What Would Grace Hopper Do?
Reclaiming Women's Place in Computer Science

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Kristin Isaacson

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Dedication

Dreams do come true, but not without the help of others, a good education, a strong work ethic, and the courage to lean in.

— Ursula Burns, CEO of Xerox

This dissertation is dedicated to every woman in technology — past, present, and future — to those who persisted and paved the way, to those who wonder whether or not they belong, to those who question whether the self-doubt and isolation are worth it, to the young women eager to prove themselves and change the world, and to the girls who will (hopefully) only know a diverse and inclusive tech industry.

Abstract

This dissertation investigated the experiences of college women pursuing computer science degrees at a mid-size university in the upper Midwest. Between the 1940s and 1960s computer programming was considered "women's work," but by the 1980s women were being systematically phased out as men recognized the importance (not to mention financial gain) of software development (Brewer, 2017). The percentage of undergraduate degrees in computer science awarded to women and employment in the field reflects the gendered attitudes towards computing. Undergraduate degrees awarded to women and the ratio of women employed in computing-related fields have been in decline in recent decades and are currently at 19 and 25 percent respectively ("Digest of Education Statistics," 2018; Funk & Parker, 2018). The number of men entering computer science since the early 2000s has outpaced that of women, meaning that as an overall, the ratio of women in the field has gone down (Trapiani & Hale, 2019). Moreover, women tend to leave computer science degree programs at nearly twice the rate of their male counterparts (Chen, 2013; White & Massiha, 2016) and there does not appear to be any one definitive reason why women are leaving. Some suggested reasons include the dominant male hegemony, preconceived notions about what it means to "be technical," stereotype threat, low confidence, and a lack of female peers and role models.

The underrepresentation of women in computing is rooted in larger cultural issues; therefore, sociocultural theory and sense of belonging were the conceptual frameworks used to guide this dissertation. A case study design was selected for its ability to gain a deeper understanding of the women's lived experiences within a specific context and how those experiences shaped their identity, self-efficacy, sense of belonging, and decisions to persist. Five women, studying software development and/or game development at North Central University participated in this research. The data used in this research included transcripts from two in-depth interviews with each of the participants, transcripts from interviews with the academic program directors, classroom observation field notes, and university enrollment numbers.

Seven themes and eight sub-themes were derived from the data analysis, were deeply interconnected, and illustrated multiple aspects of the women's experiences as students. The concept of duality, where the women were caught up in a continuous cycle of divergent cultural demands, was determined to be the most pivotal theme insomuch that it interacted with the remaining themes and shaped the women's overall experiences. Five of the themes manifested out of the dichotomous value and belief systems between broader society and the computing micro-culture. The final theme demonstrated the necessity for academic support and mentorship.

The findings of this dissertation indicate that there is hope, that there are women who persist in computing degrees, and that concerted efforts to make the computing micro-culture more inclusive show promise for bringing about gender equity. Universities can bring about change and improve women's sense of belonging in the traditionally male-dominated micro-culture by deliberately building communities of women, providing support, demonstrating empathy, and ensuring women have role models. The findings also indicate that additional research and much more work is still needed to bring about gender parity in the field of computer science.

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CHAPTER 1

INTRODUCTION

> "[A] cultural and curricular revolution is required to change computer science so that the valuable contributions and perspectives are respected within the discipline."
> — Margolis & Fisher, *Unlocking the Clubhouse*, 2002

The underrepresentation of women in computing and technology is not a new issue. The percentage of women earning undergraduate degrees in computer science peaked at 37 percent in 1984 and has plummeted to only 19 percent in 2017 ("Digest of Education Statistics," 2018). At the same time, according to a recent PEW Research Center study that utilized U.S. Census Bureau data, the number of women employed in computing-related occupations has declined from 32 percent in 1990 to 25 percent in 2017 (Funk & Parker, 2018). These declines have been occurring despite the fact that employment in the computing sector has grown by 338 percent since 1990 (Funk & Parker, 2018). By the time we were closing in on the 20th century, scholars and industry leaders were already recognizing the lack of women in science, technology, engineering, and math (STEM) fields and wondering what could be done to "STEM" the leak (e.g., Brickhouse, Lowery, & Schultz, 2000; Camp, 1997; Margolis & Fisher, 2002; Margolis, Fisher, & Miller, 1999; Margolis, Fisher, & Miller, 2000; White, 1995; and numerous reports published by the American Association of University Women). In more recent years, the awareness of the underrepresentation of women in technology has exploded outside of the exclusive realms of academia and industry. It is a topic now being regularly covered by the mass media with headlines appearing in the likes of *Forbes*, *The New York Times*, *Wall Street Journal*, *The Atlantic*, *NPR*, and *The Guardian*. Simply perform a Web search for "underrepresentation of women in technology" or "women leaving technology" and you will find thousands, even millions of results. This heightened awareness has resulted in the creation and proliferation of a number of organizations across the United States such as Hour of Code, Girls Who Code, Black Girls Code, and Women Who Code whose goals are to demystify code and encourage women to pursue degrees and careers in computing and technology.

Before understanding why there is currently a lack of women in computing and technology fields/careers, much less ascertain how to reverse the trend, it is important to consider its history and culture — the actors, beliefs, and values — and how the culture of computing has changed over the decades. Lemke (2001) suggests asking probing questions to better understand the perspectives and implications of a field/sub-culture. While Lemke (2001) was specifically examining science and science education, the similarities between science and computing (e.g., male-dominated, specialized language) make the questions relevant. How has computing "been shaped historically by the overrepresentation and underrepresentation" of "different social categories of people" (Lemke, 2001. p. 299)? How does the culture of the field "define the kinds of personal identities it welcomes and supports" (Lemke, 2001, p. 299)? How does computing culture fit within the broader conceptions of masculinity or femininity within the United States?

Definitions

The following is a short list of definitions for conceptualizations that will be used throughout this dissertation.

Computing and technology. Computing includes the design and development of hardware, software, and networks, and the processes and structures needed in their creation or maintenance. In this dissertation the terms computing and technology will be used interchangeably, even though there are nuanced differences between the terms. This is being done as to avoid overuse of either of the terms.

Computing and technology fields/sector/industry. This term refers to the general area of employment that requires technical knowledge about the design, development, or maintenance of computer hardware, software, and networks. Some careers included in this field are software developer, computer programmer, application developer, network engineer, computer engineer, and desktop and server support.

Computing majors or programs. Many colleges and universities offer a major in computer science; however, the term computer science often comes with a set of preconceived ideas about what topics are covered in a major. This is why I have opted to use the term computing majors, sometimes referred to as programs. Computing majors or programs may include, but are not limited to, computer science, computer engineering, networking, and information technology. The common link between these majors is that they require students to acquire a level of technical knowledge (e.g. programming, structure, networking) about hardware, software, networks, or systems.

A Brief History of Women in Computing

To understand the experiences of women pursuing computing degrees, it is important to first understand the voices and actors that shaped the history and culture of computing. This is not an all-inclusive history of women in computing; instead, this is a brief overview of some of the key women who contributed significantly to the development of computer programming and software. As will be shown, it is software and not hardware, that proved to be the most lucrative segment of the computing industry. Men focused on engineering new computer hardware and women were the original coders and developers; that is, until men discovered the important role software played and the money that could be made. The following sections in this historical review are organized chronologically (Figure 1.1).

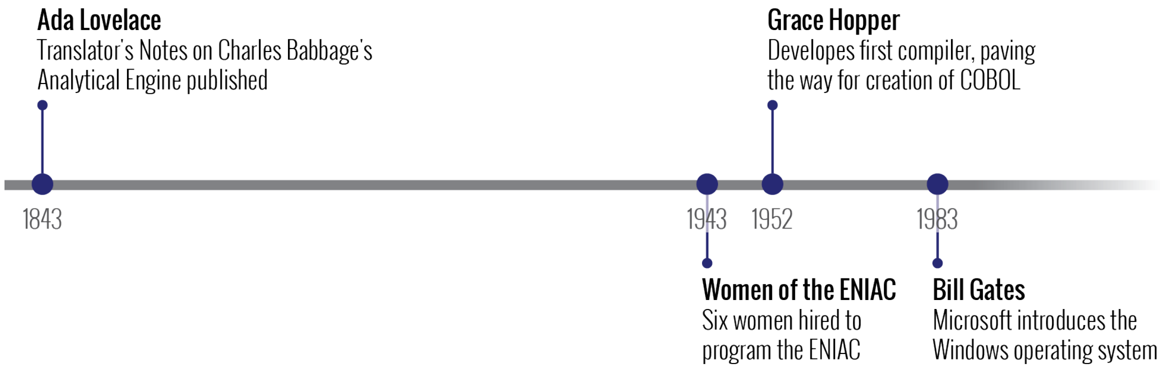

Figure 1.1. Abbreviated historical timeline of women in computing.

Ada Lovelace. It is unknown to many that the founding father of computer programming is not a founding father at all, but rather a founding mother. Ada Lovelace was the only legitimate child of the Lord Byron, a renowned English poet during the Romantic period (1800 – 1850). The Romantic era was noted for its excesses, passion, and aesthetics and was a direct contradiction to the burgeoning Industrial Revolution. Ada's mother, Annabella, feared her daughter would inherit her father's proclivities towards Romanticism and its excesses and left Lord Byron when Ada was still an infant (Isaacson, 2014). Annabella also did her best to redirect Ada's energies away from subjects associated with the Romantic period and instead directed Ada towards mathematics (Isaacson, 2014). At 18, Ada proclaimed, "I find that nothing but very close and intense application to subjects of scientific nature now seems to keep my imagination from running wild. … It appears to me that the first thing is to go through a course of Mathematics" (Isaacson, 2014, pp. 13-14).

During this time Charles Babbage, a mathematician, engineer, and inventor had in 1822, developed a precursor to the computer called the Difference Engine, which mechanized the process to calculate polynomial functions (Isaacson, 2014). Over a decade later Babbage published detailed instructions proposing a more general purpose "computer," the Analytical Engine that could perform multiple operations (Isaacson, 2014). The work was published in Italian and Ada took it upon herself to translate the work into English (Isaacson, 2014). Babbage encouraged Ada to add her own notes to the publication, which are now known as "Notes by the Translator" or the "Notes" (Isaacson, 2014). In one of Ada's "Notes" she described an algorithm that could compute Bernoulli numbers, and is considered by many to be the first published algorithm written specifically for implementation on a mechanical device or computer (Simonite, 2009).

Beyond the algorithm, Ada explored "concepts that would have historical resonance a century later when the computer was finally born" (Isaacson, 2014, p. 25). Ada recognized that machines like the Analytical Engine could be programmed and reprogrammed and were not limited to processing a single preset task (Isaacson, 2014; Thompson, 2019). She also saw beauty in mathematics and numbers. In her "Notes," Ada described that machines like the Analytical Engine, could perform operations on anything that could be expressed using symbols (Isaacson, 2014; Thompson, 2019). Nowadays we see firsthand what Ada imagined; content of all sorts, such as text, images, audio, and video, can be expressed digitally and manipulated by modern computers. In addition, Ada recorded step-by-step instructions on how the Analytical Engine could be programmed to carry out complex Bernoulli calculations, including breaking down the process into smaller chunks that could be infinitely reused (Isaacson, 2014). Today, computer scientists would recognize what Ada wrote as computer programming. Software, operating systems, and applications for digital devices are created by writing step-by-step instructions using coding languages, including reusable sequences now known as subroutines.

It is important to note that while Ada Lovelace's contributions to computer science are significant, it was only recently that she has become recognized as the "first computer programmer." When Ada published her "Notes," Babbage had asked her why she had not written her own original manuscript to be published (Isaacson, 2014). She responded that it had not occurred to her, because scientific and academic publications written by women, especially those in the natural sciences and mathematics were extremely rare (Isaacson, 2014); the "Notes" were considered to be a more acceptable contribution by a woman. Furthermore, Ada chose to use only her initials, A.A.L., to sign the translation and "Notes," most likely to increase the potential for publication and acceptance among the male-dominated scientific community.

Computing Was Women's Work. From the invention of computer programming, to the computing and programming efforts in World War II and the Great Space Race of the 1960s, women have had a long history in computer science; however, their contributions have been undervalued and often hidden in the shadows. From World War II through the 1960s women made up the majority of the technically trained workforce in computing (Hicks, 2017). During this time, women were programmers and mathematicians; they operated computers, cracked codes, calculated complex equations, and collected data (Hicks, 2017). Despite the cognitive and analytical nature of the work, computing was considered rote, menial and unskilled labor — “women’s work” — making the jobs simultaneously critical (e.g. to the success of World War II and the Space Race) and devalued (Hicks, 2017; Mundy, 2017). These women were more than low-level drones and a cheap labor pool they were perceived to be; they made significant contributions to the advancement of computing.

Women of ENIAC. Wide gaps were left when the men of America left for Europe and Japan during World War II (1941 – 1945) and women flocked to fill positions working in the shipyards and the aircraft industry and producing munitions and other war supplies. When most Americans think about women’s contributions to World War II, images of Rosie the Riveter (https://www.history.com/topics/world-war-ii/rosie-the-riveter) often come to mind; however, another lesser-known movement was happening at the same time. Soldiers needed to know the correct firing-angle settings for the various artillery being used, which meant factoring in hundreds of conditions such as temperature, humidity, and different types of gunpowder (Isaacson, 2014). “Creating a table for just one category of shell shot by one gun might require calculating three thousand trajectories from a set of differential equations,” and a single firing table could take more than one month to complete (Isaacson, 2014, p. 72). The trajectory equations were calculated by a combination of mechanical machines and by more than 170 human “computers,” most of which were women (Isaacson. 2014). To complete this herculean task, women with degrees in mathematics were recruited from around the nation as illustrated in the following text from a 1942 U.S. Civil Service advertisement in *The Philadelphia Inquirer*:

Wanted: Women With Degrees in Mathematics.
Women are being offered scientific and engineering jobs where formerly men were preferred. Now is the time to consider your job in science and engineering.

In June 1943 the construction of the Electronic Numerical Integrator and Computer, or ENIAC, began and six women (Frances Bilas, Jean Jennings, Ruth Lichterman, Kay McNulty, Betty Snyder, and Marlyn Wescoff) were hired to operate and program the new computing machine, which was able to calculate a single trajectory equation in roughly 100 seconds (Isaacson, 2014). The women underwent six weeks of training where they were given wiring diagrams for each of the ENIAC's panels and according to Kay McNulty, they were instructed to use the diagrams to "figure out how the machine works and then figure out how to program it" (Isaacson, 2014, p. 98). Lichterman and Wescoff can be seen reprogramming the ENIAC in Figure 1.2. The problem with early computers, including the ENIAC, was despite their enormous size they lacked the space to store the programs. Some of the equations needed to calculate certain trajectories were too large for ENIAC, so the women devised a way of reusing and repeating sections of their programming (Isaacson, 2014; Thompson, 2019) — what are now referred to in computer programming as subroutines. This revelation caused the women of the ENIAC to shift their thinking into more modular ways of designing and developing programs, which is still an essential element in modern day programming.

