in understanding women's underrepresentation in CS. In a study exploring the causal effect between social identity and the gender gap in CS, many participants reported anxiety in the classrooms when they felt they did not belong; Varma added that these feelings of isolation could be alleviated only if the women were in groups based on "interpersonal familiarity and acceptance" by classmates (Varma, 2006, p. X).

Another aspect of how stereotype threats play a role in women's participation in CS was documented by Cheryan et al. (2013) in a study with CS students from Stanford University and the University of Washington. The researchers found that women who did not have prior knowledge of CS classes generated a more stereotypical male image than those women who completed preparatory CS courses in high school. They also pointed out that the source of these stereotype threats may "lie outside these classes" (p. 65). They suggested encouraging women to take CS classes earlier than college, as it can help them form a "more accurate image of the CS major" (p. 65).

In the end, contrary to widespread belief, many studies argue the underrepresentation of women in CS is not due to women's "intractable lack of interest in CS" (Cheryan et al., 2016, p. 69) but instead the pervasive stereotype threat—the "computer nerd" image portrayed in television and movies that women do not identify with. This lack of identification affects women's self-confidence to stay in the major, especially as they navigate the rigorous CS

gateway courses. Although shaped by the pressure to achieve microculture, a form of bias that can manifest in CS classrooms and departments, it is not isolated from the broader and underlying cultural messages women perceive (Frieze et al., 2011, p. 12). Only by understanding the factors that affect women's experience and decision making can the situation at the university be better understood.

In a study examining CS and engineering majors, Orr et al. (2012) found student performance starts low at the freshman level, drops slightly at the sophomore level, and then increases at the junior and senior levels. These authors noted that the pattern was consistent even after controlling other variables, such as the engineering major; this pattern was essential in persistence considerations because women were more sensitive to performance earlier in their college career than men (Orr et al., 2011).

Another exciting research finding by Orr et al. (2011) was that women earned higher grades in CS than their male counterparts, with equivalent backgrounds in most CS and engineering majors. These findings were both revealing and confusing, and continued the concern of why there are still so few women in CS. Future quantitative research should further investigate the differences by testing more parameters and variables (Orr et al., 2011). It is worth noting stereotype threats were also reported in many of the research studies and led to the isolation of women (Cheryan et al., 2016; Steele, 2010). Only by understanding the factors that affect women's experience in college and their decision making can the situations of university majors be better understood.

Women who enter a CS program may feel they must work extra hard to prove themselves and fit in. Exploration of this hypothesis—why women stay in a major or why they choose to

leave—spurred the need for a qualitative case study of the FRU CS major. This pragmatic case study investigated women's experiences in the CS program without generalizing.

Network of Support: Role Models as Student Support

A supportive network including family, friends, teachers, and professors as role models cannot be underestimated in STEM programs and CS, because the involvement of women's role models is an excellent way to overcome stereotype threats. According to Carnegie Mellon professor Blum (2018), CS is not difficult. Still, CS officials make it much more difficult, which is one of the reasons why women have low participation in CS (Frieze, 2019).

Besides influencing young women's preferences for STEM subjects and choosing the CS major in the first place, effective interventions from a perceived role model can also increase a woman's sense of belonging in the face of hostile stereotype threats, isolation, and self-doubt. A University of Florida study conducted by Bossart and Bharti (2017) examined the graduation rates of women in their math and science programs compared to the national average; they found a correlation between the number of women faculty and women's graduation rates in their programs.

One of the leading defenders of women in high-ranking positions in math, science, and computing was Dr. Grace Hopper, a mathematician, physicist, and computer scientist (Yale News, 2017). Dr. Hopper was a Yale graduate and professor. She was also a Navy Admiral and a world-renowned computer scientist pioneer. She is known best for focusing on education, information, and improving leadership systems. Dr. Hopper was also known for inventing machine-independent programming compilers that led to the COBOL language (Yale News, 2017). She said in a televised lecture at the Massachusetts Institute of Technology, "Humans are allergic to change. They love to say, 'We've always done it this way.' I try to fight that. That is

why I have a clock on my wall that runs counter-clockwise" (MIT, 1995; University of Tennessee, 1933).

Dr. Hopper was not just a woman with abundant knowledge and an innovator; she was also an advocate for gender equity who had to work much harder to be recognized in male-dominated environments, the military, and the university's math and science departments. She was a pioneer in the CS revolution, inspiring women to come together to advocate for improved and equitable learning conditions and employment. Thanks to role models like Hopper, today's women in CS fields are shown more inclusion in the workforce (Google, 2020).

Local Context

FRU was established as a commuter college in the 1950s with two satellite campuses, all located in the broader Florida region. Despite being a young university, it received a preeminent status designation in 2018 from the Florida Legislature and Board Governors, placing it in an elite category among Florida's 12 public universities (FRU, 2020). The university has 14 colleges, including the Engineering College, which houses the CS and engineering departments, founded in 1980. There are four undergraduate majors, including Computer Engineering (primarily focused on hardware design), Computer Science (software design), Information Technology (IT), and Cybersecurity (security subset of IT), all of which are limited access programs (FRU, 2020).

The university's CS program serves over 2,000 students each year in all degrees, including bachelor's, master's, and doctorate (FRU, 2020). At the time of this research, the CS program had a total of 29 tenured professors, only three of whom were women (a mere 7%), and 13 full-time instructors (five women), all with doctoral degrees in the fields of electrical engineering, computer engineering, or IT (FRU, 2020). At FRU, men have always held every

position of authority at the undergraduate and graduate levels; the first woman faculty member was hired in 2010.

The CS program received its first ABET accreditation in 1989; a review was conducted in 2020. ABET's purpose is to identify high-quality engineering and technology programs in universities. ABET aims to "increase creativity and innovation, which is achieved when persons with varied perspectives, experiences, and talents work toward a common goal" (ABET, 2020, p. 5).

FRU's metropolitan region in Florida has grown immensely in the last ten years and has obtained a preeminent status (FRU, 2020). Nevertheless, the university's growth did not bring more women into the STEM or CS majors. According to a recent policy initiative set forth by the two new campus presidents, the university joined a national program to develop more inclusive faculty recruitment, hiring, retention, and teaching practices that would lead to more female faculty hiring (FLDOE, 2020, 2022). This inclusion initiative was launched in 2022, and the university joined the Association of Public and Land-grant Universities (APLU) known as Aspire—The National Alliance for Inclusive & Diverse STEM Faculty—along with the Center for the Integration of Research, Teaching, and Learning at the University of Wisconsin-Madison (FRU, 2022).

At the time of this research, the university did not have a comprehensive policy training program or workshops that discussed implicit bias in the classrooms and how to tackle and solve these issues. As noted, this underrepresentation of women could have consequences in increasing gender biases and reducing the efficiency of classroom learning for women and minorities (Varma, 2006).

Summary

Women's motivations and decisions to pursue, remain in, or leave undergraduate CS majors can only be understood with a clearer understanding of the factors contributing to their decision making. We can only learn how to increase women's participation in STEM by understanding what they consider challenges and obstacles in obtaining their college degrees. The background analysis and literature review showed that the underrepresentation of women is a national phenomenon. The literature review helps illustrate the investigated situation, other researchers' approaches, and a comprehensive picture of the research problem (AERA, 2006). Moving forward, it is up to society to determine the how, the why, and the path to investigate the research problem in local settings. Ultimately, insight into these factors may enhance the CS program by promoting more inclusive policies to increase women's enrollment and narrow the gender gap in CS in the major and tomorrow's workforce.

CHAPTER 3

INVESTIGATIVE APPROACH

Introduction and Study Type

In this qualitative study, I used a pragmatic case study approach to explore women's decision making in the undergraduate computer science (CS) major at Florida Research University (FRU). This university fuels the vibrancy and strength of the Florida regional economy by serving as a research and innovation powerhouse (FRU, 2021). For this reason, it is necessary to uncover the undergraduate CS major's significant gender disparity, where 22% of students enrolled have been women and fewer than 4% have been women of color (i.e., Black, Hispanic, or Native American; FRU, 2021). This section includes a general overview of the study type, research design, sample size, data source, analytical approach, limitations, and conclusion.

A research method needs to be justified pragmatically, as Elliott and Lukes (2008) stated, and kept open to allow for the fitness of purpose to lead the study case. A qualitative case study was best suited for my practice problem and research questions, as the reason for the study was not whether things worked well in the CS department but why current policies and practices worked differently for underrepresented students in FRU and the CS major. I observed the bounded system, as defined by Merriam (1998), in the CS major phenomenon and the unique and specific social unit of educational settings at FRU (Frieze et al., 2019; McGee, 2017; Varma, 2006). To add to this description of a qualitative case study, Yin (2009) suggested the exploratory research method to help answer the how and why questions a study seeks to investigate. In referring to the case study, Gillham (2000) argued it allows a view of the situation

being studied "from the inside out: to see it from the perspectives of those involved" (p. 11). Lastly, a case study is the

> …consummation of a work of art…it is an exercise in such depth, the study is an opportunity to see what others have not yet seen, to reflect the uniqueness of our own lives, to engage the best of our interpretive powers. (Stake, 1995, p. 136)

With this research study, I sought to explore how young women decided to pursue, stay in, and graduate with a CS major or leave and change their major. Case study research and data analysis can provide pattern matching to make sense of such complex cases and situations (Alexander, 1979; Savin-Baden & Major, 2013).

In Chapter 2, I reviewed several studies that identified factors influencing women in the CS major and my rationale for this study. The advancement and representation of women and other underrepresented students in engineering and science programs are concerning, as universities create experts and impact women's economic success in the future. Women have been overlooked and functioned in social and educational cycles, resulting in significant disparities (Ensmenger, 2010).

In the scope of this study, I shed light on women's educational experiences at the university. I used nonrandom sampling to recruit participants who met the research criteria of FTICs or transfer students, having more than 90 credits completed in the CS major, and having upper-level status. To collect data, I used in-depth interviews and focused groups with ten women who stayed in the CS major and ten women who left before graduating. To better understand the dynamics of the students' decision-making processes, I narrowed my research question but remained flexible to a certain degree to allow new data to emerge (Merriam, 1998).

Limitations

The increased demand and enrollment trends have challenged public universities to provide instruction and deal with funding issues and budget cuts (FLDOE, 2020). These occasionally cause inequalities that affect traditionally underrepresented students. As cited in Savin-Baden & Major (2013) and Pope (2007), individuals are not insensitive to investigations of subject matter in this type of study. In turn, individuals must recognize the subjectivity they bring to the task. To overcome my subjectivity, I wrote about myself in my doctoral classes before conducting this research study and disclosed my topic of interest to my supervisors.

I used three research design strategies to maximize validity and reduce researcher bias threats (Creswell, 2007); I reduced research barriers by acknowledging my past experiences, prejudices, partialities, and positioning. Finally, I relied on women in the interviews to validate the data after data analysis; this approach was recommended by Creswell (2007) when dealing with qualitative data such as interviews and focus groups. Motivations and perspectives are complicated for everyone involved; Savin-Baden & Major (2013) suggested researchers try to provide a voice to underrepresented and disfranchised individuals. As such, researchers can fully understand the power dynamics and work involved to achieve the truths in cases through dialogue.

One limitation of the study was that only undergraduate women were interviewed. The sample selected for the study was specifically women who were pursuing a Computer Science major. The results obtained in the study may not apply to students outside of science, technology, math, and engineering majors. This single-site case study was small in sample size with a unique environment. The large Florida Research University environment focused on professor research alongside CS instruction is characteristic of a case study in preeminent research educational

settings. The perspective of CS faculty members was not part of this study. This study did not use the perspective of other men or other underrepresented minorities. However, this boundary was intentional and purposeful due to the nature of the exploratory case study (Merriam, 1998).

Another possible limitation was my assumption that the participants responded fairly and truthfully to the interview guide (see Appendix A), the interview questions (see Appendix B), and in focus group discussions (see Appendix C), reflecting their experience and motivations at FRU and in the CS major. I also assumed participants in the study were free from internal or external pressure.

Research Design

This exploratory study aimed to thoroughly investigate women's experiences in the CS major using an interview guide (see Appendix A) to collect biographical information, individual interviews (see Appendix B), and focus group data (see Appendix C). An exploratory approach was best suited for this type of research as little was known about the women's lives and lived experiences in the CS major. This method helped me to understand their point of view. The problem of underrepresentation of women needed to be examined in many ways, including learning their view of their gender, race/ethnicity, socioeconomic status, and other social interactions in college. This study offered practical suggestions and solutions to improve the underlying problem and provided policy recommendations and interventions.

