A QUALITATIVE INVESTIGATION OF FACTORS CONTRIBUTING TO WOMEN MAJORING IN COMPUTER SCIENCE

by

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ABSTRACT

ALEXANDRIA WONG. A Qualitative Investigation of Factors Contributing to Women Majoring in Computer Science. (Under the direction of DR. ROSLYN A. MICKELSON)

This study investigates factors that influence young women's decision to major in computer science (CS). While there is a rapid increase of scientific advances being made in the United States and the importance of scientific fields for societal, economic, and personal advancement are expanding, women are still underrepresented among college students pursuing degrees in scientific fields. This is particularly the case in CS. Prior research identifies multiple factors that inhibit or foster women pursing CS. These include cultural stereotypes of computer scientists, sense of belonging, role models, family, peers, school curricula, informal activities, self-efficacy and confidence as a CS learner. However, this literature is largely correlational in nature. It lacks sufficient research using the actual words and explanations from women themselves majoring in CS. In-depth interviews with ten female college students about their undergraduate experiences majoring in computer science at a public 4-year college institution in the South provide the voices of young women in computing. Using a combination of social cognitive career theory (SCCT) and gender schema theory as lenses to analyze their interviews, this research describes the influences that shaped women's participation in CS. Findings of this study provides insights based on the undergraduate experiences of female students who have declared a CS major. Results may illuminate factors contributing the gender gap in CS undergraduate majors and possible avenues to address it.

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INTRODUCTION

As the United States becomes more technologically advanced, the demand for professionals in science, technology, engineering, and mathematics (STEM) is on the rise. Yet, with few exceptions, women are still underrepresented in these fields despite the research that has been dedicated to understanding and addressing the barriers that are keeping them out of STEM (Blackburn, 2017). This underrepresentation is not only generally financially detrimental to them (because STEM occupations tend to be more lucrative than those in other fields) but denies these fields of the talent and innovation that the missing women might contribute (Beyer, 2014; Lockhart & Wolf, 2012; Shapiro & Sax, 2011). In addition to the current research being done on access and engagement in STEM in general, it is essential that research be done to understand each respective field that is encompassed by STEM to better tailor the solutions for increasing the number of women entering these fields.

The field of computer science (CS) continues to have a gender gap in student enrollment and degree attainment despite the field's expansion into most domains of everyday life and its role in the globalizing economy. This extension in public and private spheres means there is an increase in the number of professional opportunities due to the broad applicability of CS skills. Thus, it is important to understand the sources of female's underrepresentation. Not only does the underrepresentation affect women's income potential, but it is linked to the labor shortage in related occupations (Beyer, 2014; Lockard and Wolf, 2012). Occupational attainment inequality can generate more status inequalities because CS would be another field in which women could not earn a wage that allows them to support themselves. Women also face biases when applying for CS jobs. Even when women perform well, employers may lean towards hiring a man based on stereotypes and the higher levels of confidence that men seem to have in this field (Del Toro,

2019). Stereotypes and the perceptions of what computer scientists are supposed to be, could explain part of why there is an inequality in pay, prestige, and power between men and women in the computer science field, and these disparities may be one source of female underrepresentation.

There are many reasons for the underrepresentation of women in CS. Previous research on CS shows that the field is often perceived as a male-dominated field requiring an individual to consistently sit in front of a computer (Beyer, 2014; Cheryan, Master, & Meltzoff, 2015; Mercier, Barron, & O'Connor, 2006). This perception is one of the reasons—along with lack of family and peer support, self-efficacy, curriculum, and informal activities (or lack of them) — that contributes to women choosing to stay away from the field. Prior research suggests the largest factor underlying an individual's participation in any given field is linked to interest (Bottia et al 2015). Women's low interest in CS can be sparked depending on factors like support systems or informal activities. Without a balanced representation of women in CS, the field loses the perspective and creativity that women can bring to it (Beyer, 2014). Therefore, more research needs to be done to understand how impactful certain experiences are for women choosing or avoiding the field as an undergraduate major so that changes can be made to increase their opportunities to become interested in CS, enroll in degree programs, and persist until graduation with their CS degree. Increasing the number of CS degree recipients who are female is the first step to addressing the gender gap in CS occupations.

To identify what factors can improve the likelihood for women to enter and persist in CS undergraduate degree programs, this study explores ten CS women's experiences that led them to declare a major in CS. This study extends prior research that identified some of the key factors that lead women into this field by asking respondents to explain their own decision-making

process and describe how previously (un)identified factors have (or have not) influenced their decisions.

In the first section is a summarization of the previous literature on CS in general, on women's underrepresentation in STEM and CS, and on factors that have shown to attract women to the CS field. Although this thesis is only centered on CS degree enrollment, it considers research in the general STEM fields because it is more extensive and helps to guide research on CS. In the next section, two theoretical frameworks are presented that guide this research: Social Cognitive Career Theory (SCCT) and Gender Schema Theory. Then, the guiding research questions that arise from the literature review and theoretical framework are presented leading to the section describing the research design of the study. Here, the qualitative methodology used to answer the research questions that motivated this thesis are discussed. The findings section highlights the experiences of the ten interviewed individuals and explores the key influences in participant's decision to major in CS. Proceeding is the discussion of the findings, using them to answer the thesis' research questions, and the limitations. In the conclusion is a discussion regarding the significance of this research, what future work can be done, and policy recommendations.

REVIEW OF PRIOR LITERATURE

The field of computer science has become one of the most important ones for basic and applied science, the economy, national security, and individual and family's lives through CS's expanding role in education, the arts, health care, transportation, and entertainment. The field offers a wide variety of careers for professionals. CS refers to the study of computers and computer systems and is typically considered to be in the technology group of STEM fields. CS is considered to be a "hard science", similar to physics and engineering rather than a "soft science" such as sociology or anthropology and offers a wide range of careers (Del Toro, 2019).

In 2022, women remain underrepresented in occupations related to CS. Ironically, this field was once one of the only STEM professions that had a significant female representation, but over the years it has declined and now women make up a small percentage of the workforce (Del Toro, 2019). Increasing women's participation in the field is important because in the next decade the field is expected to have some of the highest growth rates in occupations (Lunn, Zahedi, Ross & Ohland, 2021). Some of the CS jobs, such as information science and software development, are predicted to rise by 22% (Bureau of Labor Statistics (BLS), 2021). Additionally, the critical and logical thinking skills that are necessary for the CS field can be applied to a broad amount of other professional opportunities (Nager and Atkinson, 2016).

Understanding Women's Weak Participation in Computer Science

The National Science Board (NSB, 2018) reported that the proportion of women working in computer and mathematical sciences has declined even as the number of women with the highest degree in the field has increased. This seemingly contradictory set of statistics is possible because the field is growing so rapidly. Not surprisingly, the increase in the number of women with degrees in the field is still lower than the increasing number of men getting degrees in CS

(NSB, 2018). In 2015, women in science and engineering occupations made up only 28.4% of employees compared to the 71.6% of men that had employment in these fields (NSB, 2018). Men also held the majority percentage of employed personnel in computer science occupations– such as computer and information (64.1%), computer support (73.1%), and software development (80.9%) compared to women (35.9%, 26.9%, and 19.1% respectively) (NSB, 2018). Since this field has become deeply integrated in our everyday lives and stakeholders' calls for gender equity and diverse perspectives are becoming louder, it is important that to understand what will likely increase women's interest and persistence in CS.

The Role of Stereotypes and Sense of Belonging

Negative stereotypes that convey that CS is a field for men rather than women contribute to the gender gap. Negative stereotypes can not only reduce participation but are an important factor dissuading females from entering STEM fields even among those who have interest and ability in the field (Beyer, 2014; Del Toro, 2019). Computer scientists are often portrayed as loners who sit in front of a computer all day and as "nerdy" or "geeky" (Cheryan, Master, & Meltzoff, 2015; Mercier, Barron, & O'Connor, 2006; Beyer, 2014; Carter, 2006; Yasuhara, 2008). Additionally, computer scientists are frequently depicted as infatuated with computers or as individuals who lack interpersonal or social skills (Beyer, 2014; Cheryan, Master, & Meltzoff, 2015; Mercier, Barron, & O'Connor, 2006). Current stereotypes also depict these individuals in computer science as mostly White and Asian men (Cheryan, Master, & Meltzoff, 2015). While stereotypes are influential on both men and women, negative ones can be more damaging for women than men (Fisher and Margolis, 2002). The widespread nature of negative stereotypes about women and CS help to shed light on why females tend to drop out or lose interest in CS (Fisher and Margolis, 2002).

The perception of what a CS professional is supposed to be may also undermine women's interest in the field, especially since women are less likely to have positive estimates of their intellectual abilities and more likely to have views consistent with stereotypes of the field (Ehrlinger et al, 2018; Shapiro and Williams, 2011). Females are more likely than their male peers to believe that CS will not allow them to have a social life or many friends and that the solidarity and competitive aspects of CS mean that a career in the field will not be family friendly. This perception may keep women from pursuing the field (Hur, Andrzejewski, and Marghitu, 2017; Beyer, 2014).

Studies conclude that students in STEM fields who feel as though they belong in the discipline are more likely to persist in it (Rainey et al., 2018). Other research shows that when students are able to collaborate in STEM or CS activities with their peers, either male or female, they are more likely to claim having a "sense of belonging" within the fields (Werner, Hanks, McDowell, 2004; Leaper, 2015). However, many women believe that they do not belong in CS because of their misconceptions of the field. They value working in professions that allow them to interact with people (Falkner et al., 2015) and the stereotypes portray computer scientists as lacking in social skills (Beyer, 2014; Cheryan, Master, & Meltzoff, 2015; Mercier, Barron, & O'Connor, 2006). This may be why women stray from the field. Role models are a critical part of a student's choice to follow a specific pathway. If women see others like themselves succeed in a field, it increases their attraction to it (Goode, 2008). The small number of women in CS professions is one reason why females may decide to stray from CS because they are unable to relate to others they see as being successful.

The Role of Family and Peers

Support systems, such as family and peers, can also be significant influences in fostering a sense of belonging and encouraging interest in CS among females. Margolis and Fisher (2002) confirmed that home environments are very influential for students' sparking and nurturing interest in CS. They showed that students may first be introduced to computers in their homes. One female student explained that her family was a "family of nerds" but explained that being around computers at home allowed her to become comfortable with them and to feel as though working with computers was natural (Margolis and Fisher, 2002). Family attitudes towards computers can also be impactful. Families can be one source of reinforcing stereotypes and research shows that families that believe that females should not be interested in computers or technology can make it difficult for females to pursue CS (Margolis and Fisher, 2002). Other families may encourage females to participate in anything CS related and encourage females to branch out towards things that are not necessarily "for females", thereby making it easier for females to pursue a scientific field such as CS (Margolis and Fisher, 2002). Additional research argues that fathers and/or siblings have the highest impact on young females' interest in CS (Lazić, Pavlina, and Belović, 2017).

Parents have key roles in which formal and informal activities children have in school that can spark interest in CS. Parents not only provide support (if possible) in their child's decision to participate in activities related to any given field of study, but they also have the option to provide financial support or find any educational activities that allow their child to expand their interests (if they have the resources and information). Parents who lack a CS background or do not understand literacy may find it difficult to find activities or tools that benefit their children (DiSalvo, Reid, and Khanipour, 2014). Other research on families found

that Latina students felt more stressed when their families were not supportive of their choice in a field (Gonzalez, Aguiree, and Myers, 2020). They were also more likely to deem their personal successes as successes for their families (Gonzalez, Aguiree, and Myers, 2020). This could also be the case for failures as well and would mean that if one should fail in their field, then this could negatively impact their families. If this is correct, then it would keep women from the CS field because women are less likely to believe that they will be successful in the field (Kallia and Cutts, 2021).