The type of computer operation and programming work performed by the women of the ENIAC, and others like them, was considered to be routine, menial, and not that different than secretarial work (Hicks, 2017; Isaacson, 2014; Thompson, 2019). Women were hired because the importance of what they were doing was not recognized. Furthermore, male managers believed the women would leave as soon as they were married and had children, meaning there was no worry about demands for promotion or higher wages (Hicks, 2017). In the early days, computer programming was therefore perceived as a feminine profession and was not a desirable career track for men. Jean Jennings, one of the women who worked on the ENIAC, summed it up best when she said, “If the ENIAC’s administrators had known how crucial programming would be to the functioning of the electronic computer and how complex it would prove to be, they might have been more hesitant to give such an important role to women” (Isaacson, 2014, p. 100). In many ways Jennings was correct. By the 1970s and 1980s as computers were becoming smaller, more affordable, and ubiquitous, women were being pushed out of computing because “the government and industry had grown wise to just how powerful computers were” and they were not going to put women in charge (Brewer, 2017).

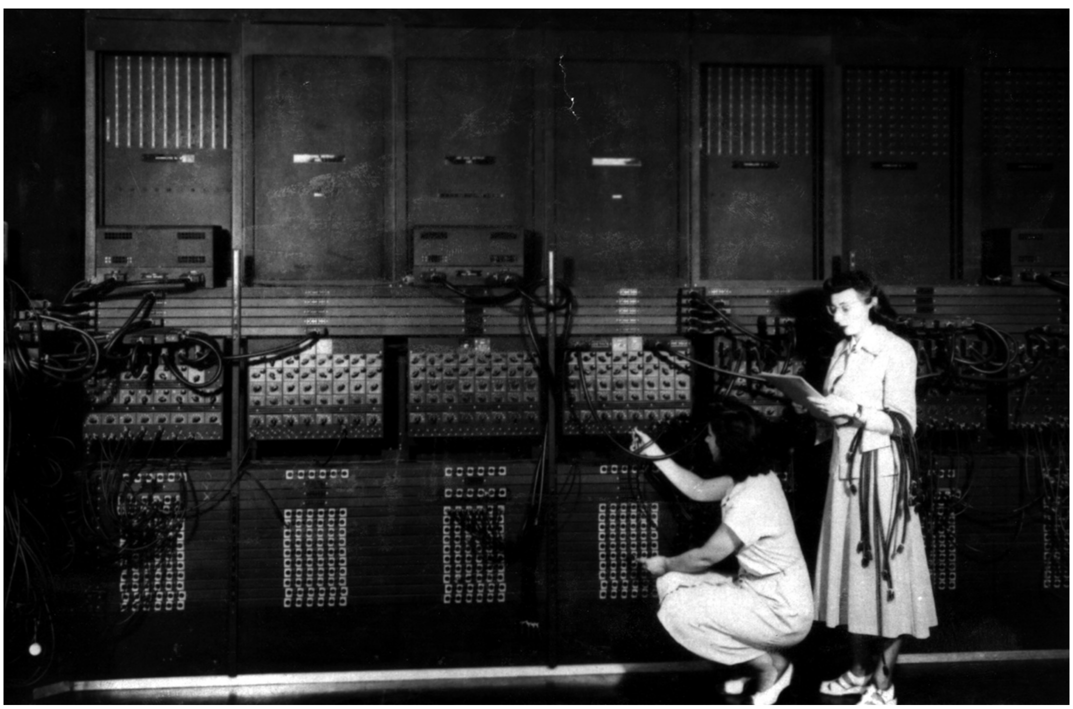

Figure 1.2. Reprogramming the ENIAC. This photograph shows Ruth Lichterman (left) and Marlyn Wescoff (right) wiring a new program into the ENIAC (U.S. Army, 1946).

Grace Hopper. According to Walter Isaacson (2014), "[t]he most colorful programming pioneer was a gutsy and spirited, yet also charming and collegial, naval officer named Grace Hopper" (p. 88). Grace Hopper and Ada Lovelace shared a similar vision in that idea that the real locus of power was in programming computers, not in the hardware. Hopper graduated with a degree in math and physics from Vassar and went on to Yale, where in 1934 she earned her Ph.D. in math — only the 11th woman to do so since 1895 (Isaacson, 2014). She taught mathematics at Vassar, and in 1941 was studying in New York when the Japanese attacked Pearl Harbor, inspiring Hopper to join the U.S. Navy at the age of 36 (Biography.com Editors, 2017). Because of her mathematics background she assumed she would be assigned to a cryptography and code group, but was instead assigned to Harvard University where she learned how to program the Mark I, a behemoth digital computer conceived of by Howard Aiken and developed by IBM (Isaacson, 2014).

After World War II, Hopper made several significant contributions to computing and computer programming in her continued work as a research fellow at Harvard University. She served as the primary programmer of the Mark I as well as Aiken's top deputy on the project. Hopper described her approach to programming as systematic; she broke down every equation or problem down into small arithmetic steps, many of which could be reused (Isaacson, 2014; Thompson, 2019). Like Ada Lovelace and the women of the ENIAC, Hopper also devised reusable subroutines that could be stored once and called up by the Mark I when needed at different points of the main program; a common practice in modern computing. In addition to creating subroutines that could be reused by the same computer, Hopper also developed the concept of a compiler, which allowed multiple machines to run the same program by translating the programming source code into the specific machine language (Isaacson, 2014; Thompson, 2019). The compiler served as the precursor to the Common Business Oriented Language, or COBOL (Biography.com Editors, 2017), the first portable standardized business language for computers that was written in an English-like language. The development of COBOL brought together Grace Hopper, who served as the technical lead and two of the ENIAC programmers, Betty Snyder and Jean Jennings ("COBOL," n.d.; Isaacson, 2014; Thompson, 2019).

Women Are Pushed Out of Computing. Ada Lovelace, the women of the ENIAC, and Grace Hopper all recognized something that the men of their time did not; it was programming and not hardware, where the true value of computing resides (Mundy, 2017). It was not until the late 1970s and early 1980s, when Bill Gates came along, that perceptions towards computer programming and software shifted. In the mid 1970s Bill Gates and Paul Allen were developing software that made it "possible for hobbyists to create their own programs on the Altair" (Isaacson, 2014, p. 332), an early computer that was sold as a kit that required assembly. In a move unheard of at the time, in their agreement with Micro Instrumentation and Telemetry Systems (MITS), the producers of the Altair, Gates and Allen retained their rights to the software (Isaacson, 2014). MITS did not own the software and instead paid Gates and Allen a licensing fee for its use. By licensing the software and maintaining ownership, Gates and Allen were able to continue refining the software and create versions to run on many types of machines. Their licensing arrangement with MITS set the tone for a similar, but much more lucrative contract a few years later, in 1980, with IBM (Isaacson, 2014). Not only did Gates convince IBM to purchase licenses for their software written in BASIC, COBOL, and Fortran, IBM also hired the fledgling Microsoft to create an operating system for their computers (Isaacson, 2014). The operating system they licensed to IBM was MS-DOS, and was later replaced by Microsoft Windows, which is now used by more than 2 billion people around the world (Microsoft, 2018). In addition, according to the Microsoft 2018 annual report, Microsoft generated more than $110 billion in revenue and its founder, Bill Gates is now one of the richest people in the world at a net worth of approximately $86 billion ("The World's Billionaires," n.d.). To further demonstrate the profitability and perceived power of technology, particularly software, in our current society, five out of ten of the richest people in the world come from the technology sector and all are men. Those men are Jeff Bezos (founder and CEO of Amazon), Bill Gates, Larry Ellison (co-founder of software firm, Oracle), Mark Zuckerberg (co-founder and CEO of Facebook), and Larry Page (co-founder of Google), with a cumulative net worth of over $403 billion ("The World's Billionaires," n.d.).

Today's Crisis

The notion that programming is a menial task and was therefore, relegated as "women's work" is a thing of the past. By the 1980s, when it became obvious that software not hardware was more lucrative (Isaacson, 2014; Mundy, 2017), women were "systematically phased out and replaced by men who were paid more and had better job titles" (Brewer, 2017). Women currently make up just over one-quarter of all computing professions in the United States (Funk & Parker, 2018; National Science Board, 2018) — a number comparable to that of 1960. What is worse is that the percentage of women entering computing fields peaked in 1984-85 at 37 percent (Funk & Parker, 2018; "The Current State of Women," 2019).

Since the beginning of the 21st century, the number of women enrolled in college in the United States surpassed that of men (Goldin, Katz, & Kuziemko, 2006) and according to most recent statistics women now make up 57 percent of college students (National Science Board, 2018). Despite this, women comprise only 20 percent of graduates with associate's degrees in computer science and 19 percent of graduates who received bachelor's degrees ("Digest of Education Statistics," 2018). While the number of women earning bachelor's degrees in computer science has increased since the early 2000s, the overall proportion of women seeking computer science degrees has decreased (Trapiani & Hale, 2019). This proportional decline occurred because the number of men pursuing computer science degrees has also increased, but at a much "faster rate than the number of women, resulting in an overall decline in women's share from 28% to 19%" (Trapiani & Hale, 2019). Therefore, even though efforts to increase the number of women in computer science have seen some success, women are still at a net loss and the ratio of women in computer science is lower now than even 15 years ago.

The underrepresentation of women in computing does not end at graduation. Of the women who graduate with a bachelor's degree in computer science, only 38 percent of them are employed in the field compared to 53 percent of men (Funk & Parker, 2018). Furthermore, women are roughly twice as likely to leave careers in computing by mid-career than men (Hewlett, & Sherbin, 2014; NCWIT, 2019; Thomas, 2015). Depending on the source, the percentage of women who leave computing careers ranges from 41 percent (Thomas, 2015) to 56 percent (NCWIT, 2019). This is substantially higher than the approximately 17 percent of men who leave computing careers (Thomas, 2015).

The "culture of tech" is frequently cited as one of the primary reasons for a lack of women in the industry (Behrens, 2017; DeNisco Rayome, 2017; Grunspan, et al., 2016; Margolis & Fisher, 2002; Mundy, 2017; Lopez, M. H., & Gonzalez-Barrera, 2014; Morris & Daniel, 2008; Riegle-Crumb, King, Grodsky, & Muller, 2012). But what is the "culture of tech" and why does it deter women? As stated previously, only one-quarter of all people employed in the computing and technology sectors are women; therefore, it is appropriate to say that it is a male-dominated field. This is true for enrollment in colleges and universities as well, where the percentage of women is even lower than those working in the industry. Reshma Saujani, founder of Girls Who Code (https://girlswhocode.com/), addressed the gender disparity issue in the technology sector this way:

> We cannot be what we cannot see, and we can't expect our girls to aspire to be something that they don't see themselves in. And so culture, I think, is the number one reason why you have this massive decline. It's not about aptitude" (Behrens, 2017, para. 10).

Saujani's thoughts are supported by Leaper (2015), who found that women who interacted with same, or similar field female experts, were more likely to self-identify as "fitting" in and therefore, also more likely to exhibit stronger levels of commitment to careers in STEM.

Stories of sexual harassment and discrimination coming out of Silicon Valley, the center of technology in the United States, has unfortunately become commonplace. According to a 2015 study called "Elephant in the Valley," women reported experiencing more subtle demeaning microagressions such as being asked to make coffee, ordering food, etc. that male colleagues have not been asked to do and male clients and colleagues making eye contact with or deferring to other men in the room instead of the female with the expertise or authority to more egregious claims of sexual harassment, sometimes even to the point of women feeling unsafe in their workplace (Vassallo et al., 2015). Similarly, in a nationwide study, 74 percent of women in computer-related professions, such as software development or data science, have experienced some form of discrimination because of their gender, ranging from earning less for the same work, being treated as incompetent, and receiving less support from their superiors (Funk & Parker, 2018). These types of reports are likely a deterrent for many young women who may be passionate about technology from pursuing degrees and careers in computing and technology.

Beyond overt issues of harassment and discrimination, more subtle attitudes and behaviors can make the culture of technology a disconcerting place for women. Because the field has been dominated by men for several decades, our society has come to associate being adept at using technology with being male and masculinity and women are perceived as "opposite of the dominant image" (Corneliussen, 2014). Moreover, Greenwald and Banaji (1995) introduced the concept of implicit or unconscious bias, where they argue that much of human behavior is driven by stereotypes we are exposed to everyday. These cultural and societal beliefs and attitudes seep into our individual beliefs without even realizing it, resulting in behaviors based on those unconsciously held values and biases (Cvencek, Greenwald, & Meltzoff, 2011). One example is the attitude commonly expressed by young women regarding math, technology, and science, such as "coding is for boys," or "I just don't do math." Practitioners in some disciplines like computing believe that "raw, innate talent is the main requirement for success" (Leslie, Cimpian, Meyer, & Freeland, 2015, p. 262) and has been exemplified in popular culture as the stereotypical "computer nerd." Individuals who "believe intelligence is an inborn trait (fixed mindset) value proving their intelligence over learning, and are more likely to give up when challenged to avoid failure" (Gorson & O'Rourke, 2019); therefore, if a person is good at computer science s/he is more likely persist. Moreover, since many cultures associate STEM, especially technology and engineering, with men, women may find fields that emphasize inherent brilliance to be inhospitable or "not for them" (Leslie, Cimpian, Meyer, & Freeland, 2015, p. 262). To compound the issue, Grunspan et al. (2016) found that male students tend to perceive fellow male students as more intelligent and underestimate the abilities of women, magnifying the resulting bias.

Gender parity is an essential element in recognizing and supporting equity, but there are also economic reasons — individual and organizational — and reasons regarding innovation that support increasing the number of women in computing occupations. The next section discusses the rationale for gender diversity in school and the workplace.

Gender Diversity Matters

Making computing degrees and industry more inclusive toward women has palpable and direct impact on the lives of women. The U.S. Bureau of Labor Statistics projects that 550,000 of the new STEM related jobs between 2018-2028 will be in computing (U.S. Department of Labor, 2019a), but only ten percent of STEM graduates (male and female) will be in computer science ("Digest of Education Statistics," 2018).

With this kind of discrepancy, there are tremendous opportunities for women to pursue degrees and careers in computing and technology. Furthermore, according to The Hamilton Project (2014), students who graduate with computer science degrees will earn on average 40 percent more during their lifetimes than those with bachelor's degrees not in computer science. The benefits to women and their families are obvious, but at the current graduation rate in computer science and representation within the field, women are missing out on lucrative career opportunities.

From classrooms to boardrooms, studies have shown that improving diversity significantly and positively impacts organizations (Cook & Glass, 2015; Corbett & Hill, 2015; Díaz-García, González-Moreno, & Sáez-Martínez, 2014; Page, 2008; Reguera-Alvarado, 2017; van 't Noordende , 2018; Woolley, Chabris, Pentland, Hashmi, & Malone, 2010). Collective intelligence and performance has been strongly correlated to three factors: (a) the social sensitivity of the group, (b) the group's ability to take turns in contributing, and (c) the proportion of women in the group (Woolley et al., 2010). Groups that included at least one female possessed more collective intelligence than all-male groups; moreover, collective intelligence was more strongly related to the diversity of the group than with the intelligence of individual members (Woolley et al., 2010). Similarly, Díaz-García, González-Moreno, and Sáez-Martínez (2014) argue that gender diversity is positively correlated to radical innovation within research and development teams and likewise, Page (2008) and Ernst and Young (2009) found that diverse groups were better at solving problems than more homogeneous groups. This likely occurs because groups made up of individuals with varying backgrounds bring differing experiences and perspectives. Additionally, based on the findings in the World Economic Forum's Global Competitiveness Report 2018, van 't Noordende (2018) indicates:

> Inclusive environments are usually able to perform better, because each individual is able to bring their authentic self to the workplace. Only when people are comfortable in their workplace does their organization get the best possible results from its workforce (para. 6).

The benefits of gender diversity also improve experiences in the classroom. When co-creation of knowledge is encouraged and each participant is allowed to make significant contributions to the learning, the whole group benefits even when students have unequal prior knowledge (John-Steiner & Mahn, 1996; Palincsar, Brown, & Capione, 1993). Conversely, if some participants are not granted the same power and privilege in co-constructing knowledge, then the outcome becomes a reflection of the actors who possess the power within the activity.