The study targeted women who pursued CS as a major and had reached their senior year, who had either remained in or left the major. Not much is known about why women leave the CS major as juniors or why some persist through graduation. Using semi-structured interviews and focus groups, I asked:

1. Why do some women decide to stay in the CS major until graduation?

2. Why do some women decide to change majors or leave the CS major?

Qualitative research can allow the researcher to find answers quickly and generally related to their problem practices (Savin-Baden & Major, 2013). Researchers should use a case study design when asking "how" and "why" questions; these questions allowed the students in my study to express their perspectives on a topic or issue and allowed me to collect comparable data across respondents (Merriam, 1998; Savin-Baden & Major, 2013; Yin, 2009). This method allowed me to get to know the participants, get close to their lives, hear their thoughts, and try to determine the factors they saw as necessary in making their decisions (i.e., their thoughts, feelings, and desires; Merriam & Tisdell, 2019, p. 32).

Sample

The CS major is among the most sought-after majors at the university and in the Engineering College. Still, very few students currently reach upper-level status in CS; out of 1,234 students, only 258 are women in upper level/division (FLDOE, 2022; FRU, 2022). I used purposeful and nonrandom sampling to explore the research questions (Merriam, 1998), which offers a great deal of information about the issues of central importance to the purpose of the research (Merriam, 1998, referencing Patton, 1990). The participants offered information-rich cases.

The criteria I used to invite women to the two groups were: (a) meets admissions criteria to pursue the CS major, (b) holds no prior bachelor's degree, (c) is a first-time-in-college (FTIC) student, (d) is a transfer student, (e) completed the FRU Introductory to CS course, and (f) has more than 90 credits in the CS major. The participants had to be representatives of different racial and ethnic groups in Florida, including Asian, Black, White, and Hispanic. Additionally, the women in my sample size would have taken Calculus I, Introduction to Computer

Programming, and Physics in college; these are the gateway CS courses, where students needed a grade of A or B to continue the CS major (FRU, 2022).

The participants were carefully selected after meeting all the criteria. The students I identified received an introductory email containing the purpose of my research study and a summary of the participation requirements: an interview session and a follow-up focus group session.

Interview Guide to Collect Biographical Information

Once the women were selected to participate, they received a scheduling tool to choose an in-person or virtual interview. Afterward, the participants received an interview guide to collect their biographical information including race/ethnicity, high school location, and any college preparatory work including advanced placement (AP), dual enrollment (i.e., college courses in high school), and other college-level credits or technical experience. These questions aligned with findings from the literature review, emphasizing the importance of first-year students' characteristics to their persistence. The data collected provided a display that assisted me in engaging with the women's freshman experiences. Completing the interview guide took, on average, 15 minutes, and the women were free to elaborate on many categories in a written format.

Interviews

Interviews are the core of qualitative research. As such, they were the primary data collection method for this research study. This study provided information about the typical lived experience of a CS undergraduate woman. I selected ten women who stayed in the CS major and ten women who left the major to interview, and I recorded all sessions using Zoom meetings and a sound recorder as a backup instrument. After selection, participants were asked the same

closed- and open-ended interview questions related to their lives and experiences at the university. All participant identities were protected, and each was assigned a pseudonym to correspond with their responses.

In the semi-structured interviews, I asked participants why they enrolled in the CS major and why they had decided to stay enrolled or to leave the major. Each interview lasted 60-90 minutes. I structured the interviews for the women in each group, allowing for conversation flexibility. The flexibility allowed me to dive deeper into the women's lives and ask them to share their perceptions of the CS major. Some needed more time to elaborate on their experiences and reflect on their decision making.

Focus Groups

The study's second phase gathered the women into two online focus groups using Zoom meetings. The first group was the women who stayed in CS and were now seniors in the major. The second group was the women who left the major but never reached their senior year in CS. Each focus group had a minimum of nine participants; the sessions were recorded and lasted 60–90 minutes. The participants were the same women from the individual interviews. I expected the focus group approach following the individual interviews to allow all students to build off each other's experiences. The women were encouraged to share their stories to expose a more meaningful understanding of their lives, development, and involvement. These experiences amplified the students' voices and allowed richness in the diversity of the student experience to emerge (Rutledge et al., 2021). As the participants had many shared experiences, I started with an open-ended question for discussion, and the conversation flowed freely if the topics aligned with the presented prompt in the interview guide. I also remained attentive to whether the women wanted to discuss their experiences on specific questions or topics.

For the women in the study who left the CS major, I structured the focus groups the same way. However, the first questions focused on their new major and its comparison to the CS major. Through this study, I sought to understand the women's perceptions during their journey. This last stage of the research study was another opportunity for me, as the researcher, to gather and interpret data from group dynamics and situations from their experiences (Merriam, 1998, p. 22).

I was the moderator and observer in the interview and focus groups. During these discussions, I maintained a log and made necessary notations based on the participants; I was the moderator for all phases of the research process. I let the participants expand on topics they continued to mention or for which they revealed enthusiasm. Each focus group interview took two hours or more. I remained as observant as possible in the focus groups and took notes. It was vital to track the participants' reflections. I paid attention to the feelings and emotions that the participants spoke of, recalling their lived experiences as college students.

This research study provided insights into understanding women's motivations and decision making in the CS major. Together, the in-depth interviews, focus groups, and my notes were the primary data sources I collected in this study. They provided further data on the factors influencing these women during their formative freshman, sophomore, and junior years in the CS major. It is evident that other studies are needed in the science, technology, engineering, and math (STEM) majors to narrow the gender gap at the university level that later translates to the technology workforce.

The information I collected and data recordings have been secured in an FSU box cloud, and I used Otter.ai as a trustworthy voice-to-sound transcription generator. After generating the

transcripts, I followed up with each interview transcript and compared it to the original interview recording in NVivo to validate the accuracy.

Data Analysis and Approach

Data analysis is one of the most critical phases in the qualitative research process (Savin-Baden & Major, 2013). The data analysis process should focus on the research questions, address all possible interpretations, and reflect the existing literature on the topic. It also informs the work of other scholars studying this topic (Yin, 2009, as cited in Savin-Baden & Major, 2013). I used a qualitative case study approach to conduct the data analysis pragmatically to obtain a "general sense of what the speaker is saying, the meaning of the whole in context" when analyzing individual situations (Savin-Baden et al, 2013, p. 447).

I used tools such as Otter.ai, NVivo, Word, and Excel to analyze my data. NVivo is a software package that allows evaluation and the ability to analyze data by individual questions or particular groups. I created a spreadsheet in Excel with rows for each woman I interviewed and a column for each question. Microsoft Word allowed me to create visuals of data represented as essential aspects of the data analysis (Hamilton & Corbett-Whittier, 2013).

After collecting data for biographical information using the interview guide, I proceeded with the interviews and focus groups; I pulled apart the data using pragmatic analysis. Savin-Baden & Major (2013) noted, "A researcher can rely on intuition and sensing, rather than being bound by hard and fast rules of analysis" (p. 441). This method followed the protocol developed by Braun and Clarke (2006), allowing me to become familiar with the data, generate initial topics, search for information, review issues, define and name concerns, and produce a report (Braun & Clarke, 2006). I added positionality for the participants in this study, as Saldana (2021) discussed the value of data analysis and how to use participants' emotions or actions to create

first- and second-depending topics that provide purpose to the research, allowing me to "prioritize and honor the participant's voice" (p. 365).

The focus of this research's interpretation was a basic description of why women decide to stay in or leave the CS major. The emerging concerns guided me when interconnections emerged from the findings. I chose this method because Savin-Baden & Major (2013) suggested through the process of analysis, "immersion in data and considering connections and interconnections between topics, concepts, and concerns that an 'aha' moment happens" (p. 440).

Miles and Saldana's Guide to Data Analysis (2020) notes three phases in qualitative data analysis. The first step is data reduction, which refers to selecting the essential data in the interview, focus groups, and researcher's notes and then focusing, simplifying, abstracting, and transforming the collected data. The second phase was data display, conclusion drawing, and verification (Miles & Saldana, 2020). The last step was concluding and triangulating by verifying the findings with the participants (Miles & Saldana, 2020). As such, I created memos, probing and descriptive summaries, and networks of my conclusions in Otter.ai and NVivo (Miles & Saldana, 2020).

Summary

In conclusion, this qualitative case study design was best suited to explore women's decisions to either remain in the undergraduate CS major or leave. The CS growth phenomenon makes CS one of the most intriguing majors to research as society demands more skilled workers. The growth of women participants in the major is crucial for gender equity at universities and in the industry. Through this exploratory single-site case study of women's experiences, I researched and analyzed the factors that allowed women to persist and graduate

and the factors that adversely affected women's success in the major. This case study contributed to the university's CS departments, faculty, and staff; advising knowledge for K–12 students; and the contributing factors in students' college major selection. This single-site case study will also help similarly sized institutions develop more inclusive policies and gender awareness in higher education topics affecting underrepresented groups in STEM.

CHAPTER 4

FINDINGS AND IMPLICATIONS

Summary

This study examined the factors contributing to the underrepresentation of women studying undergraduate Computer Science (CS) at Florida Research University (FRU), a preeminent public university. Even as the growing popularity of computing technologies has boosted enrollment numbers in CS majors over the past decade, women's attrition rate remains much higher than that of their male counterparts (FLDOE, 2021). The research literature on women in science and math majors identifies several reasons for this gender gap, including the lack of pre-collegiate exposure, stereotype threats from society and the classroom, and embedded biases in the curriculum itself (Holmberg-Wright & Wright, 2018; Ellis et al., 2016). To date, there has not been an in-depth look into women's experiences enrolled in the CS major at FRU, and this research was intended to fill that void.

The students who enter FRUs CS program are among the highest-achieving high school students, with a minimum GPA of 3.6 and SAT/ACT scores averaging 610/26, placing them in precalculus and among the highest compared to other FRU majors (FRU, 2022). In addition, all students must complete two prerequisite courses and gateway courses determined by the CS Department to progress into the upper-level CS courses.

The first condition for all first-time college students and transfer students is to obtain a 3.5 average in Calculus I and II and Physics I and II with labs (FRU, 2022). Then, they must complete a sequence of CS gateway courses, usually after completing Calculus I. Most students who do not have prior CS AP exam credit in high school take Introduction to Programming/Coding I, Program Design II (i.e., software design), and Computer Organization

(i.e., hardware components) by their 3rd or 4th semester, requiring a letter grade of A or B (B- is not passing). The CS students who don't pass these three gateway courses must reselect a new major outside of CS (FRU, 2020).

The literature review discussed the issues associated with Calculus I "as a culprit" that situates many women and minority students at a disadvantage if they did not receive calculus preparation or programming in high school (Ellis et al., 2016; Sax et al., 2017). Consequently, this narrows down the pipeline for many women in CS majors without prior exposure to calculus, physics, and computer programming classes (Ellis et al., 2016; Sax et al., 2017).

The FRU's CS Department offers Information Technology and Cybersecurity, which have a similar emphasis on computing but have different prerequisites and are more applied and technical. These two majors seem to be the best options for CS students who do not successfully pass the many admissions and prerequisite requirements to reach upper-level CS.

The study employed an exploratory qualitative case study methodology. The methods used included a written pre-interview guide, semi-structured interviews, focus group questions, and my observations in the form of notes and memos. The sample used for the study was 20 women from the 2018-2019 incoming CS cohort. The participants came from the Florida public high school system and were international students or transfers from other community colleges. All of the women had declared CS as their major, but only half had reached their senior in the CS major. The other half were also seniors, but had changed to a different major than CS.

The instruments used in the study were the researcher and the interviews. The researcher was the sole interviewer. The individual interviews were recorded using Zoom meetings. They lasted an average of 60-90 minutes. The focus group recordings were over two hours, and served as the primary means to collect data.

The data was analyzed using Otter.ai and NVivo, placing the data in codes. The profiles reflected the memos using NVivo, and were then categorized across both groups of women—the stayers and the leavers of the CS major. The data was aggregated, and the findings were revealed by analyzing the participants' similarities and differences, as well as the similarities and differences between the two groups.

Understanding the motivations of these women regarding their connection with and/or separation from the CS major drove this study to find the answer to the following research questions:

1. Why did some women decide to stay in the CS major until graduation?
2. Why did some women decide to change majors or leave the CS major?

I present the key findings from this exploratory study in the first section of this chapter, providing individual profiles for each participant and then describing commonalities and differences in the participants' experiences. As highlighted in their individual profiles, all the women encountered challenges in the CS program. The "stayers" generally reported higher levels of engagement due to early career networking and support from peers and sponsors, whereas the "leavers," who included twice as many first-generation college students, experienced weaker support systems and had less cultural capital on how to navigate academia that ultimately undermined their sense of belonging.