Peers and friends impact students' decision to participate in CS, especially for female students. Male students are more likely to find a way to build a social network that was supportive compared to female students (Stoilescu and McDougall, 2011). Women can benefit from having a supportive network when they go to pursue CS because they are able to interact with people who have similar struggles, which in turn can foster a sense of belonging (Besana and Detorri, 2004; Werner, Hanks, and McDowell, 2004; Leaper, 2014). Peers can also negatively impact a woman's decision to go into the CS field. Research on university settings show that females may face peer negative judgment in the CS program. Male peers may not believe that the female students are actually good at CS and were accepted only because they were female (Margolis and Fisher, 2002). At Carnegie Mellon, Margolis and Fisher (2002) found that the women in their study recognized the importance of having a support network of friends to help them not feel alone and help with more difficult programming courses. Additionally, female undergraduates who have friends in CS courses are more likely to pursue a CS major because they are more aware of the courses and do not feel as alone (Wang et al., 2015).

The Role of School Curriculum and Educational Institutions

Research also points out the critical role that educational institutions and curriculum play

in students developing an interest in CS. While not every school offers CS courses, it is important that those that do offer courses focus on CS concepts (Goode, 2008). Attending a school that has CS curriculum allows students to be involved and set their intentions on CS, which are two of the best predictors of persistence in STEM in college (Weston, Dubow, and Kaminsky, 2019). While some may argue that taking general STEM courses can lead females to CS fields, Weston, Dubow, and Kaminsky (2019) find that even general technology-related or alternative computing disciplines do not seem to influence CS persistence. This is why it is important for schools to implement CS concepts—like coding or data analysis—and even make connections to pop-technology or current culture to increase interest among diverse students (Goode, 2008).

The Role of Teachers as Role Models

Other school research regarding women's persistence in CS highlights the role of teachers. The best teachers not only understand the material that they are teaching but they also have an understanding of the obstacles that students may face so that they may be able to address them accordingly. Teachers can also act as role models or mentors, which is a good predictor of overall performance among students regardless of gender (Katz et al., 2006). Role models, even if they are not teachers, have been shown to improve attraction, access, and guidance into STEM programs (García-Holgado et al., 2019). Prior research in STEM has shown that high school faculty's proportion of female STEM teachers is influential on females' (but not males') decision to major in STEM fields (Bottia et al., 2015; Stearns et al., 2016) such as CS. Research on a project called "Project Her-CTI" showed that having mentors and faculty to meet with increased the sense of belonging and confidence among female students in college (Besana and Dettori, 2004). This program was able to partially reverse the trend of women feeling isolated and

lacking confidence. These results illustrate the crucial role of role models in women's intention to go into STEM or CS fields (Besana and Dettori, 2004). Students are also more likely to desire more diverse faculty, possibly so that they have similar individuals to themselves that they can look up to (Kaner and Frachtenberg, 2020). Other studies have shown that faculty members who are female can lead to retaining more females in the CS department. Showing students that their school supports women's participation in different fields seems to also help reduce the gender gap (Cohoon, 2001; Legewie and DiPrete, 2012).

The Role of Informal CS Activities

Articles on CS camps or informal activities find that participants are more likely to show higher levels of interest in CS (Clarke-Midora et al, 2019; Fisher and Margolis, 2002; Wigal et al., 2002; Chipman et al., 2018). Research has highlighted the individual versions of informal activities and how they relate to interest in CS with findings showing that programs and camps do increase interest level in CS fields (Clarke-Midora et al., 2019; Wigal et al., 2002; Chipman et al., 2018; Besana and Dettori, 2004). Studies on Project Her-CTI, the ACES program, the App Camp, and Digital Girls have shown that these programs increase interest because they specifically focus on mentorship and role models, fostering skills, and teaching about what CS entails. Programs like Digital Girls not only had a positive impact on females' future choices regarding the fields but also encouraged them to use higher critical thinking and problem-solving skills (Faenza et al., 2021). Other programs were able to focus on fun, social networking, understanding what CS is, and helped participants envision themselves in a CS career (Clarke-Midora et al., 2019). Participants in camps may not only have higher levels of self-efficacy but increase their CS skills as well (Chipman et al., 2018).

The Role of Self-Efficacy and Confidence

Self-efficacy and confidence play a vital role in women's decision-making when it comes to choosing a major. Women are more likely to have lower self-efficacy and confidence in the field for a multitude of reasons which decrease the likelihood that they decide to major in the CS field. One CS study highlighted the difference in confidence and self-efficacy between male and female students by looking at who was more likely to "tinker". This term refers to behavior that is exploratory even if that means deviating away from instructions or using "trial-and-error techniques" (Krieger, Allen, and Rawn, 2015). Women were shown to refrain from "tinkering" because it was riskier and they were afraid that they might damage or break something (Krieger, Allen, and Rawn, 2015). This highlights the idea that young women are more likely to follow the rules and instructions compared to young men and leads to the young women missing out on the opportunities to explore all what CS has to offer in terms of creativity.

Research on self-efficacy and confidence has also shown that young women are less likely to believe that they have the ability or that they will succeed in CS (Hur, Andrzejewski, and Marghitu, 2017; Kaner and Frachtenberg, 2020). In general, young women tend to believe that they will have "little natural ability" in male-dominated fields like CS which is a key component in determining occupational aspirations (Beyer, 2014). Usually due to the lack of understanding what CS entails and the male-dominance in the field, women are more likely to think that CS courses and skills are more difficult and stray from the field because they do not have higher confidence of their abilities (Lehman, Sax and Zimmerman, 2017; Hur, Andrzejewski, and Marghitu, 2017; Falkner et al., 2015). This lower confidence can also make young women feel like if they are not flawless they will not succeed and that this means that they do not belong in CS (Falkner et al., 2015).

THEORETICAL FRAMEWORK

Gender Schema Theory

Gender Schema Theory will be used as a theoretical framework to account for the external influences on women's decision to major in computer science. This theory is an extension of Kohlberg's early work on the internal cognitive mechanisms that underlie the development of gender identity. His work proposes that children develop their gender identity through cognitive processes and the categories in which they are put (i.e., being a girl that does girl things). Gender schema theory argues that individuals process information based on the what the surrounding culture provides (Bem, 1981), therefore putting more emphasis on how environments play a role in how children form and reinforce their gender identity (Martin, Ruble, & Szkrybalo, 2002). Children develop their gender identity and learn to behave through the norms of the environment, which may include stereotypes of the genders and what they do or do not do (Martin, Ruble, & Szkrybalo, 2002). Additionally, this theory argues that individuals will be motivated to behave consistently with norms, suggesting that whatever gender one identifies as will guide their behavior (Martin, Ruble, & Szkrybalo, 2002). This theory can help understand how schools, peers, and family influence children's educational attainment.

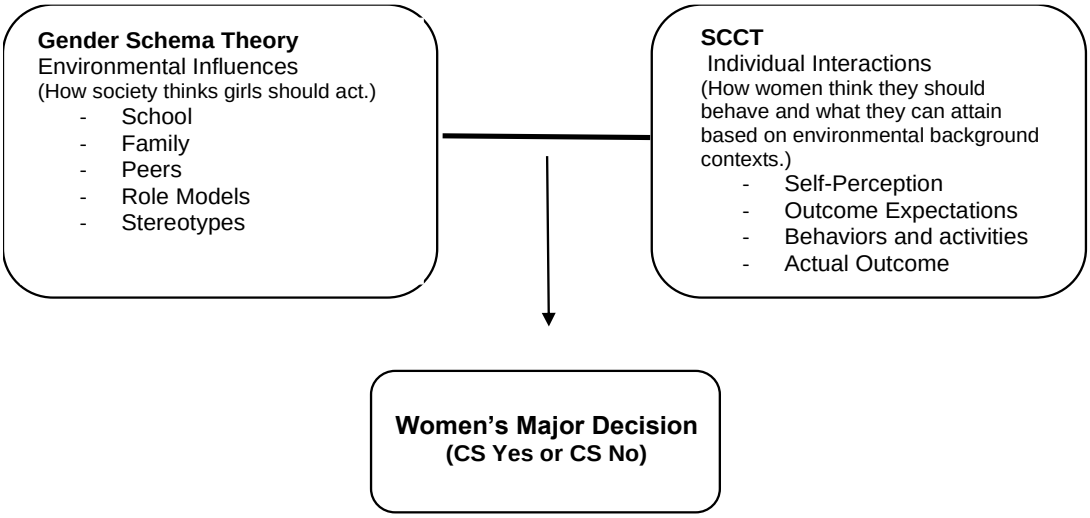
Social Cognitive Career Theory

Social Cognitive Career Theory (SCCT) helps to account for the linkage of these environmental influences identified by gender schema theory to decisions an individual makes when it comes to their academics or career through. The SCCT model is an extension of Bandura's Social Cognitive Theory (SCT). This model uses a triadic reciprocal determinism model and looks at the interactions between individuals, their own behavior and environments influences their goals and outcomes (Lent, Brown, & Hackett, 1994). Self-efficacy is one of the

three mechanisms of the model and refers to individuals' judgements and beliefs of their own capabilities and how they apply these to organize and execute the actions that they believe will help them achieve a specific type of performance (Lent, Brown, & Hackett, 1994). Second, outcome expectation is defined as what the individual expects or imagines the outcome to be from performing a behavior (Lent, Brown, & Hackett, 1994). Third, goal representations may be affected by the types of activities and behaviors that an individual executes and are defined as the desired outcomes that an individual is determined to attain (Lent, Brown, & Hackett, 1994). SCCT specifically focuses on career development, but because of the similarities between academic and career development, the framework can be used to understand academic development (Lent, Brown, and Hackett, 1994).

Using a combination of SCCT and Gender Schema Theory, this study explores the factors lead women to declare a major in computer science. Using both of these theories is critical for this thesis because together they account for the environmental influences as well as the perceptions and beliefs that individuals have about themselves when making decisions and setting goals. Women not only have their own idea of what they are supposed to be and what they should want for their future, but their environments (i.e., family, peers, schools, teachers, and so on) also shape their idea of who they should be or become. Both women's self-perception and their environments influence and shape their behavior and beliefs on certain aspects in their lives, such as whether they should consider going into a STEM field like CS. To better show how these two frameworks will work together and act as theoretical lenses for this study, Figure 1 is included below.

Figure 1: Theoretical Model



RESEARCH QUESTIONS

Using these theoretical frameworks and previously discussed literature as a basis, this study aims to explore into the factors that lead women to declare a major in CS. By asking women themselves to explain their personal experiences and searching for commonalities, this study will add to the understanding of how to address the gender gap in the CS field. Additionally, this study opens the door for insights on new or unknown factors that can be used to encourage more women to consider a career in CS by increasing interest and providing more information on what it really means to be a female computer scientist. Specifically, this study aims to answer the following research questions:

1. Do family members seem to influence the likelihood that a woman declares a major in CS? How?
2. Do peers seem to influence the likelihood that a woman declares a major in CS? How?
3. Do educational institutions seem to influence the likelihood that a woman declares a major in CS?
    a. How do curricula in middle school, high school, and/or college seem to influence women's decisions to major in CS?
    b. Do teachers in middle school, high school, and/or college seem to play a role in women's experience in CS and decision to pursue a major in CS?
    c. Do social climates of educational institutions influence women's pursuit of CS majors?
4. Do exposure to informal activities, such as computer clubs or coding camps, appear to influence women's decision to major in CS?
5. Does sense of self-efficacy or confidence in science, mathematics, or CS seem to

influence whether a woman goes on to major in CS?

6. Does “sense of belonging” in CS seem to influence the likelihood that a woman declares a major in CS?
    a. What influence do stereotypes seem to have on women in CS?
7. What other factors, if any, seem to influence women’s decision to major in CS?

DATA AND METHODS

Research Design

To gain a better understanding of which factors play roles in women's decision to major in CS, this study is conducted using a set of qualitative in-depth interviews with a group of ten self-selected female undergraduates and graduates. Conducting in-depth qualitative interviews is a suitable approach for this study because it allows for the participants to provide complete and insightful responses in their own words, and for the researcher to probe for additional information. This approach allowed for a rapport with the interviewees to be built so that interviewees would feel more comfortable sharing more information about their perceptions and motivations of majoring in CS. Additionally, interviews allowed for the identification of new factors not yet fully discussed in prior research of women's decision to major in CS. This study was submitted to UNCC's Institutional Review Board and received approval on April 13, 2022. A revision of the protocol was approved on June 8, 2022.