Because the underrepresentation of women in computing is more than just an issue of ratio, and is instead rooted in larger cultural issues, simply increasing the number of women pursuing computing majors and introducing them to programs like Girls Who Code and Women Who Code is not going to solve the problem. It is a good start, but it is only treating a symptom. We must understand the underlying cause(s) before real and tangible changes can occur. In order to do that, we must examine what is happening in college and university computing-related programs where the recruitment of women, and not retention, has been the primary focus. It is crucial to dig deeper into and understand the experiences of women pursuing (and often prematurely leaving) these degree programs, which is the primary focus of this dissertation.

Organization of Chapters

In the following chapters, I review and discuss the current literature related to gender and technology and the methodology that will be used to conduct the proposed research. In Chapter 2, I provide information about my interest in the gender disparity issue within the computing and technology fields. The chapter then illuminates some of the issues surrounding the reasons why women are abandoning computing majors in college and what some institutions have done to try and reverse the trend. In the final sections I review literature about sociocultural theory and sense of belonging, the conceptual frameworks that guide my research. In Chapter 3, I discuss epistemological paradigms, the research context, and methodologies that were used to construct my case study and analysis. Chapter 4 furnishes contextual and background information for this case study in part by describing the gender distribution of students at North Central University (NCU) within the College of Science, Technology, Engineering, and Mathematics (CSTEM) and within individual programs of study. In addition, the chapter provides profiles of the program directors and the female students who participated in the study. In Chapter 5, I present each of the seven themes that manifested from the data analysis. The themes describe the women's layered and interrelated experiences as students in a computing-related major. Finally, in Chapter 6 of this dissertation, I discuss conclusions, limitations, and implications for the research findings including recommendations on how to improve sense of belonging among female students.

CHAPTER 2

LITERATURE REVIEW

> *Right now, fewer than one in five bachelor's degrees in engineering or computer science are earned by women. Fewer than three in 10 workers in science and engineering are women. That means … half our team we're not even putting on the field. We've got to change those numbers. These are the fields of the future. This is where the good jobs are going to be.*
>
> President Barack Obama, May 27, 2014, White House Science Fair

The annual White House Science Fair (WHSF), started in 2010 by President Obama, served as a demonstration of his commitment to science and math education. In particular, the WHSF worked to engage children from historically underrepresented populations in the fields of science, technology, engineering, and math (STEM), including girls. All of this attention on encouraging youth, especially underrepresented populations to pursue careers in STEM, is bolstered by projections from the United States Department of Labor. Looking specifically at computing- and technology-related fields, the U.S. Department of Labor (2019b) expects growth rates of 21, 13, and 5 percent in the areas of software development, web development, and computer networking respectively between 2018-2028. Predictions of significant job growth may provide some insight as to why there has been an explosion of academic initiatives, online applications, and out-of-school efforts encouraging youth, especially girls, to learn how to code (e.g. Hour of Code - https://hourofcode.com/, Girls Who Code - https://girlswhocode.com/, Black Girls Code - http://www.blackgirlscode.com/, Women Who Code - https://www.womenwhocode.com/).

The decline in women in computing and technology fields combined with the increasing need for people with these skills in the workforce are the primary reasons why coding and technology initiatives for girls and other underrepresented youth have popped up all over the United States. These initiatives are receiving a fair amount of media attention because they are effective at capturing the attention of youth from a wide breadth of backgrounds, especially those in elementary through high school. I am an advocate of such initiatives because they do generate interest; however, a larger issue remains. Young women are not choosing to pursue computing-related majors in college at a rate one would expect based on the increased efforts in elementary through high school. An analysis comparing the number of boys and girls who took the 2013 Advanced Placement (AP) computer science exams discovered that boys outnumber girls almost 4:1 (Kurtzelben, 2014) and this ratio has not shifted significantly since then (Ericson, 2019). As an overall, more girls took Advanced Placement (AP) exams than boys in 2018 (Ericson, 2019). Despite the 11 percent increase in the number of girls who took the AP Computer Science A and AP Computer Science Principles exams since 2014, girls are still only 28 percent of all students who took the exams and the ratio of women who passed the two exams is even smaller ("2019 State of Computer Science Education," 2019; Ericson, 2019). "Somewhere between middle school and high-school graduation, girls' interest in tech peaks and wanes" (Cereijido & Selyukh, 2016). And of the young women who do opt to pursue a post-secondary degree in technology, they are nearly two times more likely to change majors to a non-STEM area of study once they begin coursework (Cohoon, 2001; Cohoon, 2002; Main & Schimpf, 2017; Margolis, Fisher, & Miller, 2000; Margolis & Fisher, 2002; Morris & Daniel, 2008; White & Massiha, 2016).

This “leaky pipeline” causes issues down the road when companies are looking to hire qualified workers. According to Code.org, a non-profit organization “dedicated to expanding access to computer science, and increasing participation by women and underrepresented minorities” there are over 500,000 computing jobs available in the United States, and only about 43,000 people graduating with computer science degrees and entering the workforce (“Promote Computer Science,” n.d.). Of those graduating with computer science degrees, only 19 percent of bachelor’s degrees and 20 percent of associate’s degrees are earned by women (“Digest of Education Statistics,” 2018). And according to the U.S. Department of Labor, this gap is only going to increase as approximately another half million technology jobs will be created by 2020, especially in areas such as cyber security, software and application development, and systems design (Lockard & Wolf, 2012).

The purpose of this chapter is to provide a rationale for and demonstrate the importance of my dissertation research as well as to contribute to the growing knowledge base regarding gender and technology. More specifically, this research seeks to gain insight into the experiences of women in computing majors, including the experiences of women who have switched to majors outside of computing. First, I use literature to explain my conceptualization and definition of gender. In the next section I discuss the current enrollment and attrition landscape of women in computing majors. Then I present reasons motivating women to abandon computing and technology related majors, such as low confidence, lack of peer support and role models, conceptions of what it means to “be technical,” and the pervasive male-dominated and geek cultures. This section is followed by a discussion on the actions taken by colleges and universities, organizations, and industries to slow down the rate of attrition by women and even reverse this downward trend. Finally, two conceptual frameworks for this dissertation are identified and discussed — sociocultural theory and sense of belonging.

Gender

Gender, which is at the root of this research, is a complex topic. Proponents of essentialism believe that biological make-up is a significant influencer in shaping how men and women behave, and that culture and social interaction have little impact. “Consequently, essentialism studies generally conclude that men relate to technology in differing and opposing ways from those of women” (Frieze, Quesenberry, Kemp, & Velázquez, 2011, p. 426). For example, many feel that men are naturally “hardwired” to understand math and technology; however, Barnett and Rivers (2004) have empirically demonstrated that the idea that men are biologically hardwired to be better at math is fallacious. Instead, I believe that gender is a social, cultural, and psychological construct, and any differences between genders (e.g., interests, aptitude, and intelligence) are a result of artificially created dichotomies or “relationality” (Glenn, 1999). Relationality argues that the dominant race or gender in a society or culture relies on contrasts in the formation of identity (Glenn, 1999). For example, if masculine identity is defined as being rational, logical, hard, and physically strong, then femininity must be defined by “what is not male,” in other words emotional, illogical, soft, and physically weak. Over time, these “taken-for-granted practices and assumptions make domination seem natural and inevitable to both the dominant and subordinate” (Glenn, 1999, p. 13), such has become the case in the computing and technology sector. Because gender is socially constructed, we must also accept that the experience of gender is not “the same in different times, places, and cultures, or homogeneous even within one time, place, and culture" (Lemke, 2001, p. 308). Finally, if culture, not biology dictates gender then it is logical to infer that there is no inherent predisposition for certain skills or aptitudes and both men and women are equally capable of succeeding in computing and technical fields.

The Attrition Problem

Since the 1990s the number women enrolled in college has surpassed that of men (Lopez & Gonzalez-Barrera, 2014), with women earning approximately 57 percent of all bachelor's degrees granted in the United States. However, men earn more degrees in engineering, computer science, mathematics, statistics, and physics than women, whereas women tend to pursue more degrees in the biological, agricultural, social sciences, and psychology (National Science Board, 2018). According to the 2018 Science and Engineering Indicators Report (National Science Board), the proportion of women who declare a computer science major when first enrolling has remained relatively unchanged at about 20 percent since the 1990s. Despite that, the gender gap during this time period has widened as the proportion of women who actually complete a computer science bachelor's degree has dropped from 28 percent to just under 18 percent (National Science Board, 2018). The 10 percent decrease in women pursuing computing degrees is serious and especially troubling because the number of women entering computer science fields is significantly lower than men to begin with. Sherman (2015) found that as students prepare to graduate high school and enter college, one out of five men plan to pursue degrees in engineering or computing, but only one in seventeen women make the same claim. Even more troubling than the low numbers of women entering computer science is that women are about twice as likely to switch to majors to something outside of computing and technology than their male counterparts (Cohoon, 2001; Cohoon, 2002; Main & Schimpf, 2017; Margolis, Fisher, & Miller, 2000; Margolis & Fisher, 2002; Morris & Daniel, 2008; White & Massiha, 2016). This means that not only are men five times more likely than women to pursue degrees in computing in the first place ("Digest of Education Statistics," 2018; Singh, Allen, Scheckler, & Darlington, 2007), the women who do declare majors in computing are roughly two times more likely to leave the major, thus reducing their numbers even further (Chen, 2013). By the time students reach college graduation women are greatly outnumbered by men (Corbett & Hill, 2015; White & Massiha, 2016) "Women start out so far behind in the number with appropriate majors that they can't regain the ground" (Sherman, 2015). Moreover, the trend continues as women enter the workforce.

Beasley and Fischer (2012) found that women "who had stronger grades in high school were in fact more likely to be early declarers of STEM majors" (p. 444). Moreover, performance and achievement differences between girls and boys in elementary through high school does not provide the necessary clues as to why girls are less likely to pursue computing majors in college. A new study found that there were no differences in brain activity between boys and girls who engaged in mathematical tasks (Kersey, Csumitta, & Cantlon, 2019). In particular, the research provides further evidence "that gender differences in STEM fields in adults are not derived from intrinsic differences in children's brains but likely from a complex environmental origin" (Kersey, Csumitta, & Cantlon, 2019, p. 4). There is no longer any significant disparity in scores on state math and science assessments between boys and girls ("Digest of Education

Statistics," 2018; Riegle-Crumb, King, Grodsky, & Muller, 2012). Moreover, girls typically outscore boys on all subjects, and receive comparable scores in the STEM areas of math and science (Corbett, Hill, & St. Rose, 2008; "Digest of Education Statistics," 2018).

The low number of bachelor's degrees being granted to women in STEM fields is instead more likely due to the academic environment and social interactions that occur while attending college rather than a lack of initial interest upon entering college (Beasley & Fischer, 2012). White and Massiha (2016) support this claim when they reported that women who leave STEM majors tend to do so between their first and second years when they are likely to experience low academic self-confidence, a sense of isolation, discouragement, and a lack of personal identity. The authors also make clear that the women's lack of self-confidence was not correlated with their actual academic performance or grade point average (White & Massiha, 2016). Moreover, White and Massiha (2016) also found that "[w]omen tend to rate themselves as less capable problem solvers" than their male counterparts and also tend to "internalize failure and credit others with their success, males (particularly White) tend to do the opposite" (p. 2). Sense of belonging and interpersonal affiliation with others within a desired social, or in this case, academic group, are also influential with regard to retention (White & Massiha, 2017). Therefore, a puzzle remains. What is happening that results in a disconnect between women and computer science? What happens after women enter college that makes them feel isolated or that they do not belong that ultimately drives them away from pursuing a degree in computing?

Some have speculated that young women may not be as prepared to enter computing as their male counterparts (Beasley & Fisher, 2012; De Weld, Laursen, & Thiry, 2007; Margolis, Fisher, & Miller, 2000; Margolis & Fisher, 2002; "The Current State of Women," 2019), which can lead to frustration, a loss of interest, and ultimately a decision to leave the major. According to the 2019 State of Computer Science Education report, only 45 percent of high schools in the United States teach computer science courses and those "courses still lack women and underrepresented minority students" (p. 4). This is significant because it has been shown that students who take high school computer science courses are more likely to take the Advanced Placement computer science exams and pursue computer related majors in college for both men and women (2019 State of Computer Science Education, 2019). In addition to academic training, informal, prior hands-on computing experience may also be advantageous in preparing women for a major in computer science. For example, Margolis and Fisher (2002) reported:

> About three-quarters of the men in [their] study fit the profile of someone who was magnetically attracted to computers when they were quite young and spent much of their youth consumed with computing. Among the women, in contrast, only about one-quarter fit the profile (p. 19).

Women may enter college highly qualified and competent, but they do not "dream in code" (Margolis & Fisher, 2002, p. 5) like their male classmates or feel that they have a natural aptitude for computing (Gorson & O'Rourke, 2019). While still in high school both male and female students may have taken computing and coding classes, but the boys in those classes were more likely to have spent endless hours learning everything they could about computers outside of class (Margolis & Fisher, 2002). Gorson and O'Rourke (2019) found that novice computer science students tend to perform frequent self-efficacy appraisals and judge ability on perceived prior experience, speed of typing/coding, memorization of syntax, and grades. Based on these findings, female students may perceive their male classmates as being more capable of learning computer science because of previous experience and knowledge of computer coding. These misperceptions may negatively impact female students' self-assessments of their own abilities, which in turn can contribute to their decision to persist or not. Furthermore, upon entering college, young men would be more apt to find same-sex classmates who they can relate to and turn to when they want to learn even more (Margolis & Fisher, 2002) or to demonstrate their own expertise (Gorson & O'Rourke, 2019). The "dominant culture of 'this is how you do computer science,'" (Margolis & Fisher, 2002, p. 72) as well as being surrounded by men who 'live and breathe computing' can lead to misaligned perceptions of their own abilities (Gorson & O'Rourke, 2019), which in turn can be intimidating, especially for women who may not experience computing the same way.

There does not appear to be any one definitive reason why women are leaving degree programs and careers in computer science, but some suggested reasons include the dominant male hegemony, preconceived notions about what it means to "be technical," (i.e., geek stereotype), stereotype threat (Steele & Aronson, 1995), low confidence, and a lack of female peers and role models. "Stereotype threat occurs when individuals fear that they will confirm a negative stereotype about a group to which they belong" (Corbett & Hill, 2015, p. 3). Research has shown that individuals of a minority group (e.g., women in computing) unconsciously succumb to outside pressures and underperform on aptitude tests, other performance-based activities, and major life experiences (Beasley & Fischer, 2012; Marx, Brown, & Steele, 1999; Steele & Aronson, 1995). Unconscious bias and stereotype threat can also shake women's confidence, causing them to feel as if they are lagging behind their male classmates and doubting their own basic intelligence, ultimately resulting in a loss of interest and discouragement (De Weld, Laursen, & Thiry, 2007; Margolis & Fisher, 2002; "The Current State of Women," 2019).