Altogether, the findings stress the importance of social networks supporting women's academic performance and broad campus experience, especially during the first and second years (lower division) in CS when they are introduced to challenging gateway programming courses. From an educational policy perspective at FRU, this suggests that focusing on increasing enrollment alone cannot close the gender gap in CS. In the long run, to sustainably narrow the

gap and achieve undergraduate gender parity in CS, a series of comprehensive, concerted, and incremental policy interventions are needed; top among such interventions is addressing the causes of attrition related to lack of sponsorship/mentorship and generational support that fosters a sense of belonging in a male-dominated environment.

Findings

To understand how women at FRU decided to continue in or leave the CS major, I present my findings in the next section. I begin with a general profile of each study participant, broken into two sub-groups: stayers and leavers. Through these profiles, I identify the characteristics of students who stayed in or left the CS major at FRU. In their personal stories, I highlight how they described their demographics, high school to college transitions, and overall experiences in the CS program. I then turn to the findings from the focus group conversations I held with students, where I more directly investigated their experiences in the major and their suggestions for improvement.

Stayers - Profiles

The following table and figure represent the findings from the participants who remained in the CS program until completion. The participants were college seniors in their early twenties, mostly living on campus and attending classes full-time. They were from diverse ethnic backgrounds: Asian (5), Black (2), Hispanic (2), and White (1). Two identified as first-generation college students, and three were international students. All but one either attended a specialized high school or took advanced placement classes in high school.

Table 2

Stayers' General Demographics and High School Background

Fictitious Name	Race/Ethnicity	Specialized High School	High School Location	Advanced Classes	First-Gen
Chaney	Black	Yes	International	Yes	No
Elsie	White	No	Florida	No	No
Evelyn	Hispanic	No	Florida	Yes	Yes
Janelle	Hispanic	Yes	Florida	Yes	No
Karishma	Asian	Yes	Florida	Yes	No
Meena	Asian	Yes	Florida	Yes	No
Rupa	Asian	Yes	International	No	No
Ruth	Black	Yes	Florida	Yes	Yes
Sonia	Asian	Yes	International	Yes	No
Vashti	Asian	Yes	Florida	Yes	No

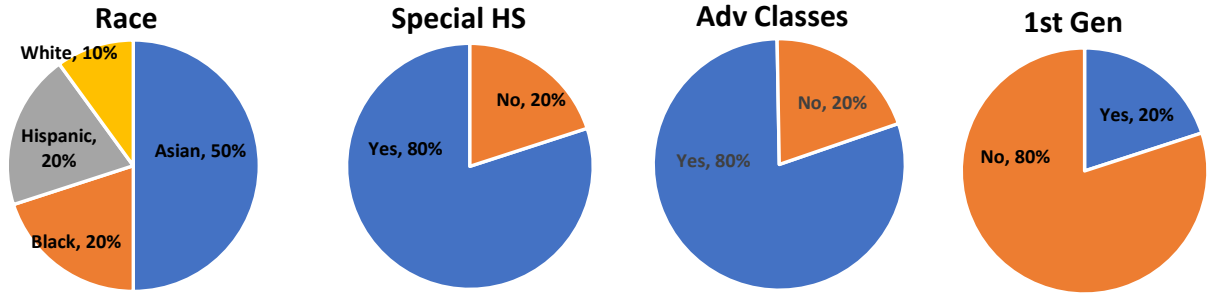

Figure 3

Stayers' General Demographics and High School Background

Chaney

Chaney, 21, identified as Black, and was an international student who joined FRU after attending a specialized high school in her home country, where she completed the rigorous Cambridge preparatory curriculum. She had no prior programming experience. She was

emulating her parents, who graduated from universities abroad before returning home. Chaney recounted her excitement at seeing so many people of color in the large lecture halls at FRU, yet she was shocked at the low number of women. Intimidated, she initially made no friends and struggled to get help in the gateway courses. She found her voice among other students from her home country in the Caribbean and soon thrived in campus organizations that promote social causes such as food drives for the needy. Those experiences allowed her to move beyond the difficult moments and start contemplating a career path in CS, fully aware of women's underrepresentation on campus and in the industry. Chaney discussed her professors as interesting and caring but mentioned that "some were just there because they were smart." Certain aspects of the CS major surprised Chaney: "All of my electives [were] all men talking about their research." Chaney wondered "where the other women professors went from the beginning courses."

Elsie

Elsie, 22, identified as White. Her parents both attended college before moving the family to the United States after Elsie finished middle school in Europe, where she excelled in STEM and first learned to code. Guided by a very involved father and her interest in video games, she went on to take advanced placement (AP) CS classes in high school in Florida before enrolling in a community college and transferring to FRU. Elsie enjoyed her community college experience, where she felt at home in smaller class sizes with friendly peers and professors who provided pragmatic academic and career guidance. Elsie said, regarding her personal drive to pursue CS, "I was not one of those people who needed support from others to get the job done. Like, I'm pretty much a self-starter." While she had difficulties adjusting to the larger classrooms at FRU, the self-proclaimed extrovert soon thrived in student organizations; Elsie said, "I liked the large

campus atmosphere. I joined the engineering fraternity. So, I made good friends." Elsie participated in social activities that kept her busy but connected personally and academically to students with similar interests.

During the logistical classroom changes brought on by COVID-19, Elsie relied on her friends for support by having constant study group interactions. She mentioned situations that really frustrated her in the CS major that made her rethink her progression: "There are projects where you think nothing is working, and then you start second-guessing everything, and you want to give up." Elsie relied on CS's friends to keep her going through those challenging situations.

Evelyn

Evelyn, 22, identified as Hispanic, and professed a strong internal drive to succeed with a love for computers. A first-generation college student, she attended a local Florida high school, taking honors and AP courses, but had no prior programming experience. She elected to enroll in a FRU due to financial considerations, and chose CS because of the broad career prospects it provided. "My family has always been my only support system." Evelyn continued, "I had problems from the start of college, but I could not let them down." Evelyn was unfamiliar with the university environment and was surprised by the larger classes compared to high school. A notable aspect of Evelyn's experience was that she did not have friends in her classes. Mostly, she studied independently and did not use tutoring or seek help from her professors; as a result, she constantly felt out of place yet made no efforts to adjust as she simply accepted her fate. She failed and repeated many classes unrelated to her major during her freshman year, when she struggled most because of the added stress of commuting to campus and work. She considered switching her major to political science but, in the end, persevered by sheer will. Her major

turning point happened when she took programming the second time around with a professor who engaged her through her passion for the subject. Evelyn said her life changed after that semester because the CS professor "understood that we probably didn't have any programming experience, and she took her time with everybody."

Evelyn was upbeat about her career path and said, "CS has no boundaries; you can work in any industry." Looking ahead, Evelyn noted that CS women should not "feel intimidated because they will be ok." Lastly, Evelyn shared that she wished she had spent more time meeting her classmates and less at her full-time job during her freshman and sophomore years. Ultimately, Evelyn demonstrated confidence in several ways by coping with her situation and never giving up on her career goals.

Janelle

Janelle, 22, identified as Hispanic and was an avid softball player who had just graduated from the CS major one week before the interview. Janelle excelled in STEM and took several AP classes from a technical/magnet Florida, high school. She really enjoyed both architecture and medicine, but her passion for video games made her decide on the CS major at FRU. Because of its proximity to her home, she could stay close to her parents, both of whom were college graduates. "My family has always been there for me; they are the reason for me pursing science," Janelle said. "They are the ones that knew that I loved computers and video games." Janelle described her CS classes as challenging but not overwhelming. She was very excited about her CS classes and explained that in her second year, her "friends became so important; they were everything." She had a close network of friends for emotional support. Janelle described how she developed different study groups based on her classes: "I had friends in every one of my electives, and I did not take classes alone." Janelle also credited her persistence in the major

partially to a remote software development internship experience where she felt important because people accepted her as part of the team and included her in discussions. Janelle said, "Unlike the groups in classes, I didn't feel I had to always prove myself to my team." During the internship, which turned into a concrete job offer for her, she said she was able to save enough money to purchase an apartment downtown.

Karishma

Karishma, 21, identified as Asian American. She enrolled at FRU as a second-choice college destination due to cost and distance considerations. While in the Florida high school system, she took AP courses in psychology, calculus, statistics, and several other general education courses but had no prior programming experience. As an undecided freshman, she was first leaning towards Psychology; however, she liked technology and, in her second semester, declared CS as her major on the grounds that it offered more stable and financially rewarding career prospects. She benefitted from a strong support system at home, where her parents were college graduates. "Physics was something that I personally never, like, completely enjoyed doing." Karishma continued, "My parents helped me overcome my challenges in physics; they knew I could do it." Karishma credited her perseverance in the major to the connections she made with students, teaching assistants, and professors. On campus, Karishma surrounded herself with "good friends" that were also in the CS major to help navigate gateway courses. "We decided also to live together, and now all of my roommates are CS majors," Karishma said positively. Aware that CS was a male-dominated field, she stayed active in the classroom and engaged in student organizations even when she was hesitant—"I had to become a leader in an organization because they nominated me, but I also knew no one else wanted to do it." Karishma

described the environment of CS classrooms as “nurturing” because if she had a question, “somebody was there to answer it.”

Meena

Meena, 21, identified as Asian. In her senior year of high school, she received the National Merit scholarship. She took AP classes in high school while attending community college for dual credits, with over fifty-five credits when she graduated. Exposure to calculus and biology led her to pre-medical studies at FRU, where she also received a Florida Bright Futures Scholarship. However, soon after her first semester, she realized she struggled with physics and chemistry and no longer wanted to be a medical doctor. One of her peers, a junior in CS, suggested she explore CS as a major—after further inquiries and in-person discussions with the CS staff, she made the switch. This pleased her parents who, both highly educated, were concerned about the length of the medical degree and the competitive nature of getting into med school after graduating from college. The transition was smooth except for overcoming her dread of physics, which was a prerequisite for progressing in the CS major. Meena recalls, “I started making friends within the major, and those friends introduced me to more friends, and then the circle got bigger.” Meena noted that “friends also were a big support system, with studying and simple encouragement.” In addition to building an extensive peer network in CS, Meena also took on hobbies such as drawing, cooking, exercising, and weightlifting to keep a balanced academic outlook.

Rupa

Rupa, 21, was an international student from Asia who received scholarships to attend FRU. The high school she attended was known for academic excellence and prepared her well for the CS major with five years of combined C++ and Java experience. Though not a first-

generation college student, Rupa was an international student in a new country and had to be resourceful to overcome cultural and financial challenges. Rupa secured employment before arriving on campus: “I had to find ways to offset my college expenses, and I earned my first two days of work being an orientation leader.” She became a tutor for the Student Success Center during her first semester at the university. “I was always good in math classes, and I also knew coding and programming.” With no family around, she built a strong support system consisting of friends, faculty, and staff at the student advising and career centers. COVID-imposed, impersonal virtual learning was particularly challenging for Rupa, and she attributed her perseverance in the major not only to her pre-collegiate exposure to programming but, most importantly, to the connections she made at the Career Center that helped her get a foot in the industry. “In the States, [she] had to have a high-paying job,” so Rupa managed to secure an internship each summer. Rupa’s last internship (in her junior year) offered her a job after graduation, and she was looking forward to moving out of the FRU area and to another state.

Ruth

Ruth, 23, identified as Black, with a double major in CS and Computer Hardware Engineering. She was fascinated with video game animation and aspired to make a difference by creating her own company. “My support system has always been my school friends from back home, and we are all over the world” (friends from her middle school time in the Caribbean, which she still keeps in touch with). Ruth mentioned that it was important for her to be successful for them and her extended family.

Ruth attended a magnet school in Florida where she took AP physics and statistics but had no programming experience. She started at a local community college while living with her parents before transferring to FRU (which also allowed her to stay close to home and receive

financial support from her family). Ruth has had many challenges throughout—from having two jobs to keeping up with demanding schoolwork to dealing with parents pressuring her to finish while coping with professors who doubted her so far as to suggest switching to nursing or business as a major. Instead, Ruth persevered thanks to her extensive network of business, engineering, and pre-medical friends, especially the master's and Ph.D. candidates she met in the CS major and looked up to. She was proud to be the first college graduate in her family.