Piloting the Interview Protocol

The protocol used to capture the experiences and perspective of the ten CS majors interviewed is an adapted version of the protocol utilized with permission from the Roots of STEM Project (Stearns et al., 2013). The original interview protocol was open-ended and focused on student participation in all STEM majors. The one used for this study was aimed specifically at the participation of women in CS rather than all of STEM fields. This researcher adapted the Stearns et al. instrument by eliminating certain questions and adding new ones. The final adapted protocol is presented in Appendix A.

The adapted interview protocol was piloted with three women who were enrolled in the CS program at UNCC in 2022. They were approached by a member of the UNCC faculty and

asked if they would serve as interview subjects. They were assured that their cooperation was voluntary, and no negative or positive consequences would follow agreeing to or declining to be interviewed. These individuals are not part of this study's sample and their responses are not included in the analysis. These interviews ranged from 30 to 60 minutes and each individual was given a pseudonym for confidentiality. Each participant gave oral consent after reviewing the informed consent form presented in Appendix B.

The pilot interviews were necessary to ensure the adapted interview protocol was appropriate for CS students and that any adjustments needed in the interview protocol would be identified. Based on the pilot interviews, questions on role models and who the interviewee looked up to in the general CS field were added by the researcher. The pilot interviews uncovered that two questions were repetitive with question 12, "how would you describe a computer scientist?", therefore they were removed.

Research Sample

The University of North Carolina at Charlotte (UNCC) College of Computing and Informatics (CCI) female undergraduates and graduates were the sampling frame used to generate a self-selected group of interviewees for the study. As a graduate student attending UNCC, the university's CCI offered a population of prospective interviewees. Importantly, CCI has become North Carolina's largest computer science degree-granting institutions. Moreover, CCI values diversity among its students (Fresina, 2021). In just four years, the program was able to increase total enrollment by 17% and the enrollment of women by 52% (Fresina, 2021). The CCI department provided information regarding the current enrollment of women in the program for this thesis. In the summer 2022, females made up 17% (n = 422) of all CCI undergraduates and 38% (n = 414) of all CCI graduate students. Overall, there are 2,435 undergraduates and

1,089 graduate students enrolled in UNCC's CCI program. By focusing on this specific program, this study was able to include those women who can identify any positive influences that contributed to their decision to major in CS and to remain enrolled in the major.

This study included individuals in their senior year of undergraduate or above in the sampling frame because doing so ensured the likelihood that the interviewee will provide answers relevant to the study's guiding research questions. Originally, this study aimed to include female CS undergraduate students in their junior year, however—because this study was conducted during the spring and summer terms—it was difficult to find willing participants that were in their junior year. Female students under their junior year were not considered because generally it is thought that students will declare their major by the end of their sophomore year or beginning of their junior year. The small sample size of the interviewees and the lack of race/ethnic diversity among CCI undergraduates and graduates in this study precluded controlling for race or socioeconomic status when selecting interviewees. However, during the interview process, interviewees were asked questions regarding self-identified race or ethnicity and questions regarding parental education and occupation. This allows for ten unique perspectives to be included in this study, but does create a disadvantage of not fully understanding how racial or economic differences influence their CS experiences.

Using the individuals who participated in the pilot interviews, a snowball sampling technique was used to identify ten women majoring in CS who attend the University of North Carolina at Charlotte (UNCC). Snowball sampling is a technique where an interviewee provided the researcher with contacts for possible recruits of other interviews. A snowball sampling technique was used for this study because it quickly put the researcher in contact with other women in UNCC's CCI program who would be willing to participate in an interview. With the

approval of the thesis committee, the interviews included a mixture of undergraduate seniors, master's students, and one doctoral student. This allowed for the collection of a sample of ten women for this study and provided a racially diverse sample. Although this study was able to complete the requisite number of interviews for this study, the expansion of the sample to include graduate students held the potential for complicating the findings. These issues are discussed in the limitations section of this thesis.

The development of the research sample for this study began with referrals from the three pilot interviewees. They suggested other women in UNCC's CS program who may be interested in participating in the actual study. Only two of the pilot interviewees responded and provided a total of four names. Out of those four individuals, two were willing to be interviewed. One of those interviewees suggested women who were part of UNCC's Girls Who Code (GWC) program and the researcher was able to recruit more respondents. Two members of the thesis committee provided other referrals to female CS students. Four individuals came from these referrals and one of those was able to suggest an additional possible interviewee who volunteered to be a part of the interviews. Through this recruitment process, this study produced a sample of six seniors, two master's students, one doctoral student, and one individual who graduated with a BS computer science in 2020, yielding a total of ten interviewees.

Process of Conducting the Interview

To best capture the perspective and experiences of these interviewees, the researcher conducted a 30-to-75-minute interview with each female CS student interviewed separately. However, some interviewees took more time describing their experiences than those in the pilot interviews which led to the fifteen-minute increase in time variation. Before the actual interview took place, each participant was e-mailed a consent form to review and was asked to give oral

consent at the beginning of the interview. Therefore, there was no need for them to sign the consent form. Once the interviewees agreed to interview and reviewed the consent form, the interview was conducted and recorded over Zoom. Additionally, participants were assigned a pseudonym in order to assure their confidentiality.

Using the adapted interview protocol, the researcher focused on general questions about majoring in CS and the perceptions or stereotypes of the CS field. Then, portions of the interview were directed to key factors that were significant to prior research: family influences, school environment, identity and sense of belonging, and concluded with asking the interviewee how they feel about recent efforts addressing the CS gender gap and if there was anything else that the researcher should have asked during the interview. Since the purpose of this study was to explore and develop a better understanding of women's experiences leading them into CS, the interviewee was encouraged to fully explain their experiences and perspectives. Thus, interviewee's answers were probed to elicit further explanation of their responses to gain as much information on their experiences.

Once the recording was complete, only the audio recording was retained. The audio file was transcribed using the Otter.ai program (https://otter.ai/). Since the recorded audio included the pseudonyms rather than the interviewees' names, using this program did not have any identifying information and kept the interviewees' identity confidential. Otter.ai is a transcription site that uses artificial intelligence (AI) rather than human transcribers and uses a speaker identification algorithm to distinguish different speakers (https://otter.ai/). It is compatible with Zoom and allows users to edit transcriptions and create a custom vocabulary to increase the accuracy of the transcription (https://otter.ai/). However, to make sure that the transcription is accurate, the researcher re-listened to the audio file while reading through the Otter.ai

transcription to correct any mistakes that were made. After the transcription was complete, the audio file of the Zoom interview was deleted as it was no longer needed.

Analytic Steps

After completing and checking the transcription, the interviews were analyzed using a deductive coding approach for each interview. This approach starts with preconceived ideas of certain groups or themes will emerge from the interviews based on prior literature and the structure of the interview protocol. However, codes for new themes that were present but were not predicted were included because they have yet to be discussed in-depth in prior literature.

Specifically, the researcher used thematic analysis coding to identify themes across the interviews. This method allows for interpretation of the data to be used and was a transparent process to produce reliable findings (Castleberry and Nolen, 2021). The researcher followed Braun and Clarke's (2006) guidelines by becoming familiar with the data, generating initial codes, reading through each transcript, reviewing themes, defining and naming themes, and finally, producing the report. To begin, codes were created for the different sections of each individual response by using a phrase that best fit the interviewees' response. Then, the researcher highlighted portions of the transcriptions, assign it a phrase or "code", and created a codebook with all interview codes. Then, codes of each interview were combined to create the main codebook that allowed the researcher to identify overlapping codes and distinguish themes within the interviews. Each theme was defined and named so that it became easier to compare to the interviews and to clarify the findings of this study.

After creating the main codebook and identifying the themes, all the interviews were reviewed a second time and compared the established themes to make sure that each identified theme is present across all interviews. Any adjustments needed were made to the themes–

whether that is combining themes or creating better fitting ones–so that each theme was as accurate as possible. Reviewing the themes in this manner increased the reliability of this study and additionally, short quotes from interviews were included as part of the findings to better explain the themes and findings of this study and to provide transparent descriptions. The findings are followed with the discussion using both SCCT and Gender Schema Theory to determine if findings from this study are consistent with the theories and prior literature.

FINDINGS

Interviewees were given numerical pseudonyms based on the order in which the interviews took place which were then converted into fictional names. Once the interviews were transcribed and coded, eleven themes emerged. Because each interviewee has their own unique story, not all themes were shared across every interview. Some themes were present in most while others were only shared among a few interviewees. In the following sections, the researcher discusses the themes and uses direct quotes from the interview to provide transparency in the findings of this study.

Below is Table 1 which includes respondents' pseudonyms, racial demographics, and current year at UNCC. This study uses Black and African American interchangeably here because of responses given by the interviewees when asked how they racially or ethnically identify. Additionally, information regarding parental education—specifically whether at least one parent attained a bachelor's degree—is provided to give insight on the individuals' family socioeconomic status.

Table 1: Interviewee Demographics

Respondent Number	Fictional Name	Race/Ethnicity	Jr/Sr/Gr/Ma/PhD	At least one parent received bachelor's degree?
1	Terrie	Black/African American	Senior	NA
2	Brianna	Asian	Senior	No
3	Donna	White	Senior	Yes
4	Hailey	Mixed (White/Asian)	MA	No
5	Nevaeh	Mixed (White/Asian)	PhD	Yes
6	Autumn	White	Senior	Yes
7	Mallory	Asian/Indian	MA	Yes

8	Francine	White	Graduated 2020	Yes
9	Michele	Asian/Indian	MA	Yes
10	Saundra	Black/African American	Senior	Yes

*Race/Ethnicity is based on interviewees self-identification

**Fourth column acronyms for senior, graduated, master's, and doctoral.

Family Support

One theme that was shared among all interviewees was the moral, academic, and role model support of family. This theme suggests that families can be influential by introducing girls to CS at a younger age and encouraging them to pursue a CS degree. Participants were asked multiple questions about their early experiences with computers at home and specifically, "how does your family feel about your decision to major in computer science?". Across all interviews, women explained that their family was supportive or happy of their decision to major in CS. In half of the interviews, respondents explained how their family members were a key factor in their interest in CS.

For the majority of respondents who reported that they were not the only child, siblings seemed to be a common point of interaction. One respondent, Nevaeh, explained that her father pushed her and her younger sister into CS but that it was a good thing because she (Nevaeh) enjoyed it. She went on to explain their CS interactions when they were children:

> **Nevaeh:** We've probably tried to make games when we were younger, but using little like, they're little RPG (Role-Playing Game) Maker games, not games, but like programs where you can like drag and drop things.

She continued discussing that their interactions were not limited to their youth but went into their high school years as well:

> **Nevaeh:** In terms of like coding, sometimes you would help each other out. If we have questions or asked each other to check things like, so like, sometimes coding with like academics and work quite a bit because she would also have the same advisor as me. So we would work on some projects together, like in school.

Additionally, Mallory mentions having a sister who was interested in CS as well. While they used to have more interactions when they were younger, college has prevented them from talking as much because of their busy schedules. However, she explains why she thinks that her parents were supportive of both of the sisters' decisions to major in CS because of the financial stability that a degree in this field could provide:

> **Mallory:** I think computer science since it's becoming such a big field, and there's so much area for growth. I think my parents feel that it's a stable career path to be in and I'll be able to be successful in that career path.

Each respondent was also asked who they looked up to in the CS field. While some individuals mentioned famous individuals or professors, Autumn states that it would be her brother, who she accredits to her decision to go into CS because that was his major as well. Her brother thought this would be a good field for her and would be financially stable as well:

> **Autumn:** I wanted to do education, but it was encouraged to me by my computer science older brother, to also do computer science, mainly for monetary reasons and for financial gain, which is understandable.