A lack of female role models, such as professors and industry leaders, and same-sex peers can also erode confidence and academic performance (Cohoon, 2006; "The Current State of Women," 2019). Faculty are common and convenient role models for university students. Regular interactions between faculty and students, regardless of gender, have been positively associated with student confidence, motivation, college performance, GPA, and retention (Kim & Sax, 2018). Similarly, Herrmann et al. (2016) reported that female students who have female role models, especially those who have overcome challenges and can help normalize feelings of isolation and exclusion, may increase performance and persistence. Furthermore, Stout, Dasgupta, Hunsinger, and McManus (2011) found female students' attitudes toward math and perceived self-efficacy improved when taking a calculus course with a female professor compared to taking a similar course with a male professor. Finally, Cohoon's (2006) nationwide study found that college and university departments with higher proportions of female students experienced higher women's retention rates. In addition to the aforementioned reasons as to why women disengage from pursuing degrees and careers in computing, the male-dominated technology culture, discussed in the next section, is also a major contributor to the lack of women in computing fields.

Male Hegemony and Technology Culture. Culture has been characterized as a group of people who share a complex system of knowledge, beliefs, behaviors, attitudes, symbols, and meaningful traditions and artifacts (Fine, 1987; Frieze, Quesenberry, Kemp, & Velázquez, 2011; Hirst & Manier, 1995; John-Steiner & Mahn, 1996; Lemke, 2001; Reiss, 1981; Scribner & Cole, 1981). Furthermore, Fine (1987) goes on to state that small groups can form micro-cultures based on shared experiences that "serve as a bases of further interaction" and "with the expectation they [the experiences] will be understood by other members" of the group (p. 125). Micro-cultures also develop distinct attitudes and assumptions about how members of the group perceive and interact with the social and physical world (Leaper, 2015; Reiss, 1981). The group paradigms are maintained and modulated through continual interaction and use of recognized and acceptable tools, signs, and symbols within the micro-culture.

There is a dominant "geek" or "nerd" culture that is integrally interconnected with computing and technology. Paradigms that define geek/nerd culture are male, white or Asian, super smart, and anti-social or socially awkward who is absorbed in technology (Corneliussen, 2014; Kendall, 2011; Margolis & Fisher, 2002; Margolis, Goode, & Ryoo, 2014; Tocci, 2009). More recently computer geeks have been associated with "hegemonic masculinity, demonstrating the increasing legitimacy of expertise in computers as a form of masculine prowess" (Kendall, 2011, p. 505). Furthermore, geek culture fits with the previous definition of micro-culture in that it has its own language, set of meaningful symbols and artifacts, and its members have shared experiences. Because "computer geeks" and computing have become socially intertwined with being male, women have become the outsiders and being female is not immediately associated with technology. According to Hofstede (1991), “women do not carry the symbols, do not correspond with the hero images, do not participate in the rituals or foster the values” dominant in the micro-culture (p. 16).

Margolis and Fisher (2002) argue that “[t]here is a dominant culture of ‘this is how you do computer science,’ and if you do not fit that image, that shakes confidence and interest in continuing” (p. 72). Leaper (2015) goes on to note that members of a group, or culture may solidify their own standing, or “fit” within a group by “exaggerating their differences with out-group members” (p. 168). Therefore, associating oneself with the pervasive negative computer geeks/nerds stereotypes, such as being “uncool” or socially isolated, may make women interested in computing and technology feel even more marginalized in that they do not “fit” within the male-dominated culture, nor do they “fit” with greater society. The decision to pursue a degree and ultimately a career in computing may feel incongruent with their broader social identity (Elmore & Oyserman, 2012).

In order to attract more girls and women into computing and technology, the micro-culture and perceptions of computing must shift so that there are multiple ways to “do” and “be” in computing. According to Lemke (2001), we must also recognize a much wider range of computer uses and computer learning that fits “with the lives and identities of a much larger fraction of the population” (p. 308). When a culture is able to shift in ways that encourage individuals to incorporate their own values into the greater community, those who may have been excluded are no longer forced to choose between one set of cultural values and another. These types of inclusiveness and the resulting interactions are “central and necessary to learning” (Lemke, 2001, p. 296) and for attracting divergent members to the community. Additionally, learning environments that are interest based and are less concerned about one way of performing certain activities become more inclusive and students become more engaged (Ito et al., 2013).

"STEM-ming" the Leak

Colleges, universities, and industry acknowledge that there is a significant gender gap in the technology sector and that this issue is getting worse. From the launch of organizations like Girls Who Code to the inception of conferences and organizations designed to provide peer support for women in the industry to changing recruiting efforts and curriculum, actions are finally being taken to reverse the trend. One of the most prominent organizations is Girls Who Code, which was founded in 2012. Girls Who Code (2019) focuses on girls in elementary through high school and offers after school programming and multiple seven-week summer immersion camps. Their most recent endeavor is reaching out to young women on college campuses to start student organizations supported by Girls Who Code (2019). The mission of Girls Who Code (2019) is to close the gender gap in technology, change attitudes of what computer scientists look like, and generate a supportive community of girls and women. According to their website, alumni of the Girls Who Code (2019) clubs are 15 times more likely than the national average to pursue degrees in computer science or technology related degrees. In 2011, a similar, but lesser known non-profit organization, Black Girls CODE (2018), was founded to specifically teach pre-teen and teenage girls of color computer programming and in-demand technology skills. Black Girls CODE (2018) offers workshops and after school programs in seven cities across the United States specifically serving underprivileged girls in an effort to close not only the gender gap, but the digital divide.

In addition to various computing and technology organizations aimed at increasing computing and technology interest in girls, CSforALL (2019) is a nationwide consortium of individuals and organizations working to build opportunities computer science curriculum in K-12 schools. The consortium was launched in 2016, with the mission of making computer science an integral part of school curriculum and to support student pathways into technology and computing careers (CSforALL, 2019). CSforALL (2019) is not specifically focused on girls but rather is a more holistic approach, working to ensure that all students, regardless of gender, color, or socioeconomic status have the opportunity to learn valuable computer science related skills that they feel are "necessary for economic opportunity and social mobility" (para. 5).

While the greatest attention has been on attracting girls and underrepresented minority youth into computer science and technology education, there has been little focus on transitioning these young people to college, much less retaining them once they get there. The National Center for Women and Information Technology (NCWIT) is one organization that works with education and industry partners to increase the number of women in the tech sector and seeks to improve women's participation in the field. NCWIT (2109) has built an alliance of colleges and universities who support their mission, establish goals for increasing the number of women pursuing computing and technology degrees, and share research and pedagogical practices on how to improve retention. The alliance provides the resources, but the efforts to retain college women pursuing technology degrees is still up to the faculty and administration at the individual institutions.

AnitaB.org is one of the most notable organizations when it comes to building a community of women technologists. The organization has been around since 1994 when Dr. Anita Borg established The Institute for Women and Technology — now known as AnitaB.org (2019). Borg was a renowned computer scientist and zealous advocate for advancing women in technology (AnitaB.org, 2019). In 1994 Borg also co-founded the Grace Hopper Celebration, an annual event that recognizes and brings to the forefront the research and career interests of women in technology. The Grace Hopper Celebration — named after Grace Hopper, a pioneer in computer programming and computer science — provides peer support, networking, and mentoring opportunities for women at every career stage and in 2019 was attended by 26,000 women from around the world (AnitaB.org, 2019).

Finally, a number of top colleges and universities around the United States have made efforts to attract women by revamping introductory courses, trying to recruit more female faculty, and adding peer support. For example, two institutions, Carnegie Mellon University and Harvey Mudd College, have seen significant increases in female enrollment in their computer science programs.

Carnegie Mellon University. Margolis and Fisher (2002) began their examination of the gender gap issue in a longitudinal study of Carnegie Mellon University’s computer science department from 1995 – 1999. During that time, they conducted multiple interviews with 51 female and 46 male computer science undergraduate students (Margolis & Fisher, 2002). The primary focus of the investigation was to understand the experiences, interests, and decisions to persist or leave the program from the perspective of the students (Margolis & Fisher, 2002). As a result of Margolis and Fisher's (2002) research, Carnegie Mellon's computer science department made a number of changes to their curriculum, teaching, and culture.

The curriculum was the first of the changes instituted at Carnegie Mellon in 1999 before the conclusion of their study (Margolis & Fisher, 2002). Fisher and Margolis (2002) found there were differences in computing experiences between men and women upon entering the computer science program. Instead of offering only one introductory computer science course, which had been the norm up until this point and may have been off-putting to individuals with less computing experience, Carnegie Mellon's computer science department provided first-year students with options targeted to experience level (Margolis & Fisher, 2002). The department created a "discovery-based, real-world orientation with an introduction to programming" for those students with less experience, providing them the necessary skills to "catch up" with their more experienced peers (Margolis & Fisher, 2002, p. 130). At the same time, a more advanced introductory course for students with more experience was also offered. The "changes increased levels of satisfaction among both more and less experienced students of both genders and indeed seemed to result in the smooth integration of the less experienced into the remainder of the curriculum" (Margolis & Fisher, 2002, p. 130).

In addition to changing the curriculum, Carnegie Mellon's computer science department also changed *who* taught the introductory courses. Historically, entry-level courses were taught by less experienced instructors or graduate students, and the "better, more experienced, and more senior teachers" taught the high-level courses (Margolis &

Fisher, 2002, p. 131). Margolis and Fisher (2002) found that the introductory courses were where women were more likely struggling; therefore, the decision was made to assign the more experienced and better teachers to the entry-level courses. In addition to changing the instructors' teaching assignments, the department provided context for computer science by situating technology into real-world settings and making the connections between computer science and other disciplines more evident, which was something Margolis and Fisher (2002) found resonated with and was appealing to the female students.

One of the other key areas where change was needed was in altering the perceptions and culture surrounding computer science. Individuals inside and outside of computing and technology tend to possess many preconceived notions about those who practice and work in computing and technology. The stereotype of the "intense hackers" (Margolis & Fisher, 2002, p. 133) who are super intelligent, White or Asian males (Kendall, 2011; Margolis, Goode, & Ryoo, 2015) needed to be overcome; therefore, Carnegie Mellon made modest changes to address this culture. One of their efforts was the creation of Women@SCS (Women at School of Computer Science), a faculty-student organization designed to help women make connections across the school that recognizes *"that it is the computer science culture*, (emphasis in original) not the curriculum, that needs to change to accommodate women" ("CMU's Proportion of Undergraduate Women," 2016).

The changes made to the computer science program at Carnegie Mellon had an almost immediate impact. From 1995 - 2000, the proportion of women entering Carnegie Mellon's undergraduate computer science program rose from 7 percent to 42 percent

(Margolis & Fisher, 2002). And almost 15 years later, in 2016, women represent nearly half (48 percent) of all first-year undergraduate students in the School of Computer Science and Engineering ("CMU's Proportion of Undergraduate Women," 2016). Carnegie Mellon attributes its success for attracting high caliber female students into computing and technology to the support of university, college, and department leaders; faculty; staff; and students, as well as strong mentoring programs and intense middle and high school recruitment ("CMU's Proportion of Undergraduate Women," 2016).

Harvey Mudd College. Harvey Mudd College, a small private college in California specializing in the fields of science, engineering, and mathematics, has increased the number and proportion of women graduating from its computing program from 12 percent to approximately 40 percent in five years (Corbett & Hill, 2015). The faculty in the computer science program at Harvey Mudd College found that "students without prior computer science experience do not really understand what computer science is" (Corbett & Hill, 2015, p. 76). Up until 2005, all Harvey Mudd College students took the same introductory computer science class where the course work was too easy for some students and too difficult for others (Corbett & Hill, 2015). Similar to Carnegie Mellon, Harvey Mudd College revised the curriculum of their introductory course. Instead of focusing heavily on Java programming, the new curriculum emphasized the breadth of applications for and social relevance of computer science (Corbett & Hill, 2015). Studies have found that illustrating how computer science knowledge can be applied outside of the field and its relevance to a broader social context particularly appeals to women but can also improve the experiences for all students (Diekman, Clark et al., 2011; Eccles, 2007; Eccles, 2011). In addition, the introductory course shifted to teaching the Python programming language, which is more flexible and forgiving than Java (Corbett & Hill, 2017).

Beyond changes to the curriculum, Harvey Mudd College also made two other significant changes that have had an impact on retention of women in their computer science program. Harvey Mudd College began providing first- and second-year students with opportunities to participate in computer science research (Alvarado, Dodd, & Libeskind-Hadas, 2012). Prior to 2007, only students who had completed a number of higher-level computer science courses were encouraged to participate in research projects (Alvarado et al., 2012). Alvarado et al. (2012) found that the earlier introduction to research had a bigger impact on the decisions of women (66 percent) compared to men (20 percent) who cited research experience as their reason for declaring a major in computer science. The other initiative taken by Harvey Mudd College was to provide young women the opportunity to attend the Grace Hopper Celebration of Women in Computing (GHC) conference for free (Alvarado et al., 2012). The faculty leaders at Harvey Mudd College "believed that attending GHC would counter the perception of a hostile CS [Computer Science] culture and the lack of mentors and role models in the field" (Alvarado et al., 2012, p. 61). Attending the conference also exposed the women to real-world computing applications, networking opportunities with female computing professionals, and increased their support network of friends and colleagues from around the nation (Corbett & Hill, 2015).

Additional School Efforts. There are a number of public and private institutions that have launched initiatives to close the gender gap in science, technology, engineering, and math majors including the California Institute of Technology, Massachusetts Institute of Technology (MIT), Northwest Missouri State University, Colby College, and North Carolina Wesleyan College (Corbett & Hill, 2015; Her Campus Team, 2015). For example, in 1998 MIT started the Women's Initiative program that works with middle and high schools around the country to introduce girls to electrical engineering and computer science ("Who Are We?," n.d.). Additional initiatives include the creation of cohort and/or mentoring programs to foster belonging and community, increasing the number of female faculty in STEM areas, research experiences that foster identity, and outreach programs that broaden the recruitment pipeline (Corbett & Hill, 2015; Her Campus Team, 2015; Marten DiBartolo et al., 2016).

Carnegie Mellon University and Harvey Mudd College have experienced successes based on changes they have made to their computer science programs; female enrollment is 48 percent and 40 percent respectively. However, recruitment campaigns aimed at increasing the number of women in technology have made little lasting impact on their retention and graduation rates. Upper-level courses are still male-dominated, demonstrating that simply "changing introductory courses isn't enough to build the pipeline of women needed to fill tech jobs" (DeNisco Rayome, 2017). Despite gender parity in introductory computer science classes, which have been revised to attract more women, at Carnegie Mellon, Stanford University, Harvard University, and University of California Berkeley the number of women who drop out after the introductory course is still significant. Despite a near 50-50 gender split in introductory courses, the female computer science graduation rates at Carnegie Mellon, Stanford, Harvard, and Berkeley are 21, 32, 29 and 28 percent respectively (DeNisco Rayome, 2017). The challenges of isolation, imposter syndrome, stereotyping, and confidence still remain. For example, Barb Ericson at Georgia Tech states, "A lot of women tend to leave the major even though they have better grades than the guys who stay, because they're not confident in their abilities" (DeNisco Rayome, 2017, para. 23). Retaining women in computing majors once they have enrolled is a much more complicated issue.

If retaining more women at the collegiate level were as "simple" as changing some of the courses taught early within the curriculum, then why are we not seeing more colleges enact these types of changes? There are deeper-rooted issues, which Margolis and Fisher (2002) and Carnegie Mellon University ("CMU's proportion of undergraduate women," 2016") recognized and referred to as a "culture of computer science." Margolis, Fisher, and Miller (2000) observed that young women who were enthusiastic about computer science when entering college lost interest because they felt they were not as zealous about technology, or at least not passionate in the same way, as their male counterparts. Common stereotypes exist of the "science nerd" and "computer geek," who are generally thought of as male, White or Asian, and obsessive in their passions for anything and everything technology (Kendall, 2011). These perceptions of computing are beneficial to the male hegemony that currently dominates the technology industry, but it also results in an unfortunate side effect that tends to exclude those who do not subscribe to the same way of thinking (Jenkins, Ito, & boyd, 2016). How do perceptions and culture of computing affect the experiences of those individuals whose gender, attitudes towards computing, or the ways they manifest their passion for technology do not "fit" with the "standard" culture of computer science?