Sonia

Sonia, 21, identified as a first-time-in-college (FTIC) international student from Asia. She attended an overseas technical high school with a concentration in STEM, where coding was part of the curriculum. Sonia had aspirations to "hit it big" as the Chief Technology Officer (CTO) of an organization where she believed her outgoing and innovative personality would be an asset. Still, she never considered CS until her second semester as a freshman at FRU, when she switched from pre-med to better use her problem-solving skills. Sonia's parents were university graduates, and she could always count on them for support, but they were far away. In the meantime, her network of CS friends stood as her immediate and strongest support group on campus, where she thrived in the welcoming atmosphere. As she reached her final year, Sonia said she had the same CS professors each semester, which helped her develop a relationship that made her "understand their teaching style better." Sonia pointed out that without CS friends, she would have had a hard time "because CS is very large; you get lost in very large environments." Sonia emphasized that because the CS curriculum is vague at the end, students like her get lost in what aspects or specializations of CS they should go to after graduation. She said, "I feel like that was really tough, as not knowing which emphasis to maneuver could impact your work as a

software engineer." Sonia reflected that she was exhausted by all the demands of her classes, internships, and social activities but remained driven by the career prospects ahead.

Vashti

Vashti, 22, identified as Asian, and attended an International Baccalaureate (IB) high school in Florida. Vashti's high school concentrated on STEM fields, but she did not have any prior programming experience. She considered her parents her "rock" for their constant support and enrolled at FRU primarily due to cost and distance considerations. Vashti appeared shy but was self-reliant; she initially made just one CS friend in her first semester and found the rigorous courses made the whole college experience very intimidating. She did not do well in her freshman year until she modified her study habits, including putting in a lot of extra hours at the library studying and teaching herself languages like Java. Vashti said, "I had to get advice from people in clubs like juniors and seniors because they knew more about campus than the faculty; they know the resources that could help me."

Vashti discussed her complications while in CS classes, saying she had to reassure herself of why she was pursuing CS. She said, "Being a woman in STEM, it's very intimidating. It can get scary at times." Vashti said at times, she felt disrespected as a teaching assistant, and the feedback she received from the male students asking for her. She said they sometimes did not want to hear her feedback and went to the professor instead. Vashti had two off-campus internships but said, "Even in the corporate world and group projects, you [as a woman] may feel not as equivalent compared to another student in your class or the group." Vashti said that her friends and family helped her "stay grounded" because she could talk to them about the situation. Vashti said she was thankful for all her gained experiences, especially her nurturing research assistantship with a professor that opened more connections for her with a circle of

upperclassmen who helped her navigate future courses and career paths. Vashti was very grateful for these opportunities that pushed her to consider a master's degree in CS.

Stayers – Similarities and Differences

The leading question of this study aimed to discover why some women decided to stay in the CS major until graduation. Despite distinct personalities, all the participants in the "stayer" group perceived their situations at FRU as transformational as they navigated from their high school and community college settings into the large university environment and CS major. All participants felt they had to adjust each semester and critically select individuals who supported their CS major decision. An overarching finding that emerged was that all ten stayers reported solid foundational support from their parents in the form of living arrangements, financial support, and substantial involvement in their educational and career choices. A second finding was that seven of the ten further added that such support might have been influenced by the fact that both parents were college graduates. Additionally, nine of the ten stayers thrived in the college environment by adding a strong on-campus connection to their support system, mostly from classmates in study groups, upper-level students in student organizations, and professors/advisors in career networks.

Ultimately, all but two of the students in this sub-group attributed their persistence in the CS major to the social and pre-career connections they made during their studies. One of the participants, Meena, was able to persist by engaging in extracurricular leisure activities to balance out the pressure from demanding coursework. At the same time, Evelyn, the lone stayer with no campus engagement, persevered out of sheer will (self-confident and determined), not wanting to waste time and money already spent on the major up to that point. Refer to the table and figure below for a view of the combination of factors that affected the stayers' decisions.

Table 3

Factors that Influenced Stayers' Decisions

Fictitious Name	College Educated Parents	Parental (Home) Support	Campus Network	Career Engagement	Deciding Factor For Staying
Chaney	Yes	Yes	Yes	N/A	Network
Elsie	Yes	Yes	Yes	N/A	Network
Evelyn	No	Yes	No	N/A	Self Determination
Janelle	Yes	Yes	Yes	Yes	Career
Karishma	Yes	Yes	Yes	Yes	Network
Meena	Yes	Yes	Yes	N/A	Curricular Activities
Rupa	No	Yes	Yes	Yes	Career
Ruth	No	Yes	Yes	N/A	Network
Sonia	Yes	Yes	Yes	Yes	Career
Vashti	Yes	Yes	Yes	Yes	Network

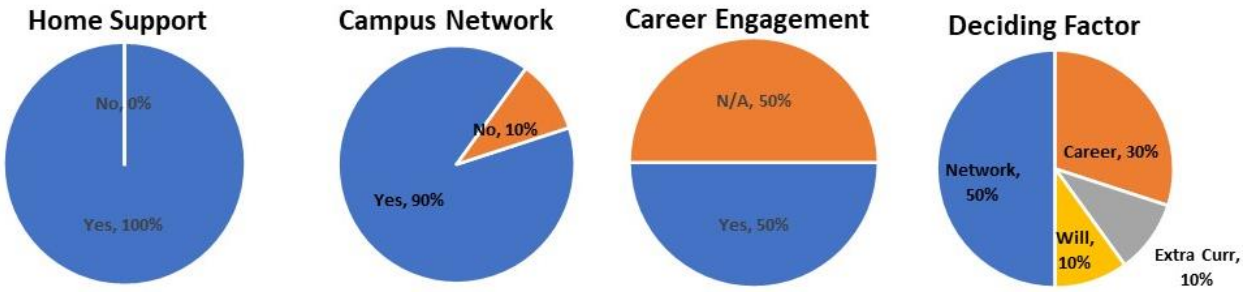

Figure 4

Factors that Influenced Stayers' Decisions

Stayers - Focus Group Findings

The group Zoom interview started with a brief self-introduction from nine out of ten participants. The women in this group were either friend or mentioned having crossed paths before. As an icebreaker, I told the story of Marie Curie, who, despite being one of the few women of that time in science, made significant discoveries that earned her two Nobel prizes. The story had the intended effect and encouraged the women to discuss their struggles and successes in the CS field.

Freshman Experiences and Resources

The participants in the focus group overwhelmingly agreed that one element of their success was the welcoming FRU campus environment that helped them overcome the challenging classes and made their overall experience a positive one. Many campus resources helped them during freshman year, including activities in the STEM dormitories that helped many women get to know other science majors in their math and physics gateway courses. These activities helped the participants deal with being away from home for the first time. The group advised others to "always reach out to professors and use university resources early" in the CS major.

The participants felt it was essential to set the ground expectations for women entering CS at FRU and to "coach them with strategies" to help them persevere in the CS major. The group brought up the freshman Engineering Foundation Course (the CS major is in the Engineering College) and their ability in that course to discuss STEM careers and the underrepresentation of women and minorities in those majors and fields. The group mentioned that it was the only class where they felt free to discuss gender issues because the faculty had introduced the topic of minorities in science and engineering. They also noted that only one CS

faculty member was teaching the course, as the others were engineering professors from other majors.

The group also spoke on the importance of the availability of FRU's math tutoring resources, such as the SMART LABS, where they obtained assistance outside the faculty's and teaching assistants' office hours and availability.

CS Gateway Courses

The focus group wanted to discuss the CS gateway courses required to progress in the program. The individual interviews and the focus group identified three main areas needing improvement—exposure to coding, physics as a gateway requirement, and real-life applicability of electives.

The group expressed the need to have CS professors "passionate about teaching new students how to code and program," as the technics they learned in the beginning courses were instrumental in understanding the many programming languages. As only 31% of CS AP exams taken in 2019 in Florida high schools were taken by women (FLDOE 2019), women generally had less exposure to coding before college than their male counterparts. The focus group emphasized that they would have liked to learn how to code much earlier than they did, some mentioning that their first coding class wasn't until their second year of college. They wanted access to "more coding classes in their first year" to allow them to become "more comfortable" and discover their areas of interest earlier.

Another revealing research finding shared in the individual interviews and then passionately discussed in the focus groups was physics as a CS gateway course and requirement. They asserted that physics was not a relevant building block to the CS skillset needed to be successful in the major. The requirement of physics was regarded as "unnecessary" by the

women, and they felt “it complicated their ability to enter the major” and was “overtly frustrating.” They also discussed the temperament of the physics faculty and the large class sizes that made their grades in the course “unpredictable” and “disappointing.”

The group discussed CS elective courses and how the content was very theoretical. The TAs assigned to the classes could not help effectively because they did not have experience with the subject matter. The women wanted CS electives to be geared toward industry and careers, incorporating real-life situations instead of only research usages. Many of the women discussed having internships that taught them innovative software that was not mentioned in their CS classes.

Stereotype Threats in the Classrooms

The focus group then discussed the “elephant in the classroom”—being outnumbered and feeling out of place. In most classrooms, “women were outnumbered and did not feel entirely comfortable” to speak up, let alone engage in classroom discussions. They discussed feelings of being “overlooked,” “tackled,” and “offended” by repeated situations in the classrooms that went unaddressed by the professors. For the stayers, the solution to improve the CS major profile was to understand and cater more to “the needs of women and other diverse populations” in the very design of the program.

The women wanted the CS faculty to “become educated” about talking to women in the classroom and comfortable addressing the diversity of backgrounds, including culture, gender, race, and religion. The group felt that the CS faculty did not want to call out discriminatory behavior. Their advice was: “Do not stay quiet when someone mistreats or discriminates based on gender, race, or ethnicity.”

Networks and Role Models as Student Support

The importance of a supportive network of peers and professors cannot be understated in STEM majors in general and CS specifically because the involvement of women role models is crucial to overcoming stereotype threats—one of the reasons women have low participation in CS (Frieze, 2019). Besides influencing young women's preferences for STEM subjects and choosing the CS major in the first place, effective interventions from a perceived role model can also increase a woman's sense of belonging in the face of negative stereotype threats, isolation, and self-doubt. The focus group wanted to see more women in academic roles. As mentioned in previous chapters, at the time of this research, the CS program had 29 tenured professors, only three of whom were women (7%). The women in the focus group wanted to address the CS department with specific topics that would improve women's lives, recruitment, and retention.

In addition to role models, the group emphasized the need to "have a study group and stay close to them because they will be your support to the end." It was evident in both the individual interviews and the focus group that peer support in the CS program positively affected perseverance.

Summary

The focus group wanted to encourage women entering the CS program: "Believe in your talents, make friends with other women, and do not let men intimidate you or make you feel inadequate in classes or in your career." The topics that emerged in the focus group reflected this sentiment and highlighted the importance of support from all angles—early intervention and resources, course design, peer networking, and faculty involvement.

Leavers – Profiles

To understand why women elected to pursue the CS major and stayed until graduation at FRU, we must also understand why others decided to leave. The following table, figures, and profiles represent the findings from the participants who left the CS program before completion. All of the women were traditional college seniors in their early twenties from diverse ethnic backgrounds, including Asian (3), Hispanic (3), White (3), and Black (1). Two were international students, and four identified as first-generation college students. Half attended a specialized high school, and 80% took advanced placement classes in high school.

Table 4

Leavers' General Demographics and High School Background

Fictitious Name	Race/Ethnicity	Specialized High School	High School Location	AP Classes	First-Gen
Adriana	Hispanic	Yes	Florida	Yes	Yes
Asimah	Asian	Yes	International	Yes	No
Beatrice	White	Yes	Florida	Yes	No
Connie	Hispanic	No	Florida	No	Yes
Fatimah	Asian	Yes	Florida	No	No
Iris	Asian	No	Florida	Yes	Yes
Jessie	White	Yes	Florida	Yes	No
Juliette	Black	No	International	Yes	No
Kelly	White	No	Florida	Yes	No
Valeria	Hispanic	No	Florida	Yes	Yes

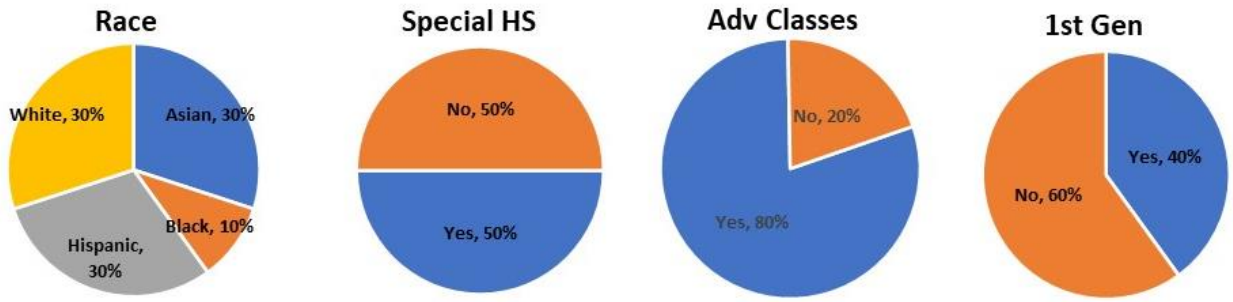

Figure 5

Leavers' General Demographics and High School Background

Adriana

Adriana, 21, identified as Hispanic and was a high-achieving student who graduated from a local Florida high school with AP classes where she excelled in STEM. She initially majored in business but was later advised by her siblings to change to CS at FRU because she had already taken AP exams in the CS field. A "straight-A student," she had no difficulties in calculus, physics, or programming gateway courses. Adriana was not very talkative, did not have many friends in CS, and did not elaborate much on what prompted her to change majors—except to say she "did not enjoy or like the classes" and "the material did not have purpose or meaning."