For respondents who did not explain relationships with siblings in this context, they explained the different ways that their family had a role in sparking their interest in CS. Francine suggested that her "addiction" to CS started with a gift:

> **Francine:** I think it was for Christmas, they bought me this, a stuffed animal called a Webkinz. I don't know if you've ever heard of it. So you got the code. And you could like go on the Webkinz website and like, register your stuffed animal and like play minigames and stuff. So that was my first experience. And ever since then, I have been addicted to the computer.

Similarly, Saundra explains how her father had her participate in a camp that sparked her initial interest:

> **Saundra:** So if I had to put it in a scope of how I came to declaring "I want to be a computer scientist" it actually dates back to 2014, when my dad actually put me in a technology camp that was for all girls.

Although Saundra's father encouraged her to see what she was passionate about, other family members had mixed feelings about her decision and it took some time for them to understand what she wanted to major in:

> **Saundra:** My grandma, she tells me to this day like "I wish you were a nurse, why don't you be a nurse?" You know? It's just not for me. But then they warmed up to it because they saw how much I'm passionate about it and they've all seen the work I've done in the field. They're like "You know what? This actually does suit you a lot". So, I think they warmed up to it definitely way more.

Not one of the interviewees expressed that their family members were was disappointed or unsupportive of their decision to major in CS. Others simply explained that their family was supportive or "pleasantly surprised" but did not go into an in-depth discussion of how their families showed that support.

Peer Relationships

Another theme that emerged from these interviews was peer relationships. This theme suggests that having like-minded peers can be a positive influence on women in CS and can help women create a support system that helps them belong. Throughout the interviews, there were multiple opportunities for respondents to discuss their relationships with friends and classmates in CS. While some of the women felt as though they had more connections to their peers than other students, two felt as though they had average connections and did not go in to further explain these connections. One individual, Donna, was an adult readmit student who stated that she felt she had less connections to her peers. Donna suggested that this was due to her age and not her field of study.

Having connections with one's peers isn't necessarily just from taking the same courses. As Terrie explains, sometimes these relationships are found through other resources, such as clubs or scholarship programs:

> **Terrie:** ...the most amount of women that I will have in one class will be four. And sometimes I was the only one. And then you'll often hear conversations about the things that they enjoy, their hobbies, and I have none of that in common with them. I'm not a heavy gamer. And anyone knows a lot of gamers go into the field of computer science. And so it's kind of like you're just the one sitting behind the conversation, but you're not engaging.

Terrie continues to explain how she found a support system of peers as a Black woman in CS:

> **Terrie:** It was definitely a factor that made me very skeptical and nervous [referring to stereotypes]. But I think joining I-PASS, meeting women and men of color, minority students, low-income students, kind of put that at ease for me.

I-PASS, first mentioned in this study by Terrie, was a project designed to address the gender and underrepresented minority (URM) enrollment gaps in CS at UNCC (Mickelson et al., 2022). Scholars who are awarded I-PASS scholarships are all low-income, female and/or URM students and receive $10,000 per year for four years (Mickelson et al., 2022). The scholars also are provided with opportunities for mentoring, tutoring, advising, and integrating into the academic and social life of UNCC (Mickelson et al., 2022). Projects such as I-PASS can bring like-minded individuals together and help introduce peers to each other to help create support systems, as suggested by Terrie.

Brianna does not specify the scholarship she was awarded, but describes an experience similar to Terrie's experience:

> **Brianna:** We kind of get grouped up because of our scholarship. So I would say like, those girls from that scholarship really helped. Yeah, like, classes get really hard. So we will struggle together some. Some nights we were stressed.

Other respondents explained how their peer and friend relationships were important to their encounters within CS because of the support:

> **Nevaeh:** I want to say like, this doesn't really answer role models, but I think I do get a lot of support from peers. I have a lot of, you know, they've been helping me like validate saying no to things and taking time off, like I'm taking this month off, which is why I asked earlier, but that's been helpful support from peers, my advisors have been really kind.
>
> **Saundra:** And even outside organization, I value those friendships and partnerships I create with people in the computer science field. So I definitely feel like everything that happened with COVID, and with current events in the world, I feel like when we finally

decided to nurture those relationships with one another and networking. I feel like that's what really definitely brought us all closer.

Early CS Curriculum Exposure

Early CS curriculum exposure was another theme emerge from the experiences of this sample of women. This theme suggests that CS courses can be the initial spark of interest for women, teach them what CS entails, and prepare them for pursuing a CS degree. This theme was present in about half of the respondents, but this could be due to the fact that not everyone was offered CS courses in high school or prior to their degree. Four women who did have the opportunity to take CS courses prior to their undergraduate education explained that these early courses helped them understand more about what CS entailed.

Brianna: [Attended STEM high school] And in high school, we chose our fields, I selected engineering, and then we took one course per year with different concentrations. So one year will be electrical engineering, the other of you mechanical and so on, for four years. On my third year, I took a manufacturing engineering class, which we utilize GM coding.

Hailey: [HS courses] And so just within these classes, they would, like teach us how to code and stuff like that. And I found that like, very interesting. And I was like, Oh, I think this is really cool that I can like, write my own things and create my own like stuff, you know, through like, technology and things like that. And, I don't know, I always felt like it was something I was really interested in.

Nevaeh: It was, it was. I really glad it was too, because I know, um, I think it was relatively new too, where there was a programming 1 and programming 2. And I really want to do programming 2 because it was like game programming. So I like did that. And

> then eventually, they had like an AP computer science. But I think it was online at first. And eventually they got like a teacher to actually like, teach it at the school. So by the time that I took it was like the first year where they had like a teacher doing it, instead of just like an online class.
>
> **Mallory:** I think definitely my parents and my school courses that I took during high school led me to this path. I took a couple of computer science courses in 10th grade, 11th and 12th. And I felt like I really had a knack for it. So that's why I went into it. But the reason why I took the courses is because my parents told me that I should give it a shot.

Terrie's high school did offer a CS course but at the time she was on a track for early education, so she did not enroll in that course. However, she does recount her freshman CS course as what led her to want to persist within the field:

> **Terrie:** I took one of the 1212 courses, our very first course that you take as a freshman, and they introduce you to programming and basically all of the foundational things. And so for me, I've never had any experience with computer science. So going in, it was very scary. But I will say, midway, when I actually started picking up on things and learning things, and completing programming assignments and getting it correct, I guess that's that fulfillment that I want to continue to do it.

Role Models

The role model theme that emerged suggests that role models, especially female role models in the same field, can be a positive influence on women's decision to major in CS. In the literature review section, role models are discussed to be teachers or faculty members of

educational institutions. However, when asked if the interviewees have any role models or someone that they look up to in the CS field, only half of them mention teachers or professors.

> **Terrie:** She [the professor] works at UNC Charlotte, my first year here, you had to take like a computer science professional type of course, and she'll help you with your resume, cover letters and things like that teaching you the professional aspect of computer science. Helping you with those soft skills and I remember thinking so far, she's been one of the only black women professors that I've had.
>
> **Brianna:** Dr. D - he is my mentor since like, day one. I took computer like, Intro to Computer Science with him, my first TA job was with him, like he exposed, like, exposure from him. Like I learned so much. I got like research... excuse me, research opportunities through him. Like, I look up to him so much. And he's so far ahead of me in knowledge, and like, life experience and like wisdom, everything.
>
> **Hailey:** ...he was my computer forensics professor. And he worked. He previously worked for the FBI. And I think now he did something with, you know, like forensics, and like, searching computers and presenting it to like court cases and stuff like that. So I think that was, that was honestly kind of a moment where I was like, I think I want to do that for a career.
>
> **Nevaeh:** He's done a really good job mentoring myself and like a lot of the other undergraduates he works with. He puts a lot of effort into, like, mentoring us. And not just like academia, but also just like personal growth. Like, for me learning how to say no, or like, early on, it was a struggle to communicate. So I had a lot of mentorship with just like basic communication, like, how do I talk to people, where he would find

opportunities for us, and he would kind of push us into them, knowing that he would learn a lot from those opportunities.

Saundra: And I would say, my computer science teacher in high school. He's been a role model to me because just seeing a black man teaching coding to me like that really put in perspective of like "wow, I could literally be you or even be working alongside you" and like, the next 10 years when I get my degree, and we can push this forward to the next generation.

In addition to her CS teacher, Saundra lists multiple different role models, including her professors at UNCC who have provided “a guiding hand” throughout her time there. Like other respondents, she also views more famous individuals as role models:

Saundra: But if I had to name just like a few, definitely Hidden Figures was like the top of my list. Katherine Johnson, Mary Jackson, and Dorothy Vaughn, those three have been like my role models since the beginning of my career.

Other respondents mentioned Alan Turing, Elon Musk and Steve Jobs. However, Donna and Autumn look up to women involved in the CS. Donna describes Reshma Saujani below:

Donna: She's a politician, she has nothing to do with computer science. But she started the group Girls Who Code and she wrote a book called Brave, Not Perfect. And so like, I think she's an amazing role model, because she decided, after going to all the schools and not seeing any of the women- little girls in STEM classes, that she needed to do something to reach out and try and get more of these young girls, because you need to start them off younger than my age.

Autumn described Katie Bouman who is a researcher at Harvard:

Autumn: An inspiration that is- that happens to be female is the woman who helped image the black hole. Like her pictures went super viral. And it was a big story about like a young woman in STEM and I thought that was pretty great. And she comes to my mind a lot.

Other respondents looked to more personal role models:

Francine: One of my coworkers, she's- I'm an associate software engineer, currently, she's a senior software engineer. And I don't know. I just really admire her work ethic, her drive to learn more, she's really into machine learning.

Mallory: I have a lot of friends who are also in computer science that are women and I have some family friends who also like, aunts who went into computer science and I saw them and what they do and how hard they work, and what they're able to accomplish. And I- I really get inspired from watching them and try to do my best as well."

Informal Activities

The influence of informal activities was a theme that suggests that participation in informal activities in high school or college can encourage women to persist in the CS field. Respondents were asked if they participated in extra- and/or co-curricular activities in high school and college to determine what, if any, influence informal activities had on their decision to major in CS. Interviewees were provided the following definition for each before answering the question: “Extracurricular would be school related but not attached to curriculum, such as CS clubs that aren’t necessarily attached to the school. Co-curriculars would be attached to curriculum, such as robotics or CS coding teams.”

Almost half of the women stated that they participated in extra- or co-curricular activities before enrolling at UNCC. Respondents Brianna and Mallory participated in robotics and/or

programming teams in high school but did not go in-depth about their experiences. Nevaeh and Saundra were both recommended to participate and provided descriptions of their experiences, but Nevaeh did not discuss the influence that participation had on her major decision. However, Saundra discussed how her father found a summer program that she enjoyed and that she participated in a number of programs outside of school, such as NCWIT. NCWIT stands for National Center for Women & Information Technology and is a network that focuses on addressing underrepresentation in computing (https://ncwit.org/). She also explains that because her high school did not have a CS club, she decided to create one:

> **Saundra:** Yeah, so I think as for like programs, I did, like outside like, not connected to the school. I know it was NCWIT... And then I was doing, like different programs that are around the area that were hosted by all women or like girl centric organizations that wanted more girls in STEM. So that was kind of like the general scope of my participation with coding like outside of school. But then when it came to connected to school, the only participation I had that was like coding related was this organization called Club Code that I actually founded it at my high school. We didn't have one. So I just created one. So that was the one I was part of connected to my school.

Donna did not participate in activities in high school but did find a summer boot camp prior to enrolling in UNCC's CS program. She explained that this bootcamp was one of the factors that best prepared her for CS. She described how she came across the bootcamp and why she decided to sign up for it.

> **Donna:** I googled "learn how to build apps", like, and I got a whole lot of different- there is apparently 5 million boot camps online. And most of them were asking for like $30,000 and UNC Charlotte Uptown boot camp was only asking for $11,000, which was

> still a crap ton of money. But I was like, I want to learn how to do it. I mean, sometimes it matters then- because UNC Charlotte, I went to school there before I rec- you know, I consider them a reputable school.