Conceptual Frameworks

Our personally held values, attitudes, and beliefs are shaped by our experiences and those experiences always affect how “we feel about ourselves and others” and the viability of those beliefs are “contingent on their consequences for the community” (Lemke, 2001, p. 301). Therefore, two conceptual frameworks, sociocultural theory and sense of belonging, serve to guide this dissertation.

Sociocultural Theory. Developed during the 1920s and 1930s by Russian psychologist, Lev Vygotsky (1978), sociocultural theory proposes that learning occurs through a series of social activities where knowledge is co-created based on the personal, cultural, and historical contexts of the social actors (e.g., learners and instructors). Because learning is co-constructed, the theory also argues that individual processes of knowledge construction and social processes of joint understanding are interconnected and interdependent and therefore indivisible one from the other (Lemke, 1996). Furthermore, the sociocultural approach suggests that learning is also mediated by language and other systems of symbols and can be best understood by examining the culture’s historical evolution (Bruner, 2009; John-Steiner & Mahn, 1996). Cultural values and beliefs are not only shared by members of communities, but are also “conserved, elaborated, and passed on to succeeding generations who, by virtue of this transmission, continue to maintain the culture’s identity and way of life” (Bruner, 2009, p. 160-161). The values, attitudes, and behaviors of cultures, such as geek culture, are preserved and perpetuated through a variety of modalities such as artwork, advertising, propaganda, storytelling, mass media, and childhood indoctrination (Hirst & Manier, 1995). For example, children learn culturally-appropriate talk, behavior, and skills by observing their parents, teachers, caregivers, and older siblings in different social situations, and then participate in similar contexts where they emulate the behavior and speech patterns they observed (Rogoff, 1991). Over the course of time, less experienced individuals "take on increasing responsibility for their own learning and participation in joint activity" (John-Steiner & Mahn, 1996, p. 192).

Learning and the co-development of knowledge by their very nature are complex. Individuals within a community may share similar cultural histories and systems of symbols, such as language, but each person also brings her or his own personal histories, experiences, and family organization. In addition, every individual holds multiple roles in their lives; some selected by the individual (e.g., career), some assigned to them by others (e.g., student), and some they are born into (e.g., gender, race). These complex social relationships and cultural values create unique contexts for learning and have a direct influence on the intellectual interdependence in the co-construction of knowledge (John-Steiner & Mahn, 1996). Another way of stating this, according to Bruner (2009):

> Knowing and communicating are in their nature highly interdependent, indeed virtually inseparable: however much of the individual may seem to operate on his or her own in carrying out the quest for meanings, nobody can do it unaided by the culture's symbolic systems. It is culture that provides the tools for organizing and understanding our worlds in communicable ways (p. 161).

Using sociocultural theory as a framework for this dissertation means that the participants were studied within their social and cultural contexts, capturing the full complexity of their experiences. Moll (1992) goes on to note that a sociocultural approach also allows the researcher to gain a more holistic perspective of the capabilities of the participants, as social and cultural contexts are also being observed and investigated. This is why it was also imperative for me to provide further context surrounding the historic roles of women in computing and the broader computing culture as part of my dissertation.

Sense of Belonging

Sense of belonging is the second conceptual framework used to guide this research and is closely aligned with sociocultural theory. In general, sense of belonging is the belief that one is an integral member of a group or community; the individual feels accepted, valued, and supported by their peers within the group (Goodenow, 1993; Good, Rattan, & Dweck, 2012; Hoffman, Richmond, Morrow, & Salomone, 2002; Strayhorn, 2012; Tovar & Simon, 2010; Trujillo & Tanner, 2014). More specifically, Good et al. (2012) state that "sense of belonging to an academic domain likely contains various components, but at its heart it reflects the feeling that one fits in, belongs to, or is a member of the academic community in question" (p. 700).

Perhaps one of the most preeminent works on how sense of belonging impacts persistence and attrition in higher education is *Leaving College* by Vincent Tinto (1987). Tinto (1987) determined that students with feelings of connectedness towards their institution were less likely to dropout or transfer to a different school. He argues that these feelings of connectedness or belonging could be heightened through both academic and social integration (Tinto, 1987). Hoffman et al. (2002) notes that "the greater a student's "sense of belonging" to the university, the greater his or her commitment to that institution … and the more likely it is that he or she will remain in college" (p. 228).

Peer groups and friendships with individuals who support academic goals are also important to sense of belonging and can improve more than student retention, but also positively impact perceived intellectual self-confidence and degree aspirations (Antonio, 2004; Hoffman et al., 2002; Leaper, 2015). “The opportunity to make friends in class and to have friends with whom to discuss academic matters outside of class directly contributed to increased perceptions of support and comfort” (Hoffman et al., 2002, p. 234). Furthermore, sense of belonging and connecting with students of a similar race or culture has been shown to positively impact student persistence toward their degree for both Asian (Lee & Davis, 2000) and Latino/a (Hurtado & Carter, 1997; Strayhorn, 2012) students. Likewise, when girls and women associate with peers who value and support STEM, their sense of belonging is validated, especially as it relates to their interest in and pursuit of a degree and career in STEM (Leaper, 2015). Time and again peer group connection and sense of belonging has been tied to student retention at colleges and universities.

In addition to understanding how a student’s sense of belonging can predict retention at the college level, sense of belonging is also important to understanding persistence and attrition at the program level, especially in STEM. Trujillo and Tanner (2014) found that sense of belonging influenced both male and female students’ decisions on whether or not to pursue mathematics majors in college. Similarly, Good et al. (2012) found that sense of belonging was more crucial to female students’ decisions to pursue math than good grades in math courses and other measures of achievement.

Female mentors, such as experts in the field, program faculty, and upper-level classmates can also contribute to sense of belonging for women in male-dominated STEM fields (Leaper, 2015). Leaper (2015) found that women in STEM majors who were able to interact with female mentors were more likely to identify with their chosen field, experienced more “positive self-concepts and stronger career commitment in

STEM" (p. 173). Similar reports have come out of Carnegie Mellon University, where the advantages that come with access to same gender role models and classmates have been identified as critical components for success (DeNisco Rayome, 2017). The need to fit in is incredibly strong and can be one of the primary factors why women are more likely to pursue traditionally feminine STEM majors (e.g., nursing) in college (Leaper, 2015) or why they leave male-dominated STEM fields like computing and technology to pursue degrees in disciplines where sense of belonging is more likely to occur (Good et al., 2012).

Sense of belonging not only can serve as a predictor of persistence, but it also significantly impacts students in other ways, such as academic motivation and achievement and well-being (Trujillo & Tanner, 2014). Improved sense of belonging may also improve other important aspects related to persistence, such as self-efficacy—the belief in one's ability to complete a desired task or activity (Bandura, 1997; Good et al., 2012; Trujillo & Tanner, 2014) and identity (e.g., identifying as a computer scientists or technology expert) (Leaper, 2015, Trujillo & Tanner, 2014). "Students who have higher self-efficacy are more likely to persist in the face of difficulty" (Trujillo & Tanner, 2014, p. 8), such as the "discouraging experiences with teachers, peers, and curriculum" (Margolis & Fisher, 2002, p. 5) that women face when trying to fit into the culture pervasive in many computing programs (and workplaces). Individuals who experience cultural "fit" and feel that they are part of a supportive community are more likely to sustain a sense of self-efficacy, even when facing difficulties (Bandura, 1997). Finally, when individuals "truly feel a sense of belonging, they are likely to show active participation in that community" (Good et al., 2012, p. 702).

Summary

The literature demonstrates that these are significant issues regarding gender parity in computing majors at colleges and universities around the United States. The literature also shows that since the mid 1980s the proportion of women opting to pursue degrees in computing is continuing to decline, despite women entering college at higher rates than men, increasing numbers of women pursuing computer science degrees, and radically growing demand for people with technical skills. Of those women who do pursue degrees in computing, a disproportionate number when compared to their male counterparts choose to change majors to something outside of technology and do not complete their computing degrees. Based on the literature, one of the predominant reasons women are leaving is because of the ubiquitous technology culture that supplants women and presupposes they are less technically competent than their male counterparts. Efforts are being made by some colleges and universities to increase female enrollment in order to reverse the trend. Unfortunately, most of the efforts are focused on improving the number of women entering computing programs and are not addressing the other issues related to the retention of women in these programs. By examining the experiences of women enrolled or formerly enrolled in computing programs through the lens of sociocultural theory and sense of belonging, I believe greater insight may be gained enabling real change to occur.

CHAPTER 3

METHODOLOGY

Issues are not simple and clean, but intricately wired to
political, social, historical, and especially personal contexts.
All these meanings are important in studying cases.
Robert Stake (1995, p. 17)

The intent of this dissertation study was to investigate women pursuing computing and technology majors at North Central University (a pseudonym), a four-year university in the Upper Midwest. Because "understanding how [women] interpret their experiences, how they construct their worlds, and what meaning they attribute to those experiences" is more important than understanding cause and effect (Merriam, 2009, p. 5), the study utilized methods of qualitative inquiry, specifically case study. Through my research, I sought a better understanding of the experiences of the women enrolled in one of three computing programs within the same university. Guided by the sense of belonging conceptual framework, I examined the women's perceptions of how they see themselves "fitting in" with the people in their major and overarching computing culture. Comprehending how the women see themselves within their major community (e.g., interacting with peers or professors) and whether or not they feel they belong, may lead to more in-depth knowledge related to the computing degrees and technology sector workforce female attrition problem. Finally, I also sought to gain deeper insight into the cultures and context of the majors and the efforts, if any, put forth by the university to attract and retain women into the CS, CN, and ICT programs.

This chapter details the case study methodology used in my dissertation. The first section describes the specific purpose of this research, the questions it sought to answer, and the epistemological paradigms that framed and guided this study. In the next section the research design and methods to collect the data are described. Finally, I discuss how the data were interpreted and analyzed.

Research Questions

According to Stake (1995), case studies are best when guided by questions that focus on conceptual issues because they recognize and appreciate the "uniqueness and complexity" (p. 16) of the case and its contexts. The resulting question(s) "draw us toward observing, even teasing out, the problems of the case, the conflictual outpourings, the complex backgrounds of human concern" (Stake, 1995, p. 17). The following research questions capture the overarching issues as I currently understand them (etic) and served to guide this research.

RQ1. How do women who are pursuing computing-focused degrees in a face-to-face, on-campus environment, at a four-year university describe their experiences?

RQ2. What impact does sense of belonging have on how the women perceive their experiences?

Epistemological Paradigms

My epistemological approach to case study design most closely aligns to that of Stake (1995) and Merriam (2009). Stake (1995) defines a case as an "integrated system" with "a boundary and working parts" making people and programs appropriate for this type of study (p. 2). Likewise, Merriam (2009) defines a case to be a "single entity, a unit around which are boundaries" (p. 40), such as a single person, a program, a group, or a community. The phenomenon or issue is complex and the real-life context in which it occurs is integrated to a point that one cannot really be studied without the other

(Merriam, 2009; Stake, 1995; Yin, 2013). Therefore, the case becomes the focus of the research and the case must have clearly defined boundaries.

This case study was initially designed to be holistic (Stake, 1995) and particularistic (Merriam, 2009) in nature. The intent was to examine the collective experiences of all of the women in the study within the contexts of their degree programs and then to delve into a particularistic investigation through smaller embedded cases. The study was designed with two embedded cases in mind. The first embedded case was to focus on women who had declared computing-focused majors and were enrolled in technical courses, which I refer to as Persisters. The second embedded case sought to understand the experiences of women who had been accepted into a computing-focused major, but changed to majors that were not technical, such as social science, art, or English. This group of participants are referred to as Separators. Collecting data and learning about the experiences of individuals within each subunit would have allowed for cross-case analysis to better understand why some women chose to persist and others to leave. Unfortunately, as will be discussed later in this chapter, identifying potential Separators was difficult and resulted in no participants for this subunit; therefore, the approach to the case study was altered and become a holistic investigation into the experiences of women who persisted in computing majors. The resulting boundaries of the case are described below.

- The participants identified as female;
- The participants were enrolled in one of four specific technology-focused majors/programs (Computer Networking, Applied Math Computer Science, Game Development, or Information Technologies) within the same university;

- The participants attended on-campus, face-to-face courses. The majority of the courses in the computer science programs are not offered online; therefore, in order to maintain consistency, only campus-based students were considered for inclusion in the study; and
- The data collection was temporally bounded by the latter part of the 2018 spring semester (March – May, 2018).

Case Selection

The case was situated within North Central University (NCU), a four-year polytechnic university in the upper Midwest that offers a variety of undergraduate computing-related majors. NCU was selected because of (1) the typicality of the programs, their curriculum, and pedagogy, (2) the university's polytechnic nature, meaning the courses are generally hands-on and instructors utilize experiential approaches to learning and, (3) convenience, as it is where I work as an assistant professor. Unlike the colleges and universities discussed in Chapter 2, the programs at NCU have not made overt efforts to explicitly attract and retain female students such as changes to pedagogical approaches or curriculum, nor has there been the formation of organizations to support women in computing or technology fields. In other words, the computer networking, applied math computer science, game development, and information technologies programs at NCU are examples of what can be experienced in similar programs at many four-year universities around the United States.

As stated earlier, one of the bounding elements of this case are the majors or programs that have been selected for inclusion. As female enrollment in computing-related majors can be quite low, multiple majors were used to bound this case. For example, in the Computer Networking program at NCU, there are five women out of approximately 150 students in the program, or about three percent of overall program enrollment. Therefore, to collect a breadth of experiences across different spectrums of the same general field of study, four undergraduate academic programs at NCU were selected for this research project. The Applied Math Computer Science (AMCS) Software Development (SD) concentration, Game Development (GD), Computer Networking (CN), and Information Technologies (IT) programs were selected because their curricula are designed to prepare students to work with computing and technology in meaningful ways.

Degree Program Descriptions

Applied Math Computer Science (AMCS). This major prepares students for a variety of careers utilizing high level mathematics, such as software development, cybersecurity, actuarial science, and business management. There is a heavy concentration on mathematics, technical skills, algorithmic principals, logic, and analysis of complex problems.

Computer Networking (CN). Students work with physical infrastructures that connect computers and technology systems. They learn how to design, implement, and administer local and wide area networks and wireless networks. They also gain experience in unified communication, IP telephony, virtualization, and information security.

Game Development (GD). Students pursuing the Game Development major learn a variety of computer science skills that prepare them to develop a variety of digital games. There is a heavy focus on computer programming languages. They also explore different game engines, mobile game development, and virtual reality.

Information Technologies (IT). This interdisciplinary technology-based major prepares students for leadership positions in information technology. Students develop foundational understandings of enterprise systems, assessing and auditing technology needs, project management, and web technologies.

Participant Selection

Participants were purposively selected based on predetermined criteria and were not in any way "atypical, extreme, deviant, or intensely unusual" (Patton, 2002, p. 236). The assumption is that the experiences of purposefully selected participants is representative of women in similar programs at colleges and universities across the United States. Their experiences, while not generalizable in the quantitative sense, may point to more *concrete universals*, which Erickson (1986) suggests can be "arrived at by studying a specific case in great detail and then comparing it to other cases studied in equally great detail" (p. 130). Merriam (2009) goes on to say:

> Every study, every case, every situation is theoretically an example of something else. The general lies in the particular; that is, what we learn in a particular situation we can transfer or generalize to similar situations subsequently encountered (p. 225).