Adriana mentioned her family network of support but did not mention friends in the CS major or being a member of any student organizations. She also did not live on campus. She stated that "the major was not well explained to her or incoming students." Adriana changed her major in her third year despite passing all the CS progression courses. She did not want to expand on the causes that propelled her to pursue Business Administration, other than having "AP classes in economics and in accounting" that made the transition seem smoother and not

setting her back from graduating in the eight-semester period with her peers. Adriana seemed content with the outcome and was looking forward to graduation.

Asimah

Asimah, 23, was an international student from the Middle East from an Asian background. Asimah dropped out of CS without graduating and had been unenrolled from FRU as of our interview. Asimah's parents did not attend college in her home country; she was expected to be the first graduate. When she started at FRU, she first took English as a Second Language (ESOL) before starting on the CS curriculum courses. Though pre-calculus and physics courses were very easy her freshman year, she began struggling with the course load as a sophomore and had to repeat several classes. Extensive tutoring did not help much, as she could not maintain the requisite GPA to progress in the CS program. Asimah indicated she "received a lot of help from people and instructors." Even though she continually stated she received a lot of help from her classmates, she did not refer to them as friends. She said she did not "get the concepts," and she was "tired of the stress of retaking math and physics courses," so she decided to switch to education, a major she was not interested in, before dropping out altogether. Asimah recounted that she moved out of state to stay with extended family until she was "prepared for the next stage in her life" and would be enrolling in another college near her new home. She was pursuing a "less demanding major" that better "suited her goals" as a "teacher's aide" or substitute teacher certified to teach Arabic. Asimah said she "did not need a college degree to teach children, "just experience from high school."

Beatrice

Beatrice, 21, identified as White and was a first-generation college student who changed her major to Cybersecurity from CS. She graduated from Florida technical high school, where

she had taken AP CS concepts; she enrolled at FRU, where initially, the large classrooms made her "nervous." She said the professors were friendly and always available to help students succeed. Beatrice mentioned she was genuinely interested in programming and had a good support network at home and on campus. Yet, despite the resources and student activities she enjoyed, the intensity of the CS major with a course load that did not particularly appeal to her quickly dampened her enthusiasm. The global COVID-19 pandemic added another layer of stress, claiming the lives of family members and changing the traditional in-person classroom to a virtual/online setting where she could not actively engage. Those challenges made her consider a change to Cybersecurity, which was "more technical" and "not as theoretical as the CS courses," and where she could focus on the security aspect of computing. Beatrice suggested that it's important that "students be aware of their interests," "try to choose a major by talking to other students," and "join organizations that are specialized in that profession" to avoid delays in graduation. Beatrice would not be the first one to attend college in her family, but she would be the first to graduate. She looked forward to graduation and working in the Cybersecurity firm she interned with the previous summer.

Connie

Connie, 29, was older than the other women in the study and identified as Hispanic. She was a product of the local high school-to-community college system that feeds into FRU, where she enrolled in the CS major without prior AP classes or programming experience. Connie was not a traditional college student. She was a pregnant, single parent working full time with a limited support system, who could attend college thanks to the Florida Bright Futures scholarship and with the help of her ex-husband's extended family. Due to financial strains, she entered FRU via one of the satellite campuses closer to her home and work; however, the CS classes were

only offered on the main campus, some drive time away. Connie failed her first year and ultimately exceeded the traditional college timeline of eight semesters, making her ineligible for Bright Futures; her full-time employment status counted against her eligibility for grants. Financially stuck and unable to commute, she switched to Information Technology (IT)—a major that seemed more compatible with her distance learning needs. Now a senior, she reported having continuous challenges completing her degree as she continued to "work as a software engineering intern." She wished the "path could have been more accessible to working mothers" and seemed to have "many regrets for not getting a math or science degree" as she had planned. Connie was still hopeful that her future master's degree would "one day be in CS."

Fatimah

Fatimah, 22, identified as Asian. She had taken many AP classes in high school and first majored in Biomedical Science at FRU. After her freshman year, Fatimah realized she "did not enjoy the science courses such as chemistry or physics" and made a change of major to CS. Yet, there again, the CS course load and content did not appeal to Fatimah, leading to the second change of major, this time to IT. In her eyes, IT had more "real life" and "society-focused courses" that aligned with her "love for databases."

She has had a lot of "setbacks due to health" and other COVID-induced "stresses," including the change to virtual classrooms that isolated her from her network of friends. However, with the many credits she had earned from her AP classes in high school, Fatimah joined the "IT bachelor's-to-master's" accelerated track and was able to graduate with her IT degree in less than three years. As a graduate student, she has landed a teaching assistantship in research labs and aspires to "continue to a Ph.D." level or "into law school."

Iris

Iris, 22, identified as Asian and was a FTIC and first-generation immigrant whose family migrated to the West Coast of the United States before settling in Florida; there, she graduated from a traditional high school with an AP focus. Iris recalled a problematic transition to school, where she lacked the social skills to connect with other kids, even those with similar Asian Pacific Island cultural backgrounds. With a passion for hardware devices and encouragement from older relatives, she majored in Electrical Engineering at FRU. During her first semester, Iris quickly became overwhelmed in the auditoriums, where she "didn't know anyone."

Living off campus, she recounted having acquaintances but "no real friendships" or connections at FRU. Iris's limited classroom interaction was in the "engineering math learning group," but it was not "structured enough to give the help [she] needed." Her interactions with TAs were "not very supportive" and made her feel "out of place." Despite her best efforts, she feared early on that she "would fail calculus" and decided to switch majors. Her decision to change to CS was primarily supported by a long-distance boyfriend. Iris recalls attending an information meeting for the Security Organization, which captured her interest. She decided to change from CS to the Cybersecurity major early in her sophomore year because it did not require Calculus 1. She mentioned being an "avid reader of mystery novels," which also contributed to her interest in Cybersecurity. Iris changed majors four times during her freshman year—from Electrical Engineering to other majors in the Engineering College.

Jessie

Jessie, 21, identified as White. She was a FTIC student from the local public magnet school program who learned coding as part of her high school dual-enrollment AA program. Jessie enrolled in CS at FRU mostly to please her parents. The COVID-19 global pandemic gave

her time to consider her natural talents and how she wanted to do more than just coding and technology. Jessie struggled for several semesters to "see the upside to CS"; but in the end, she did not find any of the electives relevant to what she wanted to do in the future. She recently changed to Environmental Engineering, which is part of the Civil Engineering department within the Engineering College. Jessie identified gender biases/inequities as her reason for leaving CS behind. Her transition to her new major was straight-forward, but breaking the news to her family and friends was not easy. The new major might take longer to complete, but she had "no regrets" despite her parents' opposition.

Juliette

Juliette, 24, identified as a Black, first-generation international student from the Caribbean, where she attended a technical high school with exposure to physics, calculus, and programming. Juliette described herself as "shy and quiet" and did not have many friends while in college. She did not have difficulties in the CS introductory courses at FRU; her challenges came only in not "understanding the concepts" in the critical, higher-level math courses needed to progress in the major. She did not want to switch out of CS but was also aware that she couldn't "continue to retake courses"—not only because she "had reached the retake limit in key courses," but also due to financial considerations as she was paying her own way through school. She struggled with her decision to change to IT, which she felt was not as in-depth in software development, but knew it was a related major with more flexible course sequencing requirements. Juliette was on track to graduate but regretted not getting to know the professors in-depth and not joining the technology-oriented organizations to help her meet more people in the majors. She believed that would have allowed her to meet more women and maybe more Black students at the beginning of her college years.

Kelly

Kelly, 21, identified as White, and was a non-traditional student who was homeschooled because her father's military career made the family move frequently. Under family guidance, she did dual enrollment, completing her high school requirements in three years while obtaining an AA degree. She scored high enough on the ACT to get a tuition scholarship and attended FRU while living at home due to financial considerations. Self-driven, Kelly was drawn to CS because of the "career prospects"; however, the good relationships she had with the professors and her peer tutor in math were so instrumental in her success in Calculus 1-3 that she decided to major in Math and minor in CS.

Her freshman experience made her question the CS curriculum, where she struggled in physics, passing the class with minimum conceptual understanding. Kelly said, "it did not get any better" as she progressed her sophomore year. She felt held back, frustratingly, by an unnecessary course with an unrealistic structure that took too much study time for a minimum reward. In her senior year, she finally dropped CS as a minor in favor of German and kept the Math major, lamenting "the lack of women in both CS and Math." Kelly said, "I may consider CS again," but she had to think about it. Kelly was "tired of her college" experience and had no desire to pursue higher degrees after graduation. She was unsure of her career destination but wanted to "return to Europe to live debt free."

Valeria

Valeria, 22, identified as a first-generation Hispanic immigrant student. She graduated from a Florida high school that offered the Cambridge program and enrolled in CS, following in her older sibling's footsteps who had just graduated a year earlier. She aspired to become a software developer because she loved technology and innovation. She had to move to another

city to attend FRU, which was the first source of friction with her family—"they did not support me going far away to pursue my dreams." Valeria felt out of place in large math classes and, just when she was adjusting to her new environment, an unplanned pregnancy rocked her freshman year. At 19, her struggles balancing the demands of the sophomore course load were amplified by a strained relationship with her family, navigating campus protocols ill-suited for new mothers, securing childcare accommodations that she could not afford, and being at risk of losing the Bright Futures scholarship. Valeria did not reach out to any advisors or faculty about her situation because she "felt embarrassed"; as a result, her grades continued to decline, leading to her being "placed on probation" at the end of her sophomore year. Heartbroken and with the baby's father (also a student) as her sole support system, Valeria could no longer attend the in-person classes; she was assigned a college advocate to help reroute her to the College of Arts and Science's Bachelor's in Information Studies with a focus on data science, where she was just an internship away from completing her bachelor's degree.

Leavers – Similarities and Differences

While a combination of unfavorable factors propelled the leavers out of the CS major, one common thread that emerged from the interviews was the lack of a campus network of friends and study groups from freshman through senior year. Of the leavers of the CS major, nine of the ten participants reported having no or limited friends in class and at FRU in general. The table below shows the factors women in the leaver group associated with their decision to leave the CS major.

Table 5

Factors that Influenced Leavers' Decisions

Fictitious Name	College Educated Parents	Parental (Home) Support	Campus Network	Career Engagement	Deciding Factor For Leaving
Adriana	No	Yes	No	N/A	No Interest
Asimah	Yes	Yes	No	N/A	Difficulty
Beatrice	Yes	Yes	Yes	N/A	Difficulty
Connie	No	No	No	Yes	Pregnancy
Fatimah	Yes	Yes	No	N/A	No Interest
Iris	No	No	No	N/A	Difficulty
Jessie	Yes	No	No	N/A	No Interest
Juliette	Yes	Yes	No	N/A	Difficulty
Kelly	Yes	Yes	No	N/A	Difficulty
Valeria	No	No	No	N/A	Pregnancy

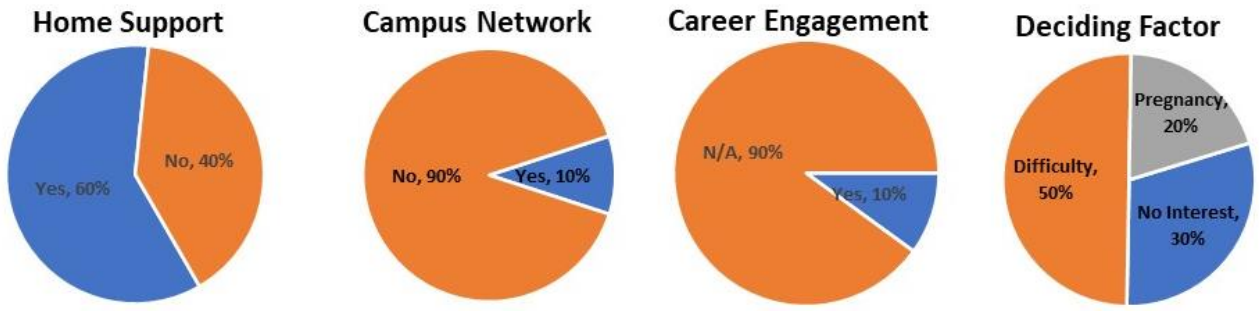

Figure 6

Factors that Influenced Leavers' Decisions

Fatimah, a leaver with limited campus engagement and a lack of friends, reported that health issues and classrooms shifting to virtual during the COVID-19 pandemic added to her struggle with the intensity of the CS course load and eventually caused her to leave. Adriana,

isolated in the CS classrooms, did not have a "positive attitude" towards the CS major or the profession in general. Juliette, who characterized herself as shy and reserved, did not develop friendships in her large CS classes. Jessie and Kelly both followed their parents' recommendations to enter CS but felt alone for many or all of their CS classes. The lack of connectivity within and enthusiasm for the CS major may have contributed to the "wearing out" of academically talented women seeking a place in the CS major and field. Juliette was discouraged by multiple failed attempts in CS courses, despite seeking tutoring assistance from her faculty members. Similarly, Asimah was resourceful in seeking help from classmates and other tutoring resources but did not develop close friends during her freshman or sophomore years. Asimah and Juliette were also far away from their home countries and did not develop a close network of friends that helped them offset their academically stressful situation.