Other respondents who were unable to describe experiences prior to enrolling at UNCC but did explain the different clubs and activities they participated in during their undergraduate studies.

> **Terrie:** I went into some code lounges for girls who code but I never became a member. It was really just to bond with other people. But I-PASS definitely provides that because we have to take- we would meet up about once a week with each other, we'll have discussions related to computer science, being minorities, low-income students, and things like that. So, I guess that was my other form of community.
>
> **Autumn:** I'm part of Duke Energy scholars, which supports diversity in computer science. It has a volunteer component, which I fulfill every semester. And that's for promoting computer science diversity. I'm also involved in a research project based on diversity in computer science on an educational level.

Francine explained that she did a hack-a-thon in college but that she did not participate in much else. Some of the respondents who did have high school activities that they participated in also participated in clubs such as Girls Who Code (GWC) and the Association Machine Computing for Women (AMCW). Both are clubs similar to NCWIT and aim to support and encourage women in the CS field (https://girlswhocode.com/, https://women.acm.org/).

Confidence

Confidence was the sixth theme to emerge from the interviews, which suggested that building confidence takes time and experience. Each interviewee was asked multiple questions to better understand how confident they were in their CS abilities. They were asked if they believed

they had the ability to complete a CS degree as well as others, when they considered themselves to be a computer scientist, and if they believed others believed they were a computer scientist. Every respondent explained that they felt they had the ability to complete a CS degree as well as others, but this confidence seems to have come from the fact that at the time of the interviews, the interviewees were either close to getting their degree or already had one.

However, these questions often brought up the topics of what led the individuals to feel more confident in their abilities. Respondents mentioned that they did not always have this confidence but rather it was something they attained over time through their experiences in CS.

> **Hailey:** I think that different courses, especially like, this past spring semester. Some like my capstone course and stuff like that, I feel that I was really able to apply the things that I knew and make different things. Like I was able to make firewalls and stuff like that, and just things that I think that I would be able to do in the - in a real job or a real world scenario.
>
> **Autumn:** I became more confident as I gained more experience in computer science, that I was equal to my peers. So I know now that the people around me aren't better than me. And I'm not the dumbest person in the room. And everyone else is just as dumb as me, regardless of whether they're a guy or not.
>
> **Mallory:** I guess the going through the courses and doing activities and projects gave me more confidence in my abilities to succeed.
>
> **Francine:** I think at the very beginning, I was kind of like, oh my gosh, I don't know. Like, I like playing video games. But am I actually smart enough to like, you know, program and figure out all the intricacies of computers, right? But as I've- as I went through my degree, and learned more and more, I was like, okay, I can do this.

> **Saundra:** Because in a male dominated field, of course, those feelings are going to come up. And I had those more at the beginning with freshman year and it was very intimidating to be like the only girl in like a lecture class full of men learning something I am passionate about. But it was more of like, "am I really able to learn this?". But I think having those connections and getting involved with UNC Charlotte definitely helped keep me in, like the zone, when it comes to computer science. And that definitely helped change my mind to be more optimistic.

Another interesting note emerged from the interview questions focused on self-efficacy and confidence. When asked about others' perceiving them as a computer scientist, those who responded that they were unsure attributed their uncertainty not to *their* thinking they lacked the skill or competence, but rather others did not understand what CS was.

> **Terrie:** Mainly because maybe they don't have that type of background, and they just see on paper that I have a bachelor's or I'm getting a bachelor's in computer science. And then they're probably going to ask me a million questions about the field. And then I guess that's how they'll find out that I'm a computer scientist.
>
> **Donna:** I mean, most of my friends don't know anything about computers. So they consider me a computer scientist, once I finished the bootcamp before I even started back into school.

Sense of Belonging

A seventh theme that emerged from these interviews was a sense of belonging. This theme suggested that women seek a sense of belonging or support group when they are furthering their education. While all of the interviewees seem to feel confident that they could complete a CS degree, the majority of them also felt out of place at some point during their CS

experience. For Donna, this was due to being a readmit student in her senior year and the age difference between her and her CS peers. Others related the feeling of not belonging to stereotypes, not having things in common with their peers, or imposter syndrome.

> **Hailey:** I don’t know if I felt out of place. But I mean, you know, there has been a few incidents where people do things because they don’t think you- there has been times where you know that you feel because you are a woman yourself that people will look down on you or think that you don’t know as much as they do, even though you’re in the same course. Um, so there’s definitely been times that I feel that that’s happened.
>
> **Michele:** Yeah, I felt it when I was in the beginning when I was new to all the concepts and everything was coming at me at once. So at that time, I felt I was that.

Although Autumn did feel like she was capable of completing a CS degree as well as others and that other people would consider her to be a computer scientist, she herself did not put herself in that category due to imposter syndrome.

> **Autumn:** There's a lot of impostor syndrome everywhere, obviously, and that's especially true in programming. And I don't think this is a gendered issue necessarily. I just don't know if I'll ever consider myself like a computer scientist. Maybe it'll be more solidified after I have a degree in computer science.

However, many of these women also explained that their sense of belonging came after they started to build relationships with others, found mentors, understood that they are capable and were not alone in their feelings of not belonging.

> **Terrie:** Because we are all women, we just sit together and then they introduce me to more women that are in the field and I guess, being able to hang out with them or not being shy anymore, building those friendships and those relationships. We often talk

about the things that we have in common, the struggles that we have in common, our experiences, and I guess that kind of eased that feeling of not belonging.

Brianna: I was never that IT crew, there is an IT Hall, there's an IT field in my high school, but I never considered it because most of the people there are like, people who grew up with like tech who have experienced like programming and who would get like, gather around during lunch to like, play video games. And then you know, like, I never clicked. It never really occurred to me that I could be like that person studying. So I just like kind of shied away from it until that manufacturing class.

Saundra: So there's more of me in this class, like it isn't just me. And if it is just me, just making sure I understand the capabilities I can bring to the table and saying that I am capable of being in this field. So I think as soon as I tapped into my self confidence and trying to get over of the - I forgot the wording of it- but feeling that imposter syndrome and really getting and taking advantage of those resources that UNC Charlotte provides, I feel like that's really when I started to feel like I belong, I feel like I'm creating that space. If it's not already provided for me.

Stereotypes

The eighth theme that emerged from these women concerned negative stereotypes. This theme suggested that stereotypes can be detrimental to women's decision to go into CS unless it is outweighed by another factor. Towards the beginning of the interview, each woman was asked what she thought the media's perception of computer scientists was and how they felt about that perception. Donna explained that mostly people do not fully understand what computer science is but did not go into the portrayal in the media. Most women explained that the media seems to portray computer scientists as "hackers" and someone who was coding all of the time.

Additionally, most of the interviewees mentioned that the computer scientist portrayed was typically a male and some mentioned race being White or Asian, with one interviewee adding Indian.

> **Terrie:** This is one thing that a lot of women in general, always talk about how there's this masculine outlook on computer scientists and a lot of STEM or engineering fields. And I think when we watch movies or TV shows, and they're showing this computer scientist, he's always hacking something. And it's an urgent thing. And it's so intense. And it seems like you have to be a super genius, because that's the way that they kind of present it to everybody, and it's always a male.
>
> **Brianna:** They are always men, and always Caucasian. And also why I never saw myself in the field.
>
> **Hailey:** So I would definitely say it's more of a, like a man orientated kind of perspective. I would say, you know, like the typical, like, honestly, probably the typical, like, white, nerdy male, I would say, would be seen as like a stereotypical computer scientist.
>
> **Nevaeh:** So, guy in the basement, doesn't leave his room ever. I feel like that's what's portrayed. And it's terrible.
>
> **Autumn:** That most computer scientists are White and Indian men predominantly, which is true.
>
> **Mallory:** I would say that it might be more like, you know, people who are more like robots and kind of like machines who kind of just work, and like, there's a set career or a set like company or set of work that only like computer science people can do. But the reality is, there's so much variety and what they can do.

Francine: Media's perception would probably be either like, you know, nerdy hermit that lives in, you know, their mom's basement, or, like a hacker.

Michele: Generally, according to the media perspective, I say, most of them have this misconception saying that computer scientists are someone who are blackbox engineers. Blackbox engineers are some people who write their codes or write their algorithms from scratch instead of- and not taking anything or any resources from other websites or other articles or anything. So, I think there is this misconception saying that every computer scientist does their work on their own but at last, everybody requires the help.

Saundra: A common example that a lot of people in the tech industry make fun of is like, basically, with TV shows, when you see like the hacker and like some Mission Impossible mission, they're like going crazy on the computer, like typing really fast.

These portrayals were typically a reason why women hesitated to look further into CS at first.

Terrie: I definitely went based off of a combination of my research and media portrayal. So I thought it was super intense. I thought I had to know all of these technical terms. My computer was going to be a dark background lit up with a whole bunch of colorful numbers and letters and that ultimately, I was going to have to become a computer. And so I guess for me, that was very intimidating.

Brianna: That was my perception. Like from media. That was my perception of computer science. That's also why I shied away from computer science so much.

The responses were mixed on how the women felt about these portrayals. Some believe there was some truth behind the perceptions, while others believed there was misinformation in what it means to be in the CS field.

Autumn: I think it's pretty accurate. It's different in different subsets of computer science. Some subsets are more diverse than others. But computer science overall is very diverse. And I think the representation in the media is getting better as representation in real life gets better. That's going up upwards.

Saundra: I feel like there's a lot of like misinformation or like misunderstanding of what hackers can be. Because there's always like, there's a line of like, there's good hackers, which I consider myself that basically someone creating solutions through a technological approach. And then there's, you know, the bad hackers trying to steal people's information and all that.

Educational Environment (Social Climate)

The ninth theme to appear was concerned they decided to join the UNCC CS program and not one at a different university. This theme suggests that women take the environment of universities into consideration when deciding where to attend, or rather it was used to help understand the social climate of the educational institution that the women attended. One reason that appeared in multiple interviews was that the campus “felt like home”. This description suggests that UNCC has an inviting climate rather than a “chilly climate”. The “chilly climate” term refers to the absence of factors such as co-ethnic peers and role models, financial strains, lack of extracurriculars, and/or weak or non-existent mentoring, tutoring, and advising programs (Mickelson et al., 2022).

Terrie: And I just love the environment. And it is one of the number one schools for computer science, other than maybe NC State here in North Carolina, that felt like home.

Hailey: And I honestly just really love the campus. I love the people and like, how diverse it was on campus and just how everyone's still accepting. And they also had a really good computer science program.

Saundra: As soon as we were walking around at Charlotte campus, like I already had so much back history with the school like my dad taught at the school in the past and I actually went to an engineering summer program in the past with them. So I was like, there's so much history with this school, it almost feels like a second home. So I literally just told my dad that I wanted to go to the school. Like, it's so much that I'm already connected to with this school, like why not basically nurture that connection with the school even further with going there."

Respondents Donna and Michele explained that their decision was based on the reputation and curriculum of the school.

Donna: I went to school there before I rec- you know, I consider them a reputable school. I figured it was worth taking the chance.

Michele: I have to say that UNCC had a very flexible and very robust course curriculum. This is the best university I think in which in terms of all the courses and the structure of courses, or the faculty or any help that we get from them.

The affordability of UNCC seemed be the deciding factor for both Respondents Terrie and Autumn:

Terrie: UNC Charlotte was the one that felt like home. And then the final decision was when I got the scholarship is called I-PASS that Dr. M is over. Once I got that, I'm like, "Yes, this is exactly what I'm supposed to be this is was meant for me".

Autumn: It was the only school I applied to. The only school I applied to purely for convenience sake because it's within driving. And it was what was affordable because of money I went to UNC Charlotte.

Understanding what it was about UNC Charlotte that pulled these women into CS was important to ask the women because it gave the opportunity to see what role educational institutions can play in increasing women's decision to major in CS.

Financials

The final theme, financials, was not expected at the beginning of this study. Throughout the interview, multiple women mentioned the important role that money had in their decision to major in the CS field. For some it was being able to afford the school and for others it was the promise of a financially stable career.