It was the intention of this study to identify participants that would fit within one of two subunits (Persisters and Separators). The subunits were then going to be part of one larger, bounded case. The recruitment process for each of the smaller cases was similar and the process and criteria for both smaller cases is described below. As will be described later, no individuals were identified as part of the Separators subunit.

Persisters. In seeking this type of generalization or transferability, it is critical to identify participants who are representative of female college students pursuing computing-related degrees. This is the first of two sub-units in this embedded case study and participants within this sub-case are referred to as Persisters because these women have intentions of continuing in and completing their selected computing-focused degree. Therefore, the following criteria were used to determine eligibility for possible inclusion in the study:

1. The participant identified as female.
2. The participant was actively enrolled in an undergraduate degree program in AMCS, CN, GD, or IT.
3. The participant was enrolled in at least one major course that was conducted face-to-face during the spring 2018 semester. A major course is defined as a required core or emphasis course that is theoretical or technical in nature.

Separators. Because of this study's holistic approach to understanding women's experiences in computing-related majors, it is also valuable to understand the experiences of women who originally declared a major in AMCS, CN, GD, or IT, but have subsequently changed their major to a non-computing or technology focus (e.g., Animation, Graphic Design, Marketing and Business). Separators, thus called because they have separated or left a computing-focused major, were going to be one of the embedded subunits in this case study. Their experiences could provide insight into why some women choose to leave. The selection criteria for these eligible participants are as follows:

1. The participant identified as female.

2. The participant had originally declared a major in AMCS, CN, GD, or IT, but was, at the time of the study pursuing a degree in a non-computing field of study within the same university.
3. The participant was enrolled in and completed at least one major course that was conducted face-to-face before leaving the major.

Recruitment. This study received approval from the Institutional Review Board (IRB) at the University of Minnesota (Study #: 00002703) on February 26, 2018 (Appendix A). Furthermore, an application for review was submitted to NCU's IRB. They determined that the University of Minnesota was the institution of record and no further review was needed by NCU. The initial step in recruiting Persisters was to contact the program directors for each major area I intended to study (Applied Math Computer Science, Game Development, Computer Networking, and Information and Communication Technologies) for a list of students enrolled in their program. Once I received the list of student names, an email invitation was sent to everyone — no assumption of gender was made. The email explained the premise of the study, described my expectations of the participants (e.g. participation in interviews, observations of their classes), provided opportunity to ask clarifying questions, and then requested them to complete a short qualifying survey if they were interested (Appendix B). The first question of the qualifying survey asked the student whether or not they identify as female. If the student did not identify as female, the survey was complete. If the student identified as female, she was asked if she would be interested in participating in the study. If the student expressed interest, the survey asked her to provide her name and contact information so that I could follow-up.

Fourteen students responded to the request for participation as Persisters and eleven agreed to participate in the study. After initial interviews with the eleven participants, the pool was narrowed to ten as one of the students was studying abroad which made classroom observation difficult. Once the interviews and classroom observations were complete, I decided to narrow the boundaries of the case to only students in two majors: Applied Math Computer Science (AMCS) with an emphasis in Software Development (simply referred to as Software Development (SD) going forward) and Game Development. This narrowing was primarily done because SD and GD are both computer science-based programs and the students shared similar experiences. Within the AMCS major, students who were pursuing concentrations in math education or actuarial science, for example, met with quite different experiences than those concentrations with a specific focus on computer science. In addition, no students from the Computer Networking program volunteered to participate and only one student from the Information Technologies program participated. Finally, a first-year student majoring in GD was excluded from the data analysis because she was not able to clearly articulate her experiences. In the end, the Persisters were comprised of five women with a fairly even split between SD and GD — some of them double-majoring in both programs of study — and range from sophomore to senior (See Table 3.1).

Recruiting Separators presented more challenges. The first step was speaking with the records and registration office where I requested the identification of individuals who would potentially meet the criteria described above. The records and registration office made initial contact by sending out an email to students they identified on my behalf. The email explained the study, described the interview process, and informed them that they could ask clarifying questions. If the student was interested in learning more about the study or wanted to participate, they were instructed to contact me. Once the students contacted me, the intent was to have them fill out an electronic qualifier survey similar to what was presented to the Persister group (Appendix C). Reaching out to the Separator participants in this way ensured their privacy and met with the Family Educational Rights and Privacy Act (FERPA). Individuals from both the Persister and Separator groups who expressed interest in participating in the study and met the criteria described earlier, received more information about the study and a consent form via email (Appendix D). Seventeen students were identified by the Records and Registration Office who met the Separator criteria. Only one student responded, and she did not qualify for the study as she changed from SD to Computer and Electrical Engineering, another male-dominated field. In the end, there were no Separator participants included in this dissertation research.

Table 3.1

Persister participants by major and year in school

Name*	Major	Year in School
Anita	SD	Senior
Katherine	GD	Sophomore
Mae	SD and GD	Sophomore
Margaret	SD and GD	Senior
Sally	GD	Sophomore

*All names are pseudonyms

Impact on the Case Study. The lack of participants who qualified as Separators altered the structure of this case study from an embedded multi-case study design to a single case where the focus was on the experiences of the Persisters. Instead of comparing similarities and differences between the two subunits of the case, my attention shifted to developing a deeper understanding of the experiences of students who have persisted in their pursuits. Furthermore, this shift allowed me to fine-tune the boundaries of the case and truly concentrate on a very specific group of women who share similar experiences. This adjustment also means that there is room for future investigations that focus on the experiences, attitudes, and behaviors of women who changed to non-technical majors. Regardless of the shift from multiple to single case study, a thematic analysis of the data was conducted to identify significant experiential themes shared by the women.

Role of Researcher

Humans are uniquely suited for collecting and interpreting the type of complex data found in qualitative research and the researcher serves as the primary instrument (Merriam, 2009; Patton, 2002; Tracy, 2013). Personal biases and their potential impact on the research should be considered when acting as the primary instrument (Merriam, 2009). Therefore, it is important to share that I am a passionate advocate for igniting interest in technology in girls and women. Additionally, my significant history as a woman working in technology must be considered and undeniably shaped my perspectives and interpretations of this research. From 2000 until 2012, when I began my career in higher education, I was employed as a front-end web designer and developer, where my skills and proficiencies in coding and technology increased year-over-year.

After leaving industry to advance my education and transition into teaching in higher education, I revised curriculum and taught web development courses at a technical and community college. I am currently employed at NCU as the program director for the Digital Marketing Technologies program and as an assistant professor where I teach a variety of web development and technology-related courses.

Peshkin (1988) argues that researchers cannot, and should not, completely free themselves from their subjectivities, but instead should monitor it and work towards enhanced awareness. By doing so, a researcher "can create an illuminating, empowering personal statement that attunes [the researcher] to where self and subject are intertwined" (Peshkin, 1988, p. 20). This is one of the strengths of qualitative research. Maxwell (2005) goes on to state that by declaring biases and assumptions, the researcher is making it clear to readers her/his/their values and expectations and how they influence the findings of the study. Therefore, "reflecting critically on [myself] as a researcher, the 'human instrument'" (Lincoln & Guba, 2000, p. 183) throughout the data collection and data analysis process, allowed me to examine my own beliefs, experiences, and perspectives. For example, many traits of my personality align closer to those characteristics that are perceived as more masculine such as independence, self-confidence, and assertiveness. I felt that these characteristics were in part why I had not only persisted in the technology sector but thrived. This may or may not be true. Furthermore, through self-examination during the data collection process, my own experiences with isolation — one of the themes that will be discussed in Chapter 5 — came to the forefront. Throughout most of my adult life I have been able to better relate to men because of our shared interests in technology and other masculine interests often associated with “geek culture.” Normally my lack of friendships with women does not negatively impact me; however, there are times when I wish to partake in more feminine activities. It is during these times that I feel alone and isolated.

There were significant outcomes of this type of reflexive activity that positively impacted this research. First, through developing a deeper understanding of my own feelings and beliefs and how they might influence the analysis of the data, I was able to tease apart the experiences of the participants from my own inherent biases and subjectivities. Secondly, being cognizant of my experiences allowed me to be an empathetic listener when I sat down with each of the participants.

Data Collection

Cases are complex, living organisms; therefore, multiple sources of data were used to capture this case in its entirety (see Table 3.3). The primary data source was the in-depth interviews with the Persisters. Secondary sources of data included (1) interviews with program directors, (2) observations and field notes, and (3) program and university data. Data was collected between March and May 2018 (Table 3.2).

In-depth interviews. According to Patton (2002), interviews are a data collection method that allow researchers to see through the eyes of another person and to enter into her/his perspective. Interviewing opens a window into “those things we cannot observe,” (Patton, 2002, p. 340) such as past experiences, “feelings, thoughts, and intentions” (p. 340), and how the interviewee makes meaning of the world around them. Because I sought to develop a holistic understanding of the experiences of the women within the case, in-depth interviews served as the primary data source.

Table 3.2

Interview and classroom observation data collection

Participant Name	Data Type	Collection Date (2018)
Anita	1st interview 2nd interview Classroom observations	March 26 May 2 April 27, April 30
Katherine	1st interview 2nd interview Classroom observations	April 18 May 4 April 24, April 26
Mae	1st interview 2nd interview Classroom observations	March 28 April 27 April 11, 18, 20, 27, 30
Margaret	1st interview 2nd interview Classroom observations	April 13 May 8 April 20, April 30
Sally	1st interview 2nd interview Classroom observations	April 4 May 1 April 11, April 18
Brian (AMCS Program Director)	Interview	March 20
Linda (GD Program Director)	Interview	April 11

Students. Individual interviews took place twice with each of the Persister participants. The first interview were conducted in March or April of the semester and second interviews occurred after the classroom observations took place. The second interviews allowed for clarification and follow-up questions based on what was observed in the classrooms. The interviews focused on the participants' feelings and perceptions towards technology, their classroom experiences, and their interactions with classmates and instructors. The information shared during interviews provided insight and a better understanding of how personal ideologies (e.g., self-efficacy and identity), educational experiences, and perceptions on the major culture and fitting affected these women's sense of belonging within their chosen major and their attitudes towards technology as a career path. The interviews were semi-structured in nature and were video-recorded and transcribed. Semi-structured interviews allowed for consistency, but also accommodated a need for flexibility and additional probing when unexpected, but relevant topics arose. The interview protocols are located in Appendices E and F.

Program directors. Interviews with the program directors provided a secondary source of data and were intended to provide further context to the case. The interviews focused on awareness of the gender gap in computing and technology fields and their perceptions on culture and attitudes within their programs, classrooms, and the industry. The interviews also aided in producing a holistic understanding of the case by providing information about and history of the program, alternative perspectives of the programs/majors, and efforts that may (or may not) have been taken to improve gender inclusivity. These interviews were also semi-structured, video-recorded, and transcribed (See Appendix G for interview protocols).

Observations and field notes. Classroom observations provided further insights into the experiences of the participants; the interactions between the women, their peers, their instructors, and the content; and also served as a method to triangulate the research (Merriam, 2009). Since human perception is highly subjective, "observational data represent[s] a firsthand encounter with the phenomenon of interest rather than a secondhand account of the world obtained through an interview" (Merriam, 2009, p. 117). Courses that are highly technical and included at least one of the Persisters were selected for observation. As classroom observations were a secondary source of data, I did not feel it necessary to observe more than two class sessions per participant to obtain the information that I required.

During each classroom observation, field notes were taken and the session was video recorded. Descriptions included notes about the setting, activities being performed, and the behaviors and actions of those being observed. Interpretive notes and reflexive comments were also documented and included impressions and speculations about what was being observed in relation to the research questions.

Program and university data. Descriptive data about the programs/majors was collected from the university to provide additional context to the case. This data provided a snapshot of the current overall enrollment, gender distribution, and retention (overall and by gender) for the majors selected for inclusion in this case study (Software Development and Game Development).

Table 3.3

Alignment of Research Questions and Data Sources

Data Sources			
Interviews with Women in Major	**Interviews with Program Directors**	**Observation & Field Notes**	**Program & University Data**
RQ1: How do women who are pursuing computing-focused degrees at a four-year university describe their experiences?			
X	^	^	C
RQ2: What impact does sense of belonging have on how they perceive their experiences?			
X	C	^	C

X = Primary data source ^ = Secondary data source C = Data is contextual to the case

Data Analysis

All student interviews were transcribed and uploaded into Dedoose (an application for analyzing qualitative data) for coding and analysis. Because the first research question is ontological in nature — I am trying to understand the nature of the female participants' lived experiences — a heuristic approach was used for the first cycle of coding (Saldaña, 2016). The codes were inductively created, as I went line-by-line through each of the transcripts, allowing themes to emerge. According to Saldaña (2016) and Charmaz (2015), this type of detailed, inductive coding promotes a deeper and more trustworthy understanding of the data. Stake (1995) states that "important meanings will come from reappearance over and over" (p. 78) in the data and that meaning can be found through the search for patterns and consistency. By analyzing the data in this manner, it allowed me to discover what the female participants had to say in their own voices instead of subjecting the data to my own ideas. Open and emergent coding "reduces the likelihood of imputing your motives, fears, or unresolved personal issues to your respondents and to your collected data" (Charmaz, 2015, p. 68). In addition, because sense of belonging is one of the conceptual frameworks guiding this research, it was anticipated to be a theme present in the data. Therefore, a deductive approach using predetermined coding categories related to sense of belonging, community, and fit, as well as their opposites (e.g., lack of fit or isolation) were also used to analyze the data. The first cycle of coding resulted in 63 primary codes (e.g., being a woman in the major, men taking over) with multiple sub-codes (e.g., feminism, exclusion) for a total of 99 codes (Appendix H).

Before coding the data a second time, a code mapping process was conducted. Code mapping is an iterative method of analysis where individual codes are organized into categories, "and then condensed further into the study's central themes or concepts" (Saldaña, 2016, p. 218). From the original 99 codes, ten categories were created: 1) not being heard; 2) peer relationships; 3) women and femininity; 4) men and masculinity; 5) stereotypically male interests; 6) harassment, isolation, and exclusion; 7) overachievement; 8) confidence; 9) support; and 10) qualities to succeed in computing major (see Appendix H for more details). Several codes were dropped between the first and second iteration of code mapping because of low frequency of the code in the data and/or relevance to the research questions. Some codes were highlighted as having cross-theme applicability and were pulled out into their own theme in the second round of mapping. During the second iteration of code mapping, the final seven themes were developed, and one category was removed because it did not relate to the women's experiences. The information for the dropped category (qualities to succeed in computing major) are interwoven throughout the descriptions of the participants, the degree programs, and the final themes.

Thematic analysis, like that described above, can lead to what Stake (1995) refers to as "naturalistic generalizations" about the phenomenon under investigation, where readers are able to recognize similarities that resonate with their own experiences. These generalizations are often more intuitive and grounded in vicarious experiences rather than from codified data derived from large data sets (Stake & Trumbull, 1982).

Thick description. According to Ponterotto (2006), "[i]t is the qualitative researcher's task to thickly describe social action, so that thick interpretations of the actions can be made, presented in written form, and made available to a wide audience of readers" (p. 542). Thick description is more than a detailed *description* of what is observed or experienced, it must also include the researcher's *interpretation* of the activity. Denzin (1989) takes it one step further in stating that thick interpretation cannot exist without thick description. Furthermore, without thick interpretation, qualitative research may suffer from a lack of credibility or the ability to resonate with readers (Ponterotto, 2006). Therefore, the findings of this study will be conveyed via thick description and thick interpretation, which includes the use of participant profiles and narratives to illustrate the experiences of the women (Stake, 1995).