Additionally, the lack of critical support at home was a compounding factor for four of the leavers; the six who had some form of family support added that their parents were too far away to make a difference. Four of the leavers, including one with family support, were first-generation college students—parents did not have firsthand experience with the rigors of college courses, and participants such as Juliette, Iris, and Asimah mentioned the pressure to choose a major based on siblings or future job opportunities. Valeria mentioned that her family was unsupportive of her moving farther from home to attend school. Two participants cited that their pregnancies were an added challenge, but even in those instances, there was already strained home support or a lack of campus support when the courses proved too difficult.

Leavers – Focus Group Findings

The leavers' focus group meeting was very similar to the stayers: a Zoom session with self-introductions from the ten women, concluding with my icebreaker. None of the women in

this focus group knew each other, even though all had been part of the 2017–2019 cohort at FRU. They each shared their new majors and current situation, and two participants—Valeria and Connie—were particularly delighted to have become mothers while in the CS major. This was shocking information to many in the group because they said they had never heard of anyone becoming pregnant during their time in CS, let alone overcoming such a challenge; this provided a segway to discussing their challenging experiences.

The major findings of the discussion were the feeling of disappointment at some of the obstacles they faced, the regret over certain decisions they could have made sooner/better, and ultimately the sense of relief in switching to their new major. Beatrice mentioned that CS courses were "too theoretical," which was an obstacle to understanding and applying the material to a future career. Fatimah echoed this sentiment, saying that her switch to IT was based on its "real-life" applicability. Math and physics requirements were an obstacle to many of the leavers—Iris left the CS program primarily out of fear that she would "fail calculus." Jessie noted specifically the gender bias in the program. Juliette regretted not spending time getting to know professors and other students, which could have helped her feel supported. They all agreed that it was not easy to leave CS and transition to their new major because they had to take additional courses that extended their graduation timeline. However, many noted the relief or excitement they felt changing to a new major, such as Asimah, who was particularly relieved by her change to a "less demanding major." Below are the key suggestions the leavers shared that might improve the recruitment and retention of women pursuing the CS major.

Key Feedback for CS Faculty and Administrators

The women felt the CS department should reevaluate the entrance GPA in math and science as a prerequisite. The resources for freshman-year classes should explain the different

fields available, such as programming or IT-related majors. They noted the difficulty in large classroom sizes and how grades earned in those classes were more a reflection of the classroom setting than the student's ability. The women discussed the need for "more CS female professors." They suggested CS professors participate in more activities outside the classroom, which helps form relationships with students; they also proposed making it mandatory for CS students to get involved early in student organizations, for example, Women in Computer Science. For sophomores and juniors, create course-specific academic support networks to tackle complex material outside classrooms. Lastly, the women considered the need for more scholarships to help during difficult times. The group noted the financial hardships that changing their major caused them, where their financial support and ability to receive a scholarship had changed, and they did not have enough financial assistance to stay out of the full-time employment sector.

Key Feedback for Women Entering CS

The focus group wanted other women to succeed in the CS major, and they decided to offer feedback to other women entering the program. The women considered their struggles with some of the prerequisite and first-year math courses and wanted to encourage other women to develop "new learning strategies for mathematical material." They stressed the importance of "developing social networks of alliances with people/students with similar gender, backgrounds, and interests." Finally, they emphasized the importance of "exploring the creative aspect of the CS major" and "exploring other degrees in technology as a fallback."

The discussions in the focus groups were very engaging for both the women who attended and me. The freedom the women felt in discussing the open-ended questions provided a sense of closure to many of them and to me as the researcher.

Stayers vs. Leavers – Similarities and Differences

In the study, I found both sub-groups of women shared similar demographic profiles. The average age of participants was early to mid-twenties, with one outlier in the leaver who was significantly older. The race distribution was also similar: Asian (5 vs. 3), White (1 vs. 3), Hispanic (2 vs. 3), and Black (2 vs. 1). Exposure to AP courses and prior programming experience in high school was also balanced between the two populations, although three more stayers had attended a specialized (technical or magnet) high school than leavers.

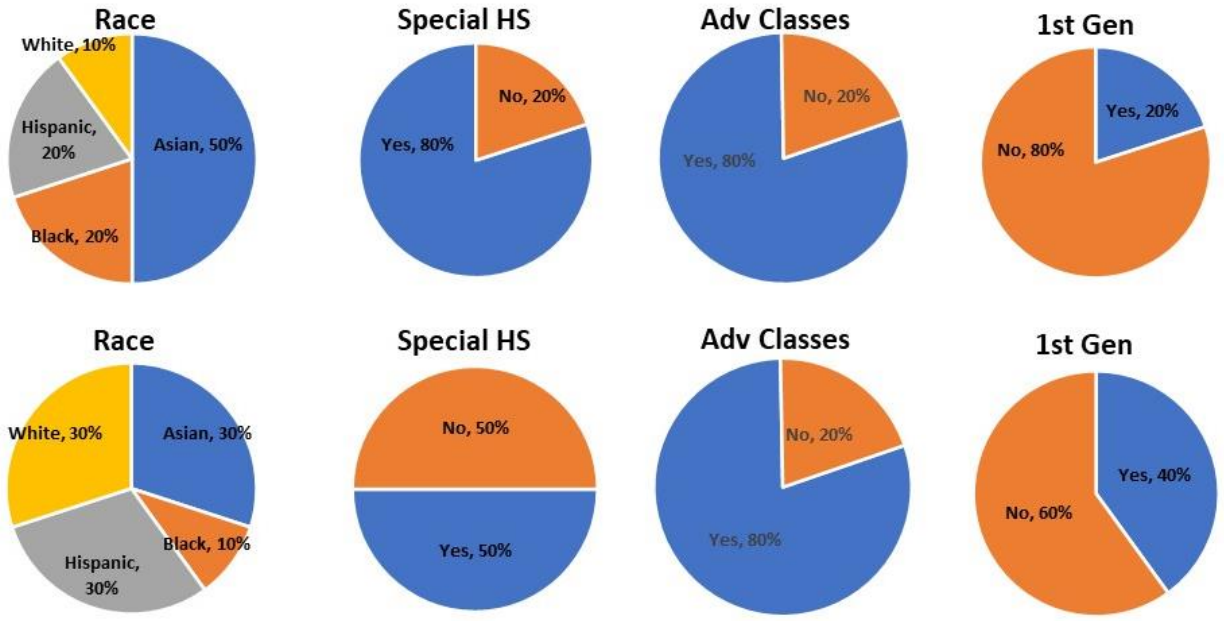

Figure 7

Stayers' (top) vs. Leavers' (bottom) General Demographic and High School Background

The first meaningful difference showed in the education level of the parent(s), with twice as many leavers being first-generation college students than their peers who stayed; said otherwise, more leavers reported that their parents did not provide support because they didn't

understand what the pressures of a college experience are let alone in a field as competitive as CS. While all ten stayers reported strong support at home from parents, mostly college graduates, only six leavers benefitted from the same type of family support. The former group received encouragement, financial aid, and otherwise strong involvement in their educational and career choices. The information passed down from family members and their educational journeys helped many women when they faced difficulties in college (Sax et at., 2017). The latter group received opposition to major changes and a general lack of support and cultural capital on how to navigate their academic and career options.

I found that nine of the ten stayers were actively involved via various connections and networks on campus. Only one of the leavers reported any form of campus engagement. This underscores the most significant finding from this study: the human connections these women made on campus ultimately contributed to their persistence in the major. Having a support network on campus that was immediately available during class, in study groups, in the dorms, or in student organizations was equally if not more important than home support because it effectively provides live feedback loops from peers going through the same academic challenges or from upper-level students who have already navigated the same challenging courses.

Finally, when the participants were asked to discuss their CS career engagement via internships, research opportunities, career advising services, or other professional student organizations, the findings suggest that it meaningfully contributed to women persisting in the CS major. Five stayers had CS industry experience while in the major; in contrast, only one leaver, Connie, reported the same. However, Connie's student experience was markedly different than the other participants, as she was a much older student, a single parent, and had a family to support.

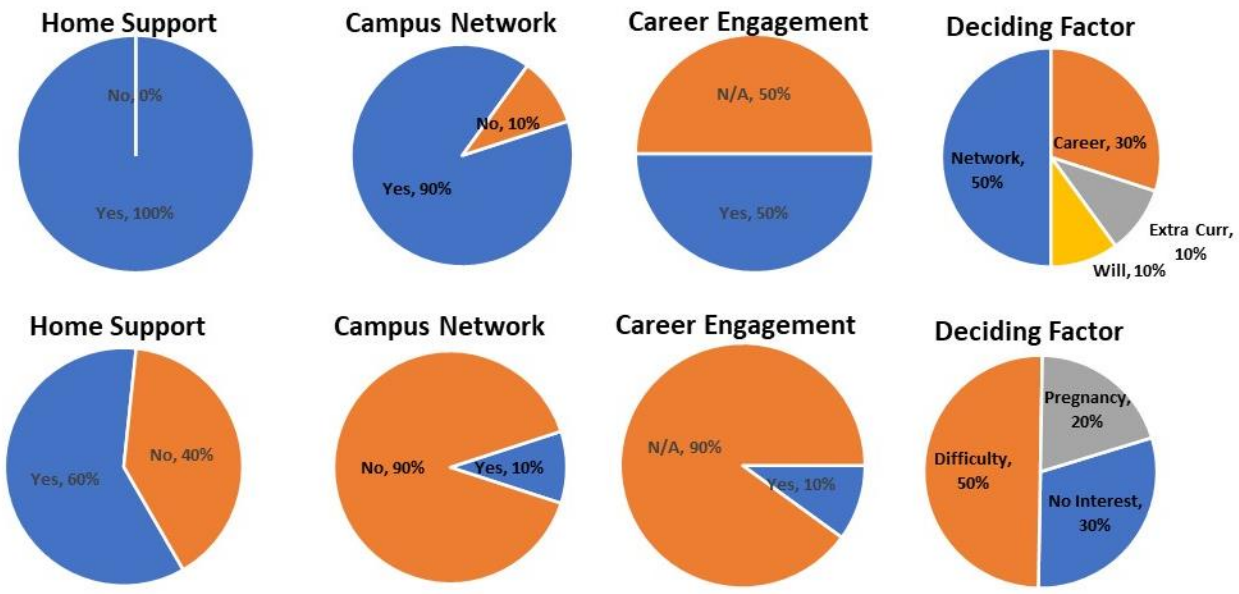

Figure 8

Factors that Influenced Stayers' (top) vs. Leavers' (bottom) Decisions

In summary, many participants chose to enroll in the FRU because it was reputable, cost-effective, and close to their home. Many women in the CS major did not have a defined college major during their first year and noted that they considered CS once they arrived at FRU. The majority of women expressed difficulties in physics and not exclusively in Calculus. Financial support and scholarships were essential in reducing economic uncertainty and stress for many women, especially in their junior and senior years. Women in the CS major also face changes in their personal lives and responsibilities, such as motherhood, that can challenge their ability to continue; more flexible and remote options are needed to retain them. This case provided insight

into the major factors contributing to underrepresentation of women in the CS major at FRU, which can help guide future university interventions and more inclusive university policies.

Implications

In this study, I examined the connection between the literature and the factors associated with women's underrepresentation in the CS major. The participants' freshman characteristics and preparations were discussed and compared to the findings. Women's lack of exposure to precalculus or AP credits for science and programming was an issue, but their social networks became more important.