Autumn: Then I was offered a substantial scholarship that covered all of my tuition for computer science, specifically. And at that point, there was no way I was going to switch majors, because such as scholarships like that are not offered very often, and certainly not for the amount that I was offered for what I was doing. So at that point, I got into it for financial reasons.

Saundra: "And with my family, we're like a middle class family. So it's always up in the air if we're able to afford stuff, but I think what helped me really like not worry so much about the financial support is seeing the amount of support I had in general from the community of tech like, I think it's called NCWIT I believe is a great organization that helps provide financial support, even technological support to women in STEM. And they were actually able to provide me a scholarship to basically apply to UNC Charlotte.

Brianna: I was pretty sure if like, I put all my effort into it, I will excel. But there's always that, like people like people telling me that you gotta do what you love. You gotta study what you love. But like back then I was like, No, it's about the money.

Brianna continued to explain that not only did she look forward to the money that a CS career could provide, but that financial aid and scholarships kept her from leaving the field.

Brianna: I do. I receive financial aid and I do have a scholarship that covers. And I mean, combine those two, I'm like covered all the way so that I don't have to worry about like taking my time out of my study time. I don't have to worry about like, getting another part time job, which gives me more time if you think about it.

Adding:

Brianna: It definitely kept me in computer science. I am lucky enough for it, like, for my tuition to be paid for and I know that computer science, it's hard work, but it pays off in the end.

While Donna's decision was not necessarily based on attending UNCC for financial reasons, the affordability of UNCC's uptown bootcamp is what led her to signing up. This is the bootcamp that she attributes to her decision to pursue a CS major at UNCC.

Donna: And most of them were asking for like $30,000 and UNC Charlotte Uptown boot camp was only asking for $11,000, which was still a crap ton of money. But I was like, I want to learn how to do it.

The other women in this study explained that financial considerations were important but that it did not influence what they decided to major in.

Differences in Gender Experiences

The women were also asked if they felt there was a difference between men and women's experiences while majoring in CS. All but two individuals agreed that the experiences of majoring in CS was different for each gender. When discussing why women experience CS differently, most of the respondents who agreed that there is a difference mention that women must prove that they are capable or as capable as the men in CS.

> **Terrie:** I would say yes, because you don't have a lot of people around you that aren't like you that think the way that you do. And then you also have to face those microaggressions, those stereotype threats, that they may not even understand that they're putting out. So, they may think that you're incapable and they'll say things in a way to make you feel incapable. And they might not truly mean it, or they don't understand it. But because they haven't had that much experience with a lot of women in the field, they may not know how to handle it. And so, there are certain things that women experience that men may not experience.
>
> **Brianna:** There's more proving yourself being a woman in computer science field because it's so concentrated with men. They're everywhere and they like undermining and undercutting you and like taking credit for what a woman would do. And if a woman comes up with an idea, they would sort of think "that's not it because this is my field, like how dare you?" sort of and you hear it every now and then. So, there are like little obstacles that you have to push through. So women, being computer science, you do need a thicker skin. Men, not to be empathetic, but I feel like they have way easier. You walk in the class, and you already look capable...the woman—you have to prove that you're capable.

Donna: I think everyone I talked to is super surprised to hear that I'm a computer science person, being female. I don't think that people are surprised when a man says it. And even though I'm really impressed with how many more women are joining it, I still think that there's that “Oh, really? Oh, well, that's good for you. You must be smart.” Like, why aren't all these women smart? Um, so I mean, I think we're making progress. But I think there's still that difference.

Hailey: I would say yes, for sure. Because definitely being a woman, like, there's that feeling that you may not always fit in, or that you're not as good or you're not good enough. So, yeah, I definitely think there's that because, you know, that was something that I had to experience—with people trying to mansplain. Because they would try to like dumb it down for you or something like that. Or they would think you don't know how to do it and they're like "here, I'll do it, just give it to me" or something like that. So, I definitely think the experience is different.

Nevaeh: Probably. I know, I think because the way I was raised, I'm very stubborn. I don't see a lot of it. But I think talking to more friends who are women and seeing the things that they sometimes deal with the thoughts they have; it brings to light there's a lot out there.

Autumn: I think there's an extra layer of judgment that women go through by default, which is only amplified when you're one of the only women in your field. And I think as a result, they may be more hesitant to reach out for opportunities. And it may create a downward spiral of just not participating as much in general and not being as comfortable.

Francine: I think A) men- well, women aren't, I guess, given as many resources that would push them in that direction. It's not really suggested to you as much. B) once you're actually in the field, you're gonna have a much different experience. Just because, I mean, at least from my experience, I definitely have had trouble with—I mean not ton of trouble, but trouble with either like other male students or male coworkers kind of looking down on you. Whether it's because of their just background or just their personal, I don't know, pride? I guess people tend to look down on you think that because you're a woman maybe you're not as capable.

Michele: Because a lot of times when it comes to their mentality, they're used to raising [their] hand first in class, even if they don't say the right answer, they truly believe that they have the right answer, when it comes to a solution in a group setting or in a class setting. But when it comes to a woman, it's hard for us to really tap into that competence of "I'm going to say this, and like, I don't care if it's wrong or right, I truly believe it. And I'm going to take turns to say it now." Because we've always had bullying on us a lot and having that self-conscious feeling just on us all the time. And I feel like when it comes to the men experience, it's easy for them to just not really care about that that much. Because that's not really what they think about that all the time. But I definitely feel like both experiences are different.

These findings were interesting because at the beginning of each of these interviews, the women all explained that they felt as though they could complete a degree as well as others. This would seem to contradict their previous statement if not for considering the time that these women have already spent in the field. Given their responses to this question, it does seem as though they have seen or experienced feelings of being incapable or not taken seriously. Nevaeh mentioned

at the end of her interview that a man had commented that she only got into the CS program because she was a girl. These types of comments may be because programs are looking to increase the number of women in their programs, therefore leading some students to think that women do not have to be as knowledgeable in CS to be accepted into the program. This could negatively affect women in the field because they would no longer be taken as seriously, and their knowledge could be disregarded.

DISCUSSION

This qualitative study has provided the opportunity to better understand the factors that lead women to declare their major in a field that women are typically underrepresented in. By expanding the parameters of the sample requirements, this study was able to collect the perspectives of more women and women of different races and increase the knowledge on women's experiences within the expanding field. By collecting the unique perspective, this study was also able to address it's seven research questions and add to voices of other women who have shared their CS experiences in previous research.

According to gender schema theory, the local environment surrounding a child—or in this case the female CS student—influences the student's gender identity and what behaviors should be done to conform to that identity. Using this theoretical lens, the researcher analyzed the roles of family, educational institutions, peers, and media (regarding role models). In a mechanical sense, the results may be seen as inconsistent with gender schema theory because the results do not reflect that the family was supportive based on the women's gender. This is because there is no discussion on how their families felt about gender playing a role in majoring in computer science in any of the interviews. However, the fact that these ten women explain how their family is supportive could possibly be related to the idea that their families encourage women's participation in the CS field and do not perceive it as solely a field for men—being more consistent with the theory. Respondents' experiences only show that the positive impact was only based on the fact that their family gave moral, academic, and role model support. These results are also consistent with the prior literature explaining how fathers and siblings were most likely to have more of influence on major decisions compared to other family members. The responses of this study do focus on how fathers were helpful, such as Saundra's enrollment in a

summer camp, and how siblings influence each other through interactions or by being a role model themselves, as with Autumn's brother. Other family members were rarely brought up and did not seem to have much influence with CS major decision. These results suggest that the answer to question 1, "Do family members seem to influence the likelihood that a woman declares a major in CS? How?" is yes, families to seem to influence a woman's decision to major in CS because family members can provide different kinds of support that encourages women to pursue a CS major.

Similar to family factors, peer relationships seem to have some consistency with gender schema theory. Although these interviews do not attribute the gender of interviewees as the reasoning why peers are supportive, this could speak to the modern perception that the CS field is not only for one specific gender. It is also important to note that the definition of "gender" have evolved in recent years which may be why being a man or woman in the CS field did not seem to influence the likelihood of finding supportive peers in these interviews. Peer relationship findings were consistent with previous literature that peers can influence and encourage persistence in CS for women. In this study, it seems that having peers created a sense of belonging and support system for these women. When women could not find peers like this in the classrooms, they still seek the relationships through programs such as I-PASS, as seen with Terrie and Brianna who found their supportive peers through scholarships. This suggests that the answer to question 2, "Do peers seem to influence the likelihood that a woman declares a major in CS?" could be yes, if the peers are involved prior to declaration. In many of these cases, women were declaring their major within the first year of undergrad, which highlights the influence of peers on persistence rather than initial declaration.

Early exposure to CS curriculum was expected to provide more findings based on prior research that expresses that earlier exposure is better. Possibly due to the lack of early curriculum in the schools that these women attended, this study does not provide much insight into how early exposure in schools is influential. However, what the findings do show is that having computer science courses prior to attending college gives students a better understanding of what to expect from a computer science major. Additionally, the courses give the opportunity for increased interest among students. Taking the courses earlier also helped these ten women combat the stereotypes that they knew because they were able experience CS for themselves. Terrie and Hailey both discussed how taking a course solidified their interest in CS and led them to continue pursuing the major. These findings may be consistent with theoretical arguments that early curricula are a resource for women that fosters preparation in CS. However, the women's decision to enroll in earlier courses when given the opportunity was not motivated by their gender identity but rather curiosity and interest—which could be argued to be inconsistent with gender schema theory. These findings are still imperative because it shows that curricula allows students to be involved and set their intentions to CS and increasing the chances of them pursuing a CS degree, which is consistent with prior literature. The findings also answer the question of "How do curricula in middle school, high school, and/or college seem to influence women's decision to major in CS?" because they suggest that the curricula may increase knowledge about the field and increase interest, leading women to pursue the field.

Role models were beneficial for these ten women. They each had people—such as professors, friends, family, or celebrities—that they could follow and learn from. Half of the women in this study name a professor or teacher that they looked up to and that provided mentorship for them throughout their experience. These professors did not seem to be chosen as

role models due to gender or racial demographics, but rather their knowledge and support. Some women in this study provided more than one role model or person that they looked up to, this was not discouraged. This allowed for more insights on what kind of individuals these ten respondents were inspired or motivated by. Friends and family members were listed because respondents such as Autumn were able to watch how their family members found success. Additionally, celebrities were named because respondents like Saundra were able to see well-known individuals that were like them be highly successful. One very common response to the questions regarding role models was their professors or high school teachers. Professors and teachers not only helped build skills, but also were able to encourage some respondents to participate in informal activities and give advice related to personal growth and academics. Naming teachers as role models occurred for half of the respondents and is consistent with literature that explains that teachers can be role models for women in CS. These findings also suggest that the role models do play a role and can be beneficial for women in CS, answering the question of "Do teachers in middle school, high school, and/or college seem to play a role in women's experience in CS and decision to major in CS?".

For the purpose of this study, the overarching theme of role models seems to be inconsistent with gender schema theory because overall the interviewees did not express that their own gender or the gender of their role model contributed to who they looked up to. However, it is important to note that Saundra did express that she looked up to the women portrayed in the movie *Hidden Figures*, Katherine Johnson, Dorothy Vaughan, and Mary Jackson, because they were successful women of color in CS. In this instance, Saundra's explanation of why these women were her role models is consistent with gender schema theory because she was able to see that as a woman, she had a place in computer science. It is also

important to note that in the United States, gender identity has evolved and this may lead women in CS to pick role models without considering gender.

The University of North Carolina at Charlotte has already begun to make impressive moves to increase the number of women in their CCI program. The women of this study commented on the successful approaches that the university is implementing, such as I-PASS. The women also commented on the fact that UNCC was attractive to them because it seemed to have a feeling of home (an inviting climate), was close to their actual home, and offered financial resources. Additionally, referring back to discussion of professors as role models, the gender or racial demographics did not influence who the interviewees looked up to. This seems to suggest that UNCC has a diverse and inclusive climate. In regard to gender schema theory, the inviting climate finding seems to be consistent because it shows how the environment can positively influence women feel accepted. UNCC seems to be aware of the underrepresentation of women, racial minorities, and socioeconomic minorities and worked to increase enrollment among these populations and is what led to the ten interviewees to enroll in UNCC's CCI program. This implies that the social climate is influential on women's pursuit of CS, answering the research question of "Do social climates of educational institutions influence women's pursuit of CS majors?".