Rigor, Credibility, and Validity

Rigor is often called into question in qualitative research. For that reason, the design of this study has taken into consideration the values of validity, consistency, and credibility (Maxwell, 2005; Merriam, 2009; Stake, 1995). According to Maxwell (2005), unlike quantitative research, which must be repeatable in order to be considered valid and reliable, validity in qualitative research is contextual to the purposes and circumstances of the research and reliability is determined not by "whether the findings will be found again, but whether the results are consistent with the data collected" (Merriam, 2009, p. 221). Lincoln and Guba (1985) refer to this as credibility, where the research findings are credible based on the available data.

Furthermore, validity and credibility in qualitative research can be determined by how the findings match the *reality* of what is being studied (Merriam, 2009). Reality is "holistic, multidimensional, and ever-changing" (Merriam, 2009, p. 213) and individual perspectives of a particular phenomenon, event, or activity are complex and varied. In qualitative research, it is people's constructions of reality that are being examined. Therefore, to increase internal validity and to clarify different meanings (or realities), data source triangulation and methodological triangulation (Stake, 1995) were used to guide my interpretations.

It must also be disclosed that I am a faculty member at the university where the data was collected. There are both advantages and limitations to selecting a location where the researcher is employed. The benefits include accessibility to program directors, instructors, students, classrooms, and other types of data useful to the study. Conversely, there are issues of an ethical nature, specifically those related to power. I am acutely aware of the perceived power imbalance in the teacher-student relationship. In qualitative studies, intellectual rigor, professional integrity, and the ethics of the investigator are tantamount to the credibility and validity of the research (Merriam, 2009). How can a reader trust the research if it done without consideration of the ethical issues involved? In addition to IRB approval, it was important to mitigate the potential issue regarding the perception of my own power in the researcher-participant relationship. Therefore, women who were enrolled in any of my courses at the time of the study were not selected as participants. This strategy was done to reduce or eliminate any perception of impropriety or bias, such as receiving favorable or negative treatment as a result of participating in the study.

Summary

In summary, this study was designed to capture the reality of women pursuing degrees in a technology-focused program or major. A case study design was selected for its ability to gain a deeper understanding of the women's lived experiences within a specific context and how those experiences shaped their identity, self-efficacy, sense of belonging, and decisions to persist. The understandings gained from this type of qualitative case study can then be generalized in a naturalistic way (Stake, 1995), meaning that the reader is able to transfer the findings from this study to their own situations with similar contexts (Merriam, 2009). Subsequent chapters will discuss the contexts of the case, convey the findings of the thematic analysis, and discuss the implications of those findings.

CHAPTER 4

CONTEXT, BACKGROUND, and PARTICIPANT PROFILES

Issues are not simple and clean, but intricately wired to
political, social, historical, and especially personal contexts.
All these meanings are important to studying cases.
Robert Stake (1995, p. 17)

This chapter illustrates the contexts in which the case existed and provides detailed profiles about the participants in the study. To better understand the experiences of the participants, this chapter will begin with a description of the environment and contexts in which the data collection took place — the university and the classroom. I share brief backgrounds of each of the program directors to provide further context to the case as well as to highlight their perspectives about the degree programs they oversee and women and technology. Once a contextual foundation has been established, descriptive profiles of each of the participants serve to highlight their individual experiences and unique journeys through the programs offered at NCU.

Contexts

The participants' experiences did not occur inside a vacuum, but instead were part of broader social and cultural contexts. The women brought with them their own personal histories and experiences, but they were also part of a major program and a broader university culture. North Central University (NCU) shares common traits with universities across the country (e.g., multiple majors, residence halls, student organizations, events), but it also has its own social and cultural contexts that contribute to a unique set of social systems and meanings in which the students exist and interact. In this section I use data to describe the university and some of its programs, fieldnotes to illustrate the classrooms I observed, and thoughts and observations shared by the program directors to provide context in which to frame the experiences of the young women who participated in this research.

University. NCU is a mid-size, public university in the upper Midwest that offers a wide array of undergraduate, master's, and applied doctoral degrees. The university is a regional institute of learning with over half of its nearly 10,000 students coming from within the state. The university is located in a picturesque small community in a rural part of the state where farming is commonplace. The campus is blocks from a lake, river, and an abundance of biking and walking trails, but is also only about 45 miles from a large metropolitan area where students, staff, and faculty can take part in a variety of cultural and sporting events, shopping, and restaurants.

According to a 2015 university report, nearly half of NCU's students were the first in their family to attend college and almost one-quarter of all students were considered to be of low socioeconomic status (SES). Therefore, completing a four-year degree may be considered significant and life altering for many of NCU's students, particularly compared to students from more affluent families who attend prestigious schools such as Carnegie Mellon University, Harvey Mudd College, or similar schools already mentioned in this dissertation. It also means that pursuing a career in computing may provide NCU's graduates with a pathway to economic stability and career success in in-demand fields.

NCU was selected in part because of its representative nature to similar programs offered at four-year college and universities across the United States. To determine this, I used data from NCU as a lens to evaluate the typicality of the two computer science degree offerings compared to national enrollment statistics. Nationally, women make up approximately 56 percent of all college and university students (Digest for Education Statistics, 2016), whereas at NCU, women make up only 43 percent (see Table 4.2) of overall university enrollment. This is atypical of national averages and may be due to the type of majors offered at NCU. As a polytechnic university, NCU tends to offer a disproportionate number of majors in the STEM fields (e.g., computer engineering, mechanical engineering, plastics engineering, industrial design, and biochemistry), which historically attract more men than women. This is clearly evidenced when examining NCU's enrollment statistics. The College of Science, Technology, Engineering, and Math (CSTEM) makes up nearly half of the university's undergraduate full-time campus enrollment and 74 percent of the students in the CSTEM are male (see Table 4.1).

Table 4.1

Gender Ratio of NCU Undergraduate Campus-based Instruction First-year Enrollment, 2018-19

NCU Institutional Segment	Females (%)	Males (%)
University	43	57
College of STEM	26	74
Applied Math Computer Science	14	86
Computer Science (Game Development)	11	89

While NCU's overall enrollment based on gender is skewed toward more men when compared to national averages, the percentage of women who graduate in the two computer science degrees — Software Development and Game Development — offered are comparable to national averages. According to the National Center for Education

Statistics (Digest for Education Statistics, 2016), women make up 16.5 percent of graduates with bachelor's degrees in computer science. The percentage of females who graduate with a degree in AMCS or GD from NCU are on par with the national average at 19 and 17 percent respectively (see Table 4.2).

Table 4.2

Gender Ratio of NCU Undergraduate Campus-based Instruction 2012 Graduation Cohort

NCU Institutional Segment	Females (%)	Males (%)
University	47	53
College of STEM	27	73
Applied Math Computer Science	19	81
Computer Science (Game Development)	17	83

Recruiting women into computing and technology degree programs has become an area of popular focus; however, the more complex and critical issue is one of retention. Women leave computing majors at disproportionate rates to their male counterparts, even at universities where significant changes have been put in place in an attempt to retain more women (DeNisco Rayome, 2017). NCU has not introduced any changes to the curriculum, provided female mentoring programs, or made other specific efforts to retain women. Across the entire university, NCU loses almost 10 percent more female students than male students between the first and second years (see Table 4.4). This reality is particularly concerning considering NCU's enrollment already skews to significantly higher male enrollment. Across CSTEM, the attrition rate is comparable between female and male students; however, there are considerable differences between

AMCS and GD. As evident in Table 4.2, only 14 percent of the AMCS students are female, and of those, half leave the major between the first and second year, whereas less than one-quarter of male students leave (Table 4.3). This means that first year classes have multiple women enrolled, but by the time students reach the upper level courses, there may be only one or two women enrolled. Conversely, the GD program experiences a higher-than-average retention rate for both women and men — and rates for both genders are comparable. While interesting, understanding why the GD program has such high retention across both genders is outside of the scope of this research project and is something for future investigation.

Table 4.3

Undergraduate Campus-based Instruction Retention by Gender at NCU from Spring 2018 to Fall 2018

NCU Institutional Segment	Females (%)	Males (%)
University	67	76
College of STEM	69	71
Applied Math Computer Science	50	78
Computer Science (Game Development)	83	82

Classroom. One of the secondary methods of data collection were fieldnotes from classroom observations. At the end of the first interview, I asked the women for their class schedules and worked with them to determine the best courses to observe. I also reached out to the instructors for each of the classes that were to be observed to gain permission to observe. Classroom observations were conducted to gain first-hand knowledge and additional insight into the experiences of the female participants. Over the course of several weeks I observed ten class sessions from each of the two majors. There was some overlap in observations as three of the courses had two participants from the study (see Table 4.4). In these classroom observations I was able to see how the participants interacted (or did not) in the classroom setting. The number of observations also provided a wide breadth of the types of classroom experiences — traditional lecture, lab, and senior capstone —that the students encounter during their time at NCU.

Table 4.4

Classroom Observation Overview

Class Topic	Participants	Class Setting	Hours Observed	Major/Program
Computer Science Senior Practicum	Anita	Flexible	2 hours	SD*
Numerical Analysis	Anita	Lecture	2 hours	SD
Game Engines	Mae & Sally	Lab	4 hours	GD**
Advanced Web Programming	Mae & Margaret	Lecture	2 hours	SD/GD
Mobile Games	Mae & Katherine	Lab	4 hours	GD

*Software Development
**Game Development

The College of STEM is located in a newer building on NCU's campus, thereby the classrooms used by the SD and GD programs are modern and welcoming. The seating and desks were oftentimes on wheels so they could be easily moved around for group work. The classrooms were well lit (many with natural lighting), included white boards and projectors with wireless connections, and there were ample outlets for plugging in laptops and phones. The size of the classes that were observed were relatively small with a mean average of 20 students and ranged in size from 18 – 23. On average, there were three female students per classroom, but ranged from as few as one to as many as nine. The classroom with nine female students was an anomaly as it included students from both the GD and the Game Design Art program. Whereas the GD program is disproportionately male, the Game Design Art program is more evenly split between female and male students, resulting in higher numbers of women in combined major courses.

Three different types of classroom settings emerged from my observations, and I have classified them as traditional, lab, and flexible. The traditional classroom setting is defined as having rows of desks all facing toward the front of the classroom where there is a station for the instructor to connect her/his laptop. The classes observed in a traditional setting were lecture-based where the instructor did the majority of the talking and there was little interaction between the students or between the students and the instructor. The lab setting consisted of clusters of pods, and each pod would typically seat four to six students. See Figure 4.1 for an illustration of this classroom structure. The pods within the lab environment also housed computer towers and monitors for each of the students. The instructor may make a few centralized announcements, but there was minimal lecturing; most of her time was spent moving around within the space answering student questions and providing guidance on projects. While this setting was conducive to teamwork, individual work was also commonplace. For example, the Game Engines class I observed was exclusively individual work. Many of the students wore earbuds and listened to music and did not interact much with one another. Conversely, the Mobile

Games class that took place in the same lab was entirely centered around team-based work, and the pod arrangement easily accommodated this. The final setting observed was a flexible arrangement, where there was no real structure to the daily activities of the class or to the seating arrangement. The flexible classroom setting was used in the senior practicum class. The instructor served as a facilitator in this setting and there was no lecturing. The student teams were fairly autonomous in how they divided up the work and what was done on a class-to-class basis. At the beginning of the semester students determined the projects that were going to be worked on and individually decided which team they wanted to be a part of. The instructor used an Agile method, which is a process common in software development and uses incremental and iterative work sequences to complete projects. The instructor/facilitator assigned a team lead to each project who was responsible for coordinating the work done by the team and ensuring that the team was ready for regularly scheduled code reviews. During the code reviews the students would share the code they created and the progress that was being made on the overall project with the rest of the class. In the flexible setting, the seating arrangement was not configured the same way from class session to class session. Instead, the students arranged desks in a manner that met the needs of the team for a given class session and ultimately allowed for a highly interactive learning environment.

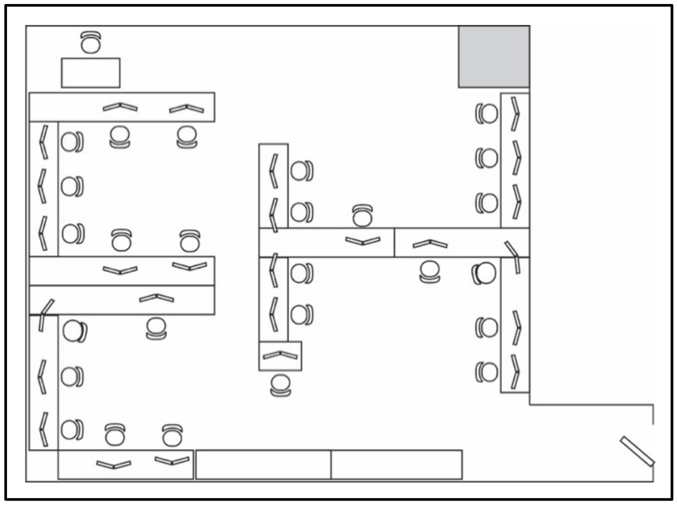

Figure 4.1. Lab classroom arrangement. Desks are arranged in clusters of pods.

Program Directors

Every degree program at NCU has a faculty member who serves as the program director. The program director's duties are to oversee the existing curriculum, work with industry partners to ensure that the curriculum meets the needs of employers and make changes as needed, to work with faculty and other leaders across campus, and of course to advise students. I interviewed the program directors for both AMCS and GD. The interviews were conducted to provide additional context about the degree programs as well as to understand the experiences, backgrounds, and beliefs of the program directors themselves as leaders that may influence the learning environments.

Applied Math Computer Science. Brian is the program director for the AMCS degree program at NCU, which includes the SD concentration. At the time of the interview Brian had been the program director for four years and had been with the university for 12 years. He is a White male in his 50s and sometimes thinks the students in the program view him "like [he is] a father figure or dad" (Brian, interview, March 20, 2018). Brian holds degrees in chemical engineering and computer science but considers himself a computer scientist. During his time at NCU, he has taught more than a dozen of the program's computer science courses (versus math courses which are also part of the program) ranging from introductory Computer Science 1 and 2 to the advanced senior-level practicums and capstones.

Brian is keenly aware of the lack of women in the AMCS major and recognizes the need to improve the diversity of the program, specifically as it relates to gender. He noted that when the program changed its name from Applied Math to Applied Math Computer Science (to more accurately reflect what the students were learning), "the number of females in the program, the percentage went down" and stayed down (Brian, interview, March 20, 2018). Anecdotally, he has observed higher percentages of women in the Actuarial Science concentration (about 20 percent) within the AMCS program, compared to less than 10 percent in the Software Development concentration (the largest of the concentrations in AMCS). He went on to say that "next to none of them become actuaries. Almost all become software developers" (Brian, interview, March 20, 2018). He speculates that more women start in actuarial science because they feel it is more socially acceptable than saying they are pursuing computer science.

His desire for increasing diversity is likely in part derived from his own professional history. Prior to entering academia, Brian worked in chemical engineering — first with the cosmetics industry and later selling chemicals to powerplants. While both positions were in the field of chemical engineering, they were drastically different experiences. He explained that the majority of his colleagues and clients when working in the cosmetics industry were female; this included a variety of engineers and other positions that are typically male dominated. By contrast, the powerplant industry was predominantly male. Brian described the conversations that occurred in his powerplant experience as "locker room dumb" and that by adding "just one female changed the entire dynamic of that group" (interview, March 20, 2018). He went on to say that he "much preferred being in the group of females [cosmetics industry]. We had much more interesting conversations about a broader range of things" (Brian, interview, March 20, 2018).