Impact of Math and Physics Requirements on CS Success

Despite most of the participants in the study having higher than average college grade point averages and college credit before arriving at FRU, many did not have calculus, physics, or programming credit or experience. The literature discussed raising women's achievement levels in math, science, and programming classes to improve success rates.

Math

FRU had a variety of academic supports available for the precalculus and calculus courses. The women mentioned the availability of faculty, teaching assistants, and mandatory computer-based tutoring in the library as part of the Calculus I initiatives. Other math classes mentioned in the interviews did not have the support to help students without prior exposure, which impacted persistence in the CS program. There were instances mentioned in the study of teaching assistants not being able to lead introductory courses such as programming, math, and physics. This issue should be further explored.

Physics

The FRU requirement of progression after completion of Calculus-Based Physics II is conflicting. The prominence of physics in the discussions was imperative in this study, as the women who stayed in the major all wanted to emphasize how physics was not fundamental in their CS courses. The ABET (2022) allows computer science programs to interpret the following requirement:

> At least six semester credit hours (or equivalent) in natural science coursework intended for science and engineering majors. This coursework must develop an understanding of the scientific method and include laboratory work. (ABET, 2022)

Most students take an introductory physics course to satisfy their general education requirements or their common core to obtain a bachelor's degree. The science and health science majors at FRU require General Physics I, a course not allowed for CS majors—only Calculus-based Physics I and II are allowed. The rigor of calculus and calculus-based physics could be a roadblock to CS majors, particularly if women entering FRU have statistically less exposure to calculus and physics in high school.

The ABET (2022) guidelines state a CS program must have at least six semester credit hours (or equivalent) in natural science coursework. The CS major guides also mention the courses must be intended for science and engineering majors. The need for extensive math and science to obtain the CS degree may need to be reviewed, as the root of the profession has shifted to designing software and no longer focuses on the hardware-required concepts of the past. FRU's interpretation of the type of science the CS student needs to take to be successful may be rooted in the FRU's CS department foundation. When the CS department separated from

the Department of Electrical Engineering, they continued to use the same curriculum and have not changed it much in over 40 years (FLDOE, 2022).

Impact of Support Systems and Self-Confidence on CS Success

The women in this research study developed their self-confidence in CS in multiple ways. Most women found a sense of belonging in peer groups; others found it in engagement with faculty—teaching assistants, and staff that provided academic support and direction needed to progress at FRU. However it was developed, self-confidence was necessary for persistence in the CS program, and support systems were integral to that confidence. As discussed, family support was also important to participants' self-confidence and financial security. One of the critical factors shown in the findings was the financial support a student needs for a time-intensive program like CS. Without familial support, students have a disadvantage due to having to support themselves financially.

Dissemination Plan

At FRU, several stakeholders will be interested in my research findings at the department, college, and university levels, such as (a) CS faculty and staff, (b) College of Engineering deans and administrators, and (c) the students in the major affected by the program's policies and procedures. I plan to disseminate this information to the university stakeholders in various modes through individual and group meetings. As part of my dissemination plan, I will discuss the results with the CS department chair and, if permitted, present the results in a faculty and staff department meeting in the Fall 2022 semester.

The biweekly CS department meetings focus on the relevant situations the department faces or wishes to improve. These meetings would be the ideal scenario to start my dissemination. The sessions are in person, and this mode may be conducive to summarizing my

literature view and then discussing my research findings. I will provide the similarities and differences between the women who stayed in their majors and those who left and changed majors. The presentation will have a visual component, such as PowerPoint. I will sample some participant biographies—those who stayed and those who left the CS major—and relate their stories, as women's perceptions and motivations were the main reason for this exploratory research study. I will also use audio and read aloud the answers of some women to engage in conversation about the struggles and issues the focus group found to be important for the growth of women and minority groups in the major. This meeting will help to inform all stages of the CS major that undergraduate students go through.

Lastly, the findings should be shared with the women in the major and other underrepresented groups of students to get feedback on what additional changes should be included to improve the CS major. I want to create a discussion group in the already existing CS organization to discuss topics like gender, race, and sexual orientation and the inclusive practices that can help narrow the gender gap at this institution and in other similar STEM majors and programs at the higher education level.

The dissemination plan also includes a meeting with the deans of the Engineering College, relating the research findings in an executive summary that will likely lead to a presentation, if permitted, where I would answer any questions they may have for me as an educational practitioner advising students. This meeting may lead to more open and transparent policies and procedures for this major and other majors where women are underrepresented at FRU.

Conclusion and Recommendations

This research study revealed undergraduate women's experiences, motivation, and factors contributing to their underrepresentation in the CS major. It exposed multiple underlying factors that affected their decision to stay or leave the major. This study found that social networks and connections strongly contributed to women's persistence in the CS major and overcoming of self-doubt and challenging situations. The interview and focus group findings emphasized "the power of belonging" in classrooms and the CS major as a whole. There is a need to make the CS major more inclusive by improving the math, science, and engineering teaching spaces and considering the need for a more interconnected curriculum that accepts newcomers and does not just cater to already skilled students. My recommendations and initiatives to universities and CS departments include the following proposals.

Proposal #1

Implement training in implicit bias in classrooms for faculty, staff, and students in Science, Technology, Engineering, and Math to increase understanding of the negative affects it has on women and other underrepresented minorities in those majors. This initiative can improve access for many students who may not have considered CS as a major. This can only be achieved with the support of administrative councils acknowledging that changes need to occur. Thaler and Sunsteim (2008) recommend that we start nudging policymakers to pay attention to what could be seen as insignificant information. By doing so, educational institutions can influence people's behaviors and adopt new transformative actions.

Proposal #2

Increase the number of women and people of color as faculty members in the Computer Science major. With a more gender-balanced faculty, the mentorship available to women in the

undergraduate major increases. A National Science Foundation (NSF) analysis discovered that women and minority (Black, Hispanic, and Native American) faculty represented only 9% of professors in STEM fields at four-year institutions (NSF, 2019). This analysis also revealed that increasing the number of underrepresented faculty could drastically eliminate the gender and achievement gap by 20-50% in courses (NSF, 2019).

Proposal #3

The CS major can adopt more inclusive paths for women to enter and remain in the CS major. Some of the paths may include allowing alternative science courses to replace physics and eliminating the third- and fourth-level admissions requirement of gateway courses in the CS major.

Broadening Participation in Computing (BPC) is an initiative led by the National Science Foundation (NFS) since 2017. They have suggested that CS departments strive to increase the participation of the underrepresented in current CS classrooms and eliminate barriers in education, such as repeated admissions to obtain a degree (NSF, 2019). The feasibility of the policies is seen as positive, because the FRU CS Department has applied to be part of the outreach from the National Science Foundation's Broadening Participation Plan to get more women in STEM bachelor's degrees and research (USF, 2020).

As researchers and college administrators, it is crucial to reflect on Fryberg's (2011) suggestion that researchers must realize that technical-rational experts are not actual experts; they are advanced beginners that accept the rational patterns of our society set by our powerful culture, which causes them to miss the condition being studied because knowledge is contested. This case study sought to give voice to the women who have pursued Computer Science degrees, and desire to see more women succeed in this field.

APPENDIX A

PROTOCOL INTERVIEW GUIDE FOR PARTICIPANTS IN THE STUDY

1) Name: _____
2) Major: _____
3) Minor: _____
4) Age: _____
5) Did you enter the university as a freshman?
   - ☐ Yes
   - ☐ No
6) Did you graduate from a Florida high school? _____
   - ☐ Yes
   - ☐ No
7) What city and state is your high school located? _____
8) Will you be the first one in your family to graduate from college?
   - ☐ Yes
   - ☐ No
9) Did you take AP, IB, Dual, or College-Level Math or Physics courses in high school?
   - ☐ Yes
   - ☐ No
10) Was your high school a magnet or technical high school?
   - ☐ Yes
   - ☐ No
11) What is your academic standing/year in college now?
   - ☐ Junior 61–70 credits
   - ☐ Senior 71–120 credits
   - ☐

12) Do you identify with any of these ethnic groups?
   - ☐ White
   - ☐ Hispanic/Latinx
   - ☐ Black or African American
   - ☐ Asian American
   - ☐ Indian or Alaskan Native
   - ☐ Other or several: _____
   - ☐
13) When do you expect to graduate?
   - ☐ Fall 2021
   - ☐ Spring or Summer 2022
   - ☐ Fall 2022
   - ☐ Or Other _____

APPENDIX B

PHASE ONE: SEMI-STRUCTURED INTERVIEW PROTOCOL WITH WOMEN IN THE MAJOR

Interview

Estimated time for each interview: 60–90 minutes.

Thank you for allowing me to interview you; please feel comfortable stopping me or asking me to expand at any point in our conversations today. This study aims to understand the decision-making of CS women to remain in the major and graduate or to change majors. It is a privilege to allow me to know more about your experiences and journey in college. This conversation will be audiotaped; please don't provide another student's name or detailed information.

1. Tell me about yourself and why you choose to attend this university?
2. How would you describe the campus environment?
3. Can you tell me your major as a freshman and why you chose it?
4. What led you to pursue the computer science major?
5. Can you tell me about your level of CS knowledge as a freshman?
6. Can you tell me about your support system or role models when you started college?
7. Can you tell me about your classroom experiences during your calculus and physics courses?
8. How would you describe the interactions between you and your classmates?
9. Can you tell me about your first CS courses and your experiences in them?
10. Can you describe your relationship with CS faculty members?
11. How would you describe the interactions between you and your TA?

12. Does the CS major have services to help those with difficulties in their classes? If so, can you provide an example of if you used them?
13. Who are the administrators that you seek support from? Why?
14. How would you describe the interactions between you and your classmates?
15. How would you describe the academic classroom environment?
16. Can you tell me when you first considered changing your majors?
17. Can you tell me about your support system now?
18. Do you think this university is doing well to promote a welcoming atmosphere for students of different gender and racial and sexual backgrounds in the CS classrooms?
19. What advice would you give another student (a first-year student or a woman) studying CS?
20. Is there anything else you want to add or share about your experience at the university and in the CS major?

APPENDIX C

PHASE ONE: SEMI-STRUCTURED INTERVIEW PROTOCOL WITH WOMEN WHO LEFT THE MAJOR OR CHANGED MAJOR

Interview

Estimated time for each interview: 60–90 minutes.

Thank you for allowing me to interview you; please feel comfortable stopping me or asking me to expand at any point in our conversations today. This study aims to understand the decision-making of CS women to remain in the major and graduate or to change majors. It is a privilege to allow me to know more about your experiences and journey in college. This conversation will be audiotaped; please don't provide your name or detailed information about other students.

1. Tell me about yourself and why you choose to attend the university?
2. How would you describe the university atmosphere?
3. Can you tell me your major as a freshman and why you chose it?
4. What led you to pursue the computer science major?
5. Can you tell me about your level of CS knowledge as a freshman?
6. Can you tell me about your support system or role models when you started college?
7. Can you tell me about your classroom experiences during your calculus and physics courses?
8. How would you describe the interactions between you and your classmates?
9. Can you tell me about your first CS courses and your experiences in them?
10. Can you describe your relationship with CS faculty members?
11. How would you describe the interactions between you and your TA?
12. Who were the administrators that you sought support from? Why?

13. How would you describe the interactions between you and your classmates?
14. How would you describe the academic classroom environment?
15. Can you describe your feelings about the programming courses?
16. Can you tell me why you changed majors?
17. What do you like about your new major?
18. Can you tell me about your support system now?
19. Do you think the university is doing well to promote a welcoming atmosphere for students of different gender and racial and sexual backgrounds in the CS classrooms?
20. What advice would you give another student (a first-year student or a woman) studying CS?
21. Is there anything else you want to add or share about your experience at the university and in the CS major?

APPENDIX D

PHASE ONE: TWO FOCUS GROUPS PROTOCOL WITH WOMEN IN THE MAJOR

There will be a focus group discussion with the participants from the one-on-one interviews. The focus groups are estimated to take 90–120 minutes. The open-ended questions will allow the students to elaborate and expand on their perceptions. When the women arrive, they will be greeted at the door. I will have a table with light refreshments and late lunch as the students get comfortable in the room they can eat. I will briefly introduce myself and the purpose of the study.

For the first 5–10 minutes, I will ask all participants to introduce themselves by sharing group introductions and discussing quotes from computer science women. These prompts will create a conversation and put the women at ease if they do not know each other. I also tell the students the purpose of the study and stress that it will all be confidential. The purpose of the study will be to understand the aim of increasing the representation of women in the major and providing more information on specific topics.