Curricula, Role Models, and UNCC's environment are all factors related to the influence of educational institutions on major declaration. Because of these themes' findings suggest that all these factors are influential, the answer to research question 3, "Do educational institutions seem to influence the likelihood that a woman declares a major in CS?" also seems to be yes.

Participating in informal activities prior to enrolling to UNCC's CCI undergraduate program seemed to help foster interest in the field. Four interviewees reported participating in

extra- or co-curricular activities and explained how it helped them prepare for CS and fostered interest. Saundra mentioned even starting her own organization of Club Code because it was not present at her high school. She also participated in community programs that were girl centric and hosted by all women. Donna participated in a summer bootcamp which solidified her decision to major in CS. A few other interviewees reported participating in clubs or activities after declaring a CS major and explained that through those, they found similar peers and it helped create a sense of belonging and community. The most commonly mentioned among this sample was Girls Who Code (GWC), which is focused on promoting female participation in the CS field. There was mention of a bootcamp that Donna participated in that was not acknowledged to be specific to one gender, Club Code was not specified for one gender, and Autumn did not specify if Duke Scholars was gender focused. Overall, it seems as though the majority of interviewees leaned towards joining clubs that were focused on women specifically, which seems to be consistent with gender schema theory. Additionally, the findings regarding informal activities suggest that participating in these activities and clubs can encourage women to persist within the CS. This suggest that informal activities increase the likelihood that women declare a major in CS, answering question 4, “Do exposure to informal activities, such as computer clubs or coding camps, appear to influence women’s decision to major in CS?”.

This study included ten women who were in their senior undergraduate or above, which is important to note when considering their response to questions of confidence. Each woman explained that she is confident in the idea that she could complete a CS degree as well as others, which could be due to the fact that they either were so close to getting their degree or already had one. However, probing questions highlighted how they were able to increase their confidence if it had previously been low. Hailey, Autumn, Mallory, Francine, and Saundra all explained that

building confidence came from making connections with others and gaining more experience over time. This would suggest that these women were able to overcome having low confidence in the field or the feeling that they were unable to be successful and continued to pursue their degree. SCCT argues that an individual will use their own believes about their capabilities to make decisions related to careers and majoring in a field. This finding seems to be consistent with this theory because the women may have all felt incapable but persevered and built their confidence in their abilities up over time. The findings also seem to suggest that confidence does influence women's decision to major in the field, answering research question 5, "Does a sense of self-efficacy or confidence in science, mathematics, or CS seem to influence whether a woman goes on to major in CS?".

Having a sense of belonging seemed to be very important to the women in this study. This theme suggested that women are more likely to persist in the computer science field if they have similar individuals to communicate with. The majority of interviewees recalled a time when they felt out of place and that they had to overcome that feeling to stay in the field. Terrie, Brianna, and Saundra explained how mentors and nurturing relationships with similar others helped create the sense of belonging in the field. Autumn specifically stated that she is unsure that she will ever feel like a computer scientist because of the imposter syndrome that she experiences. These findings are consistent with previous research that says having a sense of belonging helps women persist in STEM fields. Based on the answers of these women, a sense of belonging increases the likelihood that a woman persists in the field and answers question 6 of this study, "Does "sense of belonging" in CS seem to influence the likelihood that a woman declares a major in CS?".

Stereotypes seem to be a common obstacle for these women when it comes to having a sense of belonging. The typical CS stereotypes seem to be a negative influence for women because computer scientists are portrayed as "hackers" and someone who codes all of the time, as described by interviewees. Additionally, most of the women of this study mention that computer scientists are often portrayed as a White or Asian male—with one interviewee adding Indian when it came to racial demographics of the male. The responses of the women suggest that the stereotypes are detrimental for women debating to go into computer science. Both Brianna and Terrie shared that they hesitated to join the field because they did not see themselves as computer scientists due to the stereotypical portrayals. The findings on the negative effects of the stereotypes are consistent with previous research and answers the question of "What influence do stereotypes seem to have on women in CS?".

Both sense of belonging and stereotype themes are consistent with gender schema theory because women's sense of belonging seems to be impacted by the negative stereotypes of computer scientists. When women are exposed to stereotypes that White, Asian, or Indian men are supposed to be computer scientists, it makes it more difficult for them to see themselves in the field because they do not fit into that stereotype. This could then cause women who are interested in the field to stray if they do not have other factors—as it would seem the women in this study had—that outweighed the negative impact of the stereotypes. The stereotypes seem to create the idea that a CS degree is for "men" rather than for both men and women. Sense of belonging also is consistent with gender schema theory because it can combat the negative stereotypes if women feel like they do belong because the find that CS degrees can be a major for women as well.

One finding of this study was not expected to be found for the CS field based of the initial literature review. The influence of financial resources emerged from three interviewees who explained that having financial help to pursue their degree was a large factor in their decision to major in CS. Autumn noted that being awarded her scholarship is what kept her from switching her degree along with the promise of a financially stable career after graduation. Other respondents also commented on the fact that scholarships and financial stability influenced their decision to major in CS. This finding could be argued to be consistent with gender schema theory because the respondents did not explain anything regarding how their gender impacted the need for financial help or financial stability. However, deeper understanding regarding this factor could show to be consistent with gender schema theory because women may be offered scholarships that are gendered (as seen with Autumn). This unexpected finding also provided an answer to research question 7 "What other factors, if any, seem to influence women's decision to major in CS?". Because this was an unexpected finding and was not included in the review of literature of this thesis, looking further into this factor's literature seemed necessary.

These searches found that there were a minimal number of articles that discussed this influence of finances on majoring in CS. Instead, the articles regarding the gender gap in CS focused on the previous factors that have been discussed above with a few sidenotes relating to the differences in the importance of financial aspects between genders (Tillberg and Cohoon, 2005; Chevalier, 2002). However, some programs have taken an initiative to increase the number of women in CS by offering academic scholarship programs for students. Anderson-Rowland (2006) reports the results of the Collaborative Interdisciplinary Research Community/Maricopa Engineering Transition Scholars (CIRC/METS) project which targets women and underrepresented minorities to encourage them to choose engineering or CS. The results of this

program showed that women's persistence was 89.5% and has been deemed successful in retaining transfer students. The small amount of previous research on financial aspects and the CS gender gap could be due to the fact that prior research has explained that women are less likely to consider financial aspects when deciding what to major in compared to men.

The responses from the ten women when asked about gender CS experiences provided interesting, but not surprising results. With the majority of women agreeing that the experiences were different for women, it seems like the largest difference was based on the idea that women were not as capable as men. Respondents stated that they felt that they needed to prove themselves more and seek out resources that were suggested to men because they were not suggested to women. These responses from the sample of women seem to be consistent with gender schema theory because the women explain that men have different experiences because computer science was thought to be a field for men and not women. Therefore, these particular women believe that the men in CS do not have to prove themselves as much, feel judgment, or have other people "dumb it down" for them.

Limitations

This thesis has some important limitations. For one, this study suffers from survivor bias because the interviews are only conducted with women who have declared their major in CS and persisted through their senior year in CS (or beyond). It does not include any interviews with women who enrolled in UNCC's computer science program and decided to leave, meaning that this study cannot compare experiences between those who leave and those who persist. While the purpose of this study was to identify what keeps females engaged in CS, the absence of information among those who left the major is a limitation. This limits the findings from the

study because it cannot accurately explain the severity of influential factors or whether certain factors possibly have a different impact for those who decided to leave the CS program.

The study also only focuses on how these factors influence women and does not provide insights on how these factors influence men entering the CS. It focuses on how the factors encourage or dissuade women from the field and provides only the perspective of women in the field. Therefore, this study does little to distinguish the differences or similarities between men and women's considerations when choosing a major.

Another limitation is the number of interviewees in the sample and does not include women across all different races or ethnicities. Due to the time constraints of this study, there had to be a smaller number of participants than would have been optimal. This meant that demographics such as race and socioeconomic status could not be key aspects of this study because there are not enough participants to create smaller samples and provide accurate findings that controlled for these demographics. Additionally, this sample was selected from the UNCC CS program and does not include any female students from other computer science programs from other universities. UNCC's program may have a different recruiting process and acceptance routines than other universities which means that this study's findings should not be generalized to all undergraduate women. Therefore, these findings pertain to a small, self-selected, and nonrepresentative sample of CS female students.

Because of the timing of this study's data collection (May and June of 2022), it was difficult to obtain a large sample of senior CS undergraduate female interviewees. Consequently, the purposive, self-selected sample of 10 interviewees used for this study included students in UNCC's computer science MS and PhD programs. Even though the interviews focused on their

childhood and undergraduate experiences, their graduate student status introduced possible factors into the interviews that would not be present among a sample of only undergraduates.

CONCLUSION

Summary

Using this sample of women in CS from UNCC, this study was able to gain a better understanding of the factors that lead women to pursue an undergraduate degree in CS. With the combination of gender schema theory and SCCT, this study was able to gain knowledge on how environments are influential on individuals and their process of making their own decisions. The findings of this study seem to support prior literature regarding the influence of family, peers, curriculum, role models, informal activities, confidence, sense of belonging, and stereotypes. This study highlighted the importance of financial aspects for women, which could be further explored. Additionally, this study did not do much to distinguish female from male students' choice of majors due to the limitation of not having male participants, but it did provide insights on how women feel they are experiencing the major differently.

The women who participated in this interview seemed delighted and happy to discuss this thesis topic with the researcher. While quotations were used to provide transparency, it was not possible to fully capture the emotional aspects of the interviews. Respondents felt as though they were helping spread awareness and encouraged the researcher to continue researching this topic in hopes to make positive changes. At the end of the interview, the respondents were asked what they believed they, and others like them, brought to the CS field. All the interviewees said something along the lines of creativity and different perspectives. They also expressed the necessity of increasing the number of women in CS. Despite the limitations enumerated above, the findings offer important insights of how women are influenced by the family support system, peer relationships, curriculum, informal activities, stereotypes, confidence, sense of belonging, role models, college social climate, and financials. And while there is no basis for generalizing

the findings from this sample to a larger population of female undergraduates, the findings from the study provide insight into why there may be female underrepresentation in CS's student body. These CS specific findings are suggestive of larger dynamics that future researchers can explore.

Significance

This study was able to extend the knowledge on what factors contribute to young women's decision to major in CS. While prior research had previously highlighted factors contributing to major decisions, this study allowed for women themselves to explain their own experiences and share their perspective on the gender differences in CS. This research also identified other key factors in CS major declarations that heretofore had not been studied in-depth. It was found that financial aspects are a key part of the process of persisting until graduation with a CS degree. Knowledge like this is essential to understanding what keeps women interested and persistent in the field and can work towards closing the gender gap in the CS field. This specific study is significant because it uses a combination of two theoretical lenses to analyze the findings which come directly from women attending a minority serving institution in North Carolina who declared a major in CS and their self-description of their CS experience.

Without addressing the gender gap in CS, the field along with the United States' economy and society will continue to lack the benefits of what all women can potentially contribute by pursuing CS careers. The findings of this research show how factors like family, schools, informal activities, peers, role models, and stereotypes affect women's decision-making process regarding their future major. This study was successful in providing insight on how institutions and individuals can better address the gender gap in CS by finding ways to attract or encourage more females to go into the CS field.