In addition, Brian's awareness for the need for diversity is also likely fueled by the fact that he has a teenage daughter who at one time expressed interest in becoming a computer science professor like her father. She has since changed her mind and is interested in medical research, but still recognizes the usefulness of knowing how to write code. Based on what he has seen in the AMCS program and its classrooms, he wishes that more women would enter the field so that it would not be so isolating for them and that it would benefit the industry as a whole. Brian goes on to say, that, "as a 50 some year old male, I get nervous about the blind spots that have been ingrained into me over time," and is unsure what changes are needed (interview, March 20, 2018). He believes that some form of professional development on more inclusive teaching practices could be beneficial to him and his colleagues.

Game Development. Linda is a White female in her 50s and has been the program director for the GD degree program for 10 years and prior to that was the program director for the AMCS program. She has been with NCU for 25 years. Linda holds degrees in chemistry, math, and materials science. In her tenure at NCU, she has taught a variety of computer science, math, and game development courses.

The Game Development program came about as an effort to grow the AMCS program. After the 2000-2001 dot com crash, enrollments in AMCS were trending downward and Linda and her colleagues from both AMCS and the NCU art department recognized students' increasing interests in computer and video games. Working across departments, Linda spearheaded the development of the Game Design and Development program. The original iteration had two concentrations, one in computer science and the other in art and design for video games. Due to credentialing requirements in both the computer science and art departments, along with recommendations from industry, the two programs separated. The Computer Science program with the Game Development concentration are accredited by the Accreditation Board for Engineering and Technology (ABET) — one of the most recognized accrediting organizations for post-secondary technology degree programs.

As a woman who has worked in the computing industry and currently holds a leadership position at NCU in computing, Linda knows all too well the issues of recruiting and retaining women. Linda's career began at Cray Research, an American supercomputer manufacturing company. For nearly a decade she worked in the research and development department and holds four technology patents, specifically related to microchip processors. Her masters and doctoral degrees are both in materials science, which is also male dominated. As a result of her own experiences, she acknowledges the isolation that the young women in her program feel and the need for persistence. Speaking from her own experiences, she stated, "I understand that because I was in so many classes that I was the only female that you don't think about it after a while" (Linda, interview, April 11, 2018).

Reminiscent of the literature presented earlier in this report, Linda has also observed behaviors and attitudes in her own daughter with regards to seeking a career in computing. Linda's daughter needed convincing that she could have a career in computing if she wanted. Linda described her daughter as "doing marvelous things with computers" as early as elementary school (interview, April 11, 2018). Her older brother was an avid computer enthusiast and regularly taught his little sister how to write code. According to Linda, her daughter was coding websites by the time she was in sixth grade. Her daughter's interest in computers continued throughout high school, but when it came time to start thinking about careers, she proclaimed, "That's Alex's [her brother] thing" (Linda, interview, April 11, 2018). Despite growing up with a mother in a high-tech research and development career and working with coding since she was young, she needed convincing that she could excel in a career in computing and that it was not just a career path for her brother. Linda's daughter is now attending college where she dual majors in applied science and AMCS. She intends to enroll in graduate school for bioinformatics, a field that analyzes complex biological data, after graduation.

Recruitment and Retention. Individual programs at NCU do not do much with regards to direct recruitment of students — male or female. The major programs rely on university marketing, recommendations from high school counselors, and parents who may be alumni. Both AMCS and GD are large programs at NCU, with 160 and 240 full-time students, respectively. Because degree programs are growing quickly and are understaffed, little time is available to focus on recruitment, much less recruiting more female students. This does not mean that nothing is being done.

Throughout my interview with Linda, she repeatedly used phrases like, “you get used to it” and “you don’t think about it after a while,” when referring to the lack of women in computing (interview, April 11, 2018). This may sound like resignation and despair, but that is not the case at all. Linda and Brian regularly work together to create opportunities and support for the women in their respective programs. They try to pair up female students with female advisors to serve as role models. If there are scholarships or campus job opportunities, such as tutoring in the computer science and math lab, Linda and Brian work hard to make sure the female students are given priority.

Persisters

The primary sources of data for this dissertation were collected from five female students enrolled in the SD and/or GD major programs and were in their sophomore or senior years of college. Each participant was interviewed twice. The first interview helped me get to know their personalities, their background and experiences in their major, as well as their attitudes about being in the minority within their chosen major and profession. Next, I observed each of the women at least twice in a classroom setting. After the classroom observations were complete, a second round of interviews was conducted. The second interviews provided me with the opportunity to ask follow-up questions about what I observed. The students were also asked if they thought they would persist in their major through to graduation and about their career aspirations.

The profiles included in the next section introduce each of the students who participated in this research, thus providing further context for the case. Each young woman brings with her a unique background, experiences, and people who have influenced her prior to matriculating at NCU. These experiences shape their beliefs, and contribute to the larger, overall social context of the SD and GD programs. The Persisters were all White, ranged in age from 19 to roughly 26 years old (I did not ask for age, but inferred it based on year in school and our conversations), and came from the same state where NCU is located or a neighboring state. With the exception of Katherine, each of the women expressed that they were highly interested in math and/or science and indicated that there was a person or class in high school that influenced their decision to pursue a degree in computing.

Student Profiles

Anita. Anita is a White woman in her mid 20s and was nearing the completion of her second bachelor's degree — this one in Software Development — when the interviews took place in spring 2018. Her first degree was in environmental sciences from another regional university. She expressed in the interviews that she has always had a passion for math, however, was unsure as to the kind of careers that would allow her to tap into those math skills. Anita stated, "I thought like you couldn't really do anything with math. I thought you had to teach, and I'm not interested in being a teacher. And I was like, this isn't for me, I'll go to law school" (interview, March 26, 2018). However, when it came time to apply to law schools, she found herself unable to answer the question of "why" on the entrance applications. This left Anita in a quandary. She talked with her older brother who holds a degree in computer science and works as a software developer for a large technology corporation. He shared his experiences with Anita and explained how his career incorporates a variety of math skills. In addition, Anita's younger brother, Caleb, is pursuing SD at NCU. Influenced by her brothers, she enrolled at NCU. According to Anita she "had to take Computer Science 1 [entry level computer science course] and I really liked it and I'd never done anything with computers before that, so it was kind of like, just like this crazy thing. So, I decided I'm just going to keep going with it" (interview, March 26, 2018). Anita graduated with honors in December 2018.

Upon first meeting Anita, I noted that she was soft-spoken, friendly, and modest about her abilities. She has long, dark hair and dresses with a flair for fashion. Both times we met she was well dressed and wore fashionable scarves. Anita is a self-proclaimed feminist, overachiever, and is intrinsically motivated to work hard and succeed at whatever she puts her mind to. Despite her internal motivation to succeed, she is also "hyper aware of being the only girl [in class]" and the societal pressures to "do better than the men to be perceived as doing as well as the men" (Anita, interview, March 26, 2018).

Sally. Sally is a vivacious and outgoing White woman between 19 and 21 years old and was finishing her second full year at NCU in spring 2018. She described herself as a "huge math and science nerd" who loves using logic to solve problems (Sally, interview, April 4, 2018). She is pursuing a degree in Game Development. In addition to her course work, Sally is a member of the student chapter of International Game Developers Association (IGDA) and a student organization the coordinates networked gaming events on campus. She also works with the Linda, the GD program director, to coordinate the NCU student game expo.

While in high school, Sally was active on her school's robotics team, but despite her interests in math, science, and engineering, as a junior in high school, Sally informed me that she did not know what she wanted to pursue in college. She thought that because of her participation on her school's robotics team she would likely pursue electrical engineering or software engineering, but neither of the paths felt right. At this point Sally shared with me a fond childhood memory where she was playing a video game and "was stuck, like I could not get any further" so she asked her father, "Dad, you're good at this, help me" (interview, April 4, 2018). She went on to describe her father as an avid player of World of Warcraft and that he took the time to explain the game to an eight-year old Sally. Her gaming experiences with her father planted the seed that was later nurtured by a computing teacher at her high school when she took an introductory game design course he taught. Sally expressed:

> He kind of got me really interested in going to, like really made it very clear to me, that that was a thing I could do [program computer games]. Like I could go and create the games that I've been playing forever (interview, April 4, 2018).

Sally took both sections of the game design course in high school and "was hooked. I'm like, Yep, we're good. We found it, let's go" (interview, April 4, 2018). She had discovered that using computer science to program and create games appealed to her math and engineering interests, her love of logic, and introduced an element of creativity.

Sally's experience on the robotics team in high school also prepared her in some unexpected ways for her chosen major of computer science. During her years on the robotics team there were as many as four girls (including Sally) out of 50 team members and at its low point Sally was the only female on the team. When asked about being one of only a few women in several of her in-major courses at NCU, she referenced her robotics team experiences and said, "I've been used to this [being in the gender minority] for gosh, six years now, seven years now because I've been always interested in math and science and engineering" (Sally, interview, April 4, 2018).

Mae. Mae is an independent and self-reliant 19 to 20-year old White woman and was finishing her second year at NCU in spring 2018. To say Mae is driven is an understatement. She is dual majoring in GD and SD. While still in high school, Mae took computer science courses at a university near her hometown and was able to transfer those credits to NCU. Mae is the recipient of a prestigious scholarship offered to only three NCU students each year based on ACT/SAT scores and GPA; the scholarship is renewable for four years. She intended to graduate in three years, but because of the addition of a second degree and the ability to renew the scholarship, Mae intends to be done in four years. In the spring 2018 semester Mae was taking 17 credits (15 is the average credit load), working as a math teaching assistant, and serving as the vice president for the residence hall association. During the interview, Mae also informed me that she will be working as a resident advisor during the 2019-20 academic year.

Mae's hometown has a population of less than 2,000 people and is predominantly made up of blue-collar, working class residents. Her hometown did not offer any sort of computing or programming courses, but she credits a math teacher for recognizing and nurturing her aptitude for math and her father for introducing her to programming. Mae recalled, "being a little kid and sitting with [her father] while he was programming, like at one in the morning and would just sit and watch him program and he would try to explain it to [her] sometimes" (interview, March 28, 2018). She also described how her father would start programming by writing down information on a yellow legal pad. Mae's parents divorced when she was young and when her father would pick up her and her younger brother every other weekend, they would spend four hours in the car returning to his home. Her father would ask Mae to write down some of his coding ideas on his yellow legal pad during the drive. According to Mae, it was because of this that "Linux came to me so easily because I realized I've seen it before" and that programming, in general, came fairly easy to her (interview, March 28, 2018).

When it came time to start thinking about careers in high school, Mae decided she was not going to copy her dad, so opted to pursue mechanical engineering instead. She also contemplated architecture and electrical engineering before she finally decided on programming because it, "just felt like where I should be, like I'm good at organizing things and the logic just clicks" (Mae, interview, March 28, 2018). She stated that she was driven to find a career where she could make a good living and not be reliant on others. She also described herself as never being "super girly" and that the majority of her friends were male (Mae, interview, March 28, 2018). Even at her young age, Mae experienced the social pressures to choose more feminine careers (e.g., secretary); however, as she explained in the first interview, she likes "to push the boundaries and go a little bit against the flow and a lot of that comes from doing things that normally men do, such as programming" (interview, March 28, 2018). At the same time, she recognized how isolating it can be to go against the flow by choosing a non-traditional career path, where she was often one of only a few women in her courses.

Katherine. Katherine is a quiet and somewhat shy 19 to 21-year old White woman who speaks deliberately and matter-of-factly. At the time of the interview, Katherine was finishing up her second year at NCU and pursuing a bachelor's degree in GD. She also informed me that she enjoys playing video games in her free time as well as the fantasy-based card game, *Magic: The Gathering*.

Unlike the other participants in this study, Katherine does not have a passion for math, robotics, engineering, or science, and instead sort of stumbled into her major. In high school, Katherine loved painting and drawing and really wanted to pursue some sort of art degree where should could express her creativity. Katherine's parents were a strong influence on her decision-making process, and they expressed concern about pursuing a career in art where they felt there may be limited opportunities and a lack of financial stability. She then considered becoming a veterinarian because of her love of animals; however, she was worried that her math and science abilities could prove to be a detriment in the extremely competitive field.

After much research and thought, Katherine finally landed on the idea of becoming a video game designer because it was "a platform that you can share with other people, share stories, experiences, or just ideas that you might have" (interview, April 18, 2018). Katherine was more interested in the artistic side of game design as it would allow her to be creative and delve into story development, which is the part of game design she really likes. After doing some more research, she also found that there were good paying career opportunities and was able to convince her parents of the viability of the career path. She applied to NCU, but inadvertently selected the computer science game development major and not the fine arts game design major as she intended. She was accepted into the Game Development program and then sought input from the president of a small video game company where she worked as part of her high school senior project. The president of the video game company advised her that programmers typically have more say than artists in the final direction of a game. As a result of the conversation, Katherine decided to pursue the computer science Game Development degree.

Katherine struggles with the degree's required math classes (e.g., having to take the second-level calculus class twice because of grades), and as a result it tends to affect her confidence in her abilities. With regard to her math courses, she stated, "I feel like I'm struggling to understand topics that other people are picking up right away" and described similar feelings about her programming skills, "I always feel like, oh, this is not good enough yet or like other people's games, theirs are so much better" (Katherine, interview, April 18, 2018). At the same time, Katherine's feelings of inadequacy may also be rooted in her perceptions that men know more about computers. She explained that she is often one of only a few women in her major-related courses and that it sometimes feels like "this is a major [Game Development] for guys like, you know, guys are supposed to be nerdy and know how to work a computer" (Katherine, interview, April 18, 2018).

Margaret. Margaret, a White woman in her early- to mid-twenties, was finishing her last semester at NCU during the spring of 2018 where she graduated with two degrees, one in SD and the other in GD. Margaret was in her final year at NCU and was, as she described, suffering from senioritis because she had already landed a job set to start shortly after graduation. She was excited to start her new career, but still was not sure what she wanted to do for a career long-term. Margaret chose the degrees she did because, "[t]here's so many different places I could work, I could work almost anywhere. ... I like that openness" (interview, April 13, 2018).

In high school, Margaret thought she was going to go to college and pursue a degree in business; however, when taking business courses in high school, she thought, “this is boring and too easy for me” (interview, April 13, 2018). She had been taking a number of science courses and also participated in the Science Olympiad, a K-12 based science competition, which she found to be more interesting. It was through the Science Olympiad that she was introduced to NCU and decided that was where she wanted to go to college. In her senior year of high school, a friend from the Science Olympiad suggested that she take a C++ programming course. Margaret described her experiences, “I struggled with it so much at the beginning of the semester, but by the end of the semester I was helping my friend do it” (interview, April 13, 2018).

Margaret explained that her fascination with programming was not sparked by a person, such as a teacher or family member, but instead by computers themselves. She studied French in high school and wanted to learn more languages, but, was unable to do so because of the number of elective science courses already in her schedule. Margaret came to the realization that learning a programming language was similar to learning a language like French. According to Margaret, “you're just learning how to talk to the computer and some of the words are still in English” (interview, April 13, 2018). It’s not a spoken language — “no one's going to talk in C++ or Java” — but she discovered that programming languages allow humans to communicate and interact with computers in very specific ways in order to accomplish different types of tasks (Margaret