Focus group questions and discussions:

The discussions will start with these ice-breaking quotes:

Quotes for Discussions in Ice Breakers

- "Nothing in life is to be feared. It is only to be understood." -*Marie Curie*
- "If you haven't failed yet, you haven't tried anything." -*Reshma Saujani, Founder of Girls who Code*

1. Please tell me what your think about these quotes concerning your college experience?

Introduction

- Please introduce yourself and tell us what makes CS meaningful to you as a major?

- How did you feel about your selection and expectations when selecting the university?
- Tell me about prerequisites, physics, math, and CS classes?
- Do you think some factors can affect women (but not men) from studying CS at this the university? Please explain?
- Is the topic of gender discussed in your CS classes? What do you think of gender diversity training in the CS major?
- What strategies do you suggest could solve or overcome these problems and increase the number of women in the CS? Please explain.
- How do you see women's career opportunities and job prospects in CS?
- Can you tell me about your internship experiences?
- What are some of your goals after graduation?

APPENDIX E

PHASE ONE: TWO FOCUS GROUPS PROTOCOL WITH WOMEN THAT LEFT THE MAJOR OR CHANGED MAJOR

There will be a focus group discussion with the participants from the one-on-one interviews. The focus groups are estimated to take 90–120 minutes. The questions will be open-ended, allowing the students to elaborate and expand on their perceptions. When the women arrive, they will be greeted at the door. I will have a table with light refreshments and late lunch as the students get comfortable in the room they can eat. I will briefly introduce myself and the purpose of the study.

For the first 5–10 minutes, I will ask all participants to introduce themselves by sharing their day and group introductions. These prompts will create a conversation and put the women at ease if they do not know each other. I also tell the students the purpose of the study and stress that it will all be confidential. The purpose of the study will be to understand the aim of increasing the representation of women in the major and providing more information on specific topics.

The discussions will start with these ice-breaking quotes:

Quotes for Discussions in Ice Breakers

- "Nothing in life is to be feared. It is only to be understood." -*Marie Curie*
- "If you haven't failed yet, you haven't tried anything." -*Reshma Saujani, Founder of Girls Who Code*

2. Please tell me what you think about these quotes about your college experience?

3. Please introduce yourself and tell us what major you are pursuing?

4. What do you like about your major?

5. What differences do you see in your major compared to the CS major?

6. What did you think about the prerequisite course?

7. Do you use programming in your new major?
8. What were some things that you enjoyed in CS?
9. Do you think some factors can affect women (but not men) studying CS at this the university? Please explain?
10. Is the topic of gender discussed in your CS classes? What do you think of gender diversity training in the CS major?
11. What strategies do you suggest could solve or overcome the underrepresentation of women in the CS? Please explain.
12. Does your new major have more gender-balanced classrooms? Are they 50 women/50 men?
13. Can you tell me about your internship experiences?
14. What are some of your goals after graduation?

APPENDIX F

RECRUITMENT AND DEBRIEFING COMMUNICATION

Title: Exploring the Motivations and Experiences of Women in the Computer Science Major

Thank you for taking part in our study. Below is additional information about our study.

When we told you about the study, we said that the purpose of the study was to find out why undergraduate women in the computer science major provided for pursuing the computer science major. However, the real purpose of this study is to find out why some first-time college women select the computer science major and graduate, and others change major.

You were not told about the real purpose of the study in case that might have changed your answers or how you acted. This is an ongoing study, and we do not want the real purpose to affect persons who may later participate in our study. We ask that you do not tell others about the real purpose until the study until Spring 2022 is over.

All the information we collect in our study will be confidential. We will ensure that there will be no way to link your name with your answers or the information we gathered in our study records. We are not interested in any specific person's responses. Instead, we want to look at the general results when everyone's responses are combined.

Your participation in our study is appreciated and will help us obtain new knowledge about our study topic. Again, we ask that you do not discuss the nature of our research with others who may later take part, as this might affect how they answer our questions or act in our study.

If you have any questions or concerns about our study, you may contact Marjorie Fontalvo at xxxxxxxxx@fsu.edu at the FSU Educational Leadership and Policy Studies. If you have any questions about subjects' rights, you may contact the FSU Institutional Review Board (IRB), a

committee that reviewed and approved our study, at (XXX) XXX–XXXX or xxxxxxxxxxxxx@fsu.edu.

If taking part in this study has caused you concerns, anxiety, or otherwise upset you, you may contact:

If you or someone you know is experiencing a personal or emotional crisis after hours, please call our 24-hour number at (XXX) XXX–XXXX and press option 3 to speak with a licensed mental healthcare professional.

If you would like to learn more about this research topic, we suggest the following references: Women in Computing at Carnegie Mellon, the university increasing Participation of Women in Computer Science https://resources.sei.cmu.edu/library/asset-view.cfm?assetid=517087

Title of the Study: Exploring the Motivation and Experiences of Women in the Computer Science Major at a Florida Research University

Principal Investigator:

Name: Marjorie Fontalvo

Department: Florida State University, College of Education, Educational Leadership & Policy Department.

Degree Sought: Doctor of Education (EdD)

Email Address: xxxxxxxxx@fsu.edu

Faculty Advisor Dr. Stacey Rutledge

Telephone number: (XXX) XXX–XXXX

Email Address: xxxxxxxxx@fsu.edu

You are invited to take part in a research study. Please find below information about this research to consider before you decide to participate. Ask us if you have any questions about this information or the research before you choose to participate.

Key Information for You to Consider
Statement of the Research Study. You are being invited to volunteer to take part in our research study. It is up to you whether you choose to take part or not. There will be no penalty or loss of benefits if you choose not to participate or decide later not to take part. **Purpose**. We are doing this research to explore the motivation of undergraduate women in the computer science major to remain or to change majors. **Duration**. We anticipate that participating in our study will last 60 to 90-minute interviews and a two-hour focus group. **Research Activities.** You will be asked to complete an online interview guide, talk about your life in an individual interview and join a focus group activity. **Risks:** The risks or discomforts of participating in this study include becoming *uncomfortable at answering some questions, but you can skip them.* **Benefits:** As a result of this research, we think you may benefit by learning more about your experience and reflecting on how it contributes to your life decision-making. This *study will allow for further understanding of the major selection and broaden the participation of underrepresented groups in computer science. This will also help researchers learn more about women in the university using the computer science major at a large the university and how to improve the major.*

What is this study about?

Researchers at Florida State University are studying women in computer science. Researchers are interested in discovering more about the perception and motivation of undergraduate women who select computer science as a major. You are invited to participate in the study because you are declared, and the university pursued computer science as a freshman, reached the upper level, and are now a senior in college. You are one of 20 people to take part in this study. Your involvement in the study is expected to be 90 minutes in an interview and two hours in a focus group.

What will happen during this research?

Suppose you agree to be in this research. In that case, your participation will include a one-on-one interview and a group focus group event where you will discuss the factors contributing to your decision to the university, remain, or change your major. We will tell you any new information that may affect your willingness to continue participating in this research.

Please be aware that this study will be for educational research purposes only, and the exact study questions and materials or your responses will be released. Your name and personal

information identifying you will not be shared. At the end of your participation in this study or if you withdraw, we will provide you with additional information.

What will you do to protect my privacy?

The study results may be the university published or presented, but no information identifying you will ever be provided or released in the university publications or presentations. We will take steps to protect your privacy and confidentiality. These steps include encrypted software that will only be available to the researcher and the university. Despite taking steps to protect your privacy or the confidentiality of your identifiable information, we cannot guarantee that your privacy or confidentiality will be protected. For example, if you tell us something that makes us believe that you or others have been or may be physically harmed, we may need to report that information to the appropriate agencies.

Individuals and organizations responsible for conducting or monitoring this research may access and inspect the research records. This includes the Florida State the university Institutional Review Board (FSU IRB), which reviewed this study. The University Institutional Review Board.

Only the faculty adviser and the principal investigator will access your personal information. Only after the research study is published in the university will access the research suggestions and conclusion for this study.

Other individuals and organizations to list in this statement include the IRB, faculty advisors, collaborating institutions/organizations, state or federal agencies, sponsors, etc.

The information collected in this research will not be used or distributed for future studies, even if all of your identifiers are removed.

What are the risks of harm or discomforts associated with this research?

There are no significant risks to this study, but there may be, by nature, some emotional distress and anxiety while recalling past experiences. There could be discomfort by being asked questions about sensitive topics such as why you repeated a course or if you wanted to change majors. You reserve the right not to discuss highly personal matters in your life. In addition to the risks of these harms or discomforts, this research may have risks of harms or discomforts that

are unknown at this time. If we become aware of any additional harms or distress that may affect you in the future, we will tell you.

How might I benefit from this research?
There may be no personal benefit from your participation, but the knowledge received may be of value to society.

What is the compensation for the research?
The participants in this study will receive a $20 gift card from Amazon for their time and effort after the interview. You will also receive lunch on the day of the focus group event.

What will happen if I choose not to participate?

It is your choice to participate or not to participate in this research. Participation is voluntary. Alternatives to participation are _____.

Is my participation voluntary, and can I withdraw?

Taking part in this research study is your decision. Your participation in this study is voluntary. You do not have to participate in this study, but you can stop at any time if you do. Your decision to participate will not affect your relationship with the researcher, FSU, the university, or other organizations. There are no consequences or loss of benefits to which you are otherwise entitled if you do not participate.

You have the right to choose not to participate in any study activity or completely withdraw from continued participation at any point in this study without consequences or loss of benefits to which you are otherwise entitled.

If you withdraw from the study, the data collected to the point of withdrawal will be used unless you would also like to withdraw it from use. The data will be destroyed and will not be used in the study.

Can I be removed from the research without my OK?
We may remove you from the research study without your approval. Reasons we would do this include disrupting other study participants during the interview or focus group or not following study instructions.

Who do I talk to if I have questions?

If you have questions, concerns, or have experienced a research-related injury, contact the research team at:

Name: Marjorie Fontalvo

Department: Florida State University College of Education, Department of Educational Leadership & Policy.

Degree Sought: Doctor of Education (EdD)

Email Address: xxxxxxxxx@fsu.edu

Faculty Professor: Dr. Stacey Rutledge

Telephone number: (XXX) XXX-XXXX

Email Address: xxxxxxxxxx@fsu.edu

The Florida State University Institutional Review Board ("IRB") oversees this research. The FSU IRB is a group of people who perform an official independent review of research studies before studies begin to ensure that the rights and welfare of participants are protected. If you have questions about your rights or wish to speak with someone other than the research team, you may contact:

Florida State the University

XXXX Levy Drive, Suite XXX

Tallahassee, Florida XXXXX

(XXX) XXX-XXXX

xxxxxxxxxxxxx@fsu.edu

STATEMENT OF CONSENT

I have read and considered the information presented in this form. I confirm that I understand the research Purpose and the study procedures. I know that I may ask questions at any time and can

withdraw my participation without prejudice. I have read this consent form. My signature below indicates my willingness to participate in this study.

I consent to participate in this study.

Printed Name of Adult Participant

Signature of Adult Participant

Date

I agree to be audiotaped

YES (initial) ____ NO (initial) ____

I agree to allow the use of audio in presentations or the university publications

YES (initial) ____ NO (initial)

I agree to use of audio for educational purposes _____

YES (initial) ____ NO (initial) ____

Researcher's Signature

I have fully explained the research study described in this form. I have answered the participant and parent/guardians' questions and will answer any future inquiries to the best ability. I will tell the family and/or the person taking part in this research of any changes in the procedures or the possible harms/possible benefits of the study that may affect their health or willingness to stay in the study.

Printed Name of Research Team Member Obtaining Consent

Signature of Research Team Member Date

APPENDIX G

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BIOGRAPHICAL SKETCH

Marjorie Fontalvo completed her doctoral degree in Educational Leadership and Policy Studies, focusing on Education Policy and Program Evaluation at Florida State University. Marjorie also attended Florida State University for her undergraduate degree in Geographical Information Systems and International Affairs, and holds a master's degree in Social Science and Humanities, with an emphasis on College Administration and Law, from Nova Southeastern University in Ft. Lauderdale. Her prior education, training, and experience have provided Marjorie with numerous professional opportunities within the fields of higher education policy including immigration and veteran affairs regulations, testing and proctoring services, professional development including academic coaching and educational research, and policy at the community and institution levels. Marjorie is the current president of the Parent, Teacher, and Student Association at Riverview High School in Riverview, Florida. Marjorie has been a member of the American Association of University Women (AAUW) and an active committee member of TechTrek. She currently serves as a Senior Program Advisor to the Computer Science and Engineering programs at the University of South Florida. She also serves on the University's Presidential Advisory Committee for the Status of Latinos (SOL) and the Committee on Accessibility charged with evaluating and monitoring the university environment for problems and issues related to these matters.