Future Work and Policy Recommendations

This study leaves multiple directions for future research. Since this study focuses specifically on women in the UNCC CCI program, future researchers could examine similar university programs to determine if the results of this research are consistent with others. Results of studies of that nature could speak to the validity of this study and help determine what university efforts are effective in increasing participation among women. Future research should also include interviews with women who pursued a CS degree but decided to leave the field. This could help better determine the influence of the environmental and individual factors that this study examines and would help address the survivor bias that this study suffers from. Another possibility for future research would be to interview men as well. This would create the opportunity to compare and contrast how men and women are influenced by the discussed factors regarding individual beliefs and environments.

Results of this study show that women are still recognizing that are experiencing this field differently and that they face obstacles that they do not believe men face. While many respondents of this study agreed that efforts aimed to increase participation in CS among women have been effective, they also realize the importance of exposure and finding new ways to better address the issues. Some areas that could be improved given the results of this study are in high school curriculum and addressing the negative stereotypes in any environment. School Administrators and teachers should focus on how they can incorporate more than just the basic typing or programming courses into their curriculum and increase knowledge about what CS entails. Increasing visibility of successful women and racial minorities and differentiating the CS concentrations to the general public would be another possible way to combat the negative stereotypes that have been shown to intimidate and keep women from the field.

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Appendix A
Adapted Interview Protocol

CS Major Interview Protocol
Edited/Adapted by Dr. Roslyn Mickelson for Alexandria Wong 2/3/2022
Roots of STEM Project
Used with Permission from Dr. Roslyn Mickelson

For the purpose of illuminating other factors that go into women's decision to major in CS, I would like permission to probe for further information depending on the respondent's answer to the following questions.

Warm-up:

- Thank you for agreeing to be interviewed by me.
- I am Alexandria Wong. I am currently a second-year sociology graduate student at UNCC. This interview is part of my thesis that aims to understand the experiences of women in CS.
    - Confirm the respondent's name. Tell them you won't use the name again in order to assure confidentiality.
    - Mention the respondent's number (i.e., you are respondent #2, #3, etc.) and say you will refer to them as that
- Press record.
- Give them a chance to ask questions about the process.
- Get verbal consent:
    - "You have read the information in this consent form. You have had the chance to ask questions about this study, and those questions have been answered to your satisfaction. You are at least 18 years of age, and you agree to participate in this research project. You understand that your verbal acknowledgement indicates your informed consent."

General Questions about Majoring in Computer Science at UNCC:

1) Currently you are a woman in your [junior/senior] year at UNCC, correct?
2) You have declared a major in Computer Science as well, correct?
3) When it comes to your race/ethnicity, how do you identify?
4) I am interested in hearing your story of how you came to major in computer science. Thinking back over the course of your life, what would you say contributed to your decision to major in CS?
    a) What were the two or three most influential factors?
5) What do you think <u>the most influential factor</u> in your decision to major in CS?
6) At what point or age did you first know that you wanted to go into the career of computer science?
7) Did you have any career/life plans in mind when you chose CS?

If yes:

    a) What were the reasons behind these career plans?
    b) How did CS fit in with these plans?

8) What made you decide to attend UNCC?
9) How did you first learn about the computer science program at UNCC? (i.e., recruitment, word of mouth, peers, etc.)
10) Are you happy with your decision to major in CS?
    a) If so, why?
    b) Would you pick a different major if you could start over? If so, which major and why?
11) Why did you decide not to major in a different STEM field? (i.e., physics, biology, mathematics, or engineering?)

Computer Science General Questions (Stereotypes/Perceptions of CS and Role Models):

12) How would you describe a computer scientist?
13) How would you describe the media's perception of computer scientists? (Probe for differences in gender.)
    a) How do you feel about these portrayals?
14) Do you feel like you have any role models in the CS field?
15) Before majoring in CS, what did you think your major would entail?
    a) Would you say you were correct?
16) Have your experiences in CS changed your opinion of the typical computer scientist or CS major?
17) How applicable do you believe CS skills are to other STEM career fields?
18) Do you think CS skills have become more necessary and/or applicable in our current society?
19) How often do you use a computer or your CS skills outside of your major? (i.e., gaming, personal coding, etc.)
20) Has your ability to pay, or the way you pay, for your college education impacted what you major in?
21) Is there anyone in the CS field that you look up to?
    a) If so, why? If not, why do you think that is?

Family Influences

22) What was the highest level of education your parents attained?
23) What occupations did your parents have?
24) Can you remember the first computer you had at home?
25) Was it yours or a family computer?
    a. If family, who used the computer the most?
        i. What would they typically use it for?
        ii. How often would you use the computer yourself?
        iii. What did you typically use it for?
26) If something went wrong with the computer, what would you do?
    a. Who would work to fix it?
    b. If not interviewee, ask if they would try to learn how to fix the computer by watching as well?
27) How does your family feel about your decision to major in computer science? [Probe to explain why if they do or if they don't.]
28) Was there anyone else in your family that was interested in computers or computer science?
    a. If so, what were they interested in?
    b. How often did you interact with this family member?
    c. Did you and this family member do any CS-related activities together?

School Environment (Teachers, Peers, Academic Preparation)

29) Were CS courses offered at your high school?
    a. At your middle school?
    b. Did you take any CS courses in HS?
        i. Were these required for graduation?
        ii. If not, why did you take them?
    c. What kind of credit was this course? (Did it replace math or science or was it a separate credit?)
    d. Did you enjoy taking CS courses?
        i. Why or why not?
    e. Was your CS instructor a woman or man?
    f. Do you feel as though your instructor was knowledgeable in CS?
    g. Did you feel as though the HS CS course was taught well?
        i. If not, do you think this was due to the instructor or to the way that the curriculum was designed?
    h. How well did you do in the computer science course(s)?
30) Did you take more math and/or science courses in HS than what was required for graduation?

   a. Why or why not? (i.e., personal interest, external expectations from family, society, college admissions, etc.)
31) Did you enjoy the science and mathematics course(s)?
32) Do you feel these courses were taught well?
33) How well did you do in the science and math courses?
34) Roughly, what percent of all math and science teachers were women compared to men?
35) Do you feel as though your HS teachers cared about you and your learning?
36) To what extent did your math, science, or CS teachers lecture vs using more active approaches such as student discussions or hands-on activities?
   a. What type of learning did you prefer (lecture vs active learning)?
37) Do you feel as though any teacher or course was influential on your decision to major in CS?
38) Do you feel as though these courses prepared you to be successful in the CS field?
39) With your best "guess-timate", how many girls were in your HS CS courses? What about in math or science?
   a. What about in your college courses?
40) Did you have any childhood friends that were interested in CS as well?
   a. Did you and your friends do any CS-related activities together?
41) Co- and Extra- Curriculars
42) Did you participate in any extracurricular or co-curricular CS activities in high school?
   a. Extracurricular would be school related but not attached to curriculum (i.e., CS clubs that aren't necessarily attached to your high school)
   b. Co-curricular would be attached to curriculum (i.e., robotics or CS coding teams)
43) Do you participate in college extracurricular or co-curricular CS activities prior to declaring?
      i. If yes to one of the above questions about extra/co- curricular activities, ask how they learned about these activities.
44) **Identity and Sense of Belonging**
45) Do you feel you have the ability to complete a CS degree as well as others?
46) Have your feelings about your ability to do CS changed over time?
   a. If so, what led to these changes?
   b. Do you feel like you belong in CS?
47) Have you ever felt out of place? Has this feeling changed over time?
   a. If so, what led to the changes?
48) If anything, what do you think you or others like you bring to the field? (i.e.: unique perceptions or new ideas).
49) How often do you socialize with people who also majored in CS?
50) Do you enjoy socializing with them?
51) Do you feel like you are connected to your CS classmates more or less than a typical student in CS?
52) At what point did you consider yourself a "computer scientist"?
53) Do you feel like others consider you a "computer scientist"?
54) Do you think the experience of pursuing a CS major is different between men and women?
   a. If so, how?
   b. If not, why not?

Final Questions:

55) Do you think that there have been more recent efforts (i.e.: in the last decade or last five years) to equalize the participation in CS between men and women?
   a. If yes, how do you think those efforts have worked?
   b. If no, in your opinion, what kind of efforts could be made and where should they be made? (i.e.: the home, school, higher education institutions, communities, etc.)
56) I am interested in understanding why women major in computer science and their experiences within the field. Is there anything else along these lines that I have not asked about and I should have?

Thank you for taking the time to sit down with me and participating in this interview. Press stop on recording.

Appendix B
Participant Informed Consent Form

Department of Sociology
9201 University City Boulevard, Charlotte, NC 28223-0001

Consent to Participate in a Research Study

Title of the Project: Women Majoring in Computer Science
Principal Investigator: Alexandria Wong, Master in Sociology Student, UNCC
Faculty Advisor: Dr. Roslyn Mickelson, Chancellor's Professor in Sociology, UNCC

You are invited to participate in a research study about the experiences of female undergraduates majoring in Computer Science. If you agree to participate, I will interview you about your experiences and perceptions of the key factors that interested you in the major and then about what enabled you to persist in the field once you were in college. These may include family, community, school, or cultural experiences. The interview will take between 30 and 60 minutes and will be recorded for transcription purposes. All interviewee information will be confidential.

Important Information You Need to Know

- I am asking other UNCC female junior and senior undergraduate computer science majors to participate in a zoom interview discussing their pathway to computer science.
- Participation in this research study is voluntary and you can decline to answer any question.
- Please read this form and ask any questions you may have before you decide whether to participate in this research study.

Why are we doing this study?

The purpose of this study is to better understand why there is still a gender gap in Computer Science. Specifically, these interviews are aimed to explore the key influences and factors that lead women to declare a major and persist in the computer science field.

Why are you being asked to be in this research study.

You are being asked to be in this study because you are a junior or senior woman who has declared computer science as a major at the University of North Carolina at Charlotte.

What will happen if I take part in this study?

If you choose to participate in this study, you will be asked to describe personal experiences that contributed to your decision to major in computer science. The questions will be focused on experiences relating to your family, community, school, or cultural experiences and how what roles you think these factors played in your decision to major in computer science. Specifically, the questions aim to identify influential factors contributing to your major choice, any experiences and/or relationships you developed

that assisted you in your educational journey. We will set up a time in which you can log on zoom for an in-depth interview that will be recorded and transcribed for analysis. Your name and the interview will be treated as confidential.

What benefits might I experience?

You will not benefit directly from being in this study. Others might benefit because this research may provide clarity on sources of the gender gap within the field.

What risks might I experience?

There are no known risks to participating in this study.

How will my information be protected?

If you are to participate in an interview, your information and identity will be confidential to protect your privacy. Due to zoom recordings, participants video will be recorded but the video file will be deleted and only the audio file will be retained. Each audio recording will be transcribed and then deleted. A pseudonym will be used in place of your name to ensure confidentiality and throughout the interview. After the transcriptions are complete, the audio file will be deleted. If any information is recorded that could directly identify you, it will be omitted from transcription.

How will my information be used after the study is over?
After all interview data are collected and analyzed, the interviews will become the basis of Wong's graduate thesis. Some of your words may be quoted but will be attributed to a pseudonym you have chosen for yourself. Any identifiers will be removed from the data to keep confidentiality and will not be used in future research studies without additional informed consent.

What are my rights if I take part in this study?

Participating in this study is voluntary. Even if you decide to be part of the study now, you may change your mind and stop at any time. You do not have to answer any questions you do not want to answer.

Who can answer my questions about this study and my rights as a participant?
For questions about this research, you may contact Alexandria Wong by email awong13@uncc.edu or by phone (509) 910-2703. You may also contact Dr. Roslyn Mickelson by email roslynmickelson@uncc.edu.

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Office of Research Protections and Integrity at 704-687-1871 or uncc-irb@uncc.edu.

Consent to Participate

By signing this document, whether in person or electronically, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. You will receive an electronic copy of this document for your records. You will also be asked to give verbal consent at the beginning of the interview as an acknowledgement that you have read this form and to give consent if you are unable to sign the document electronically. If you have any questions about the study after you sign this document,

you can contact the study team using the information provided above.

I understand what the study is about and my questions so far have been answered. I agree to take part in this study.

_____

Name (PRINT)

_____

Signature Date

_____

Name & Signature of person obtaining consent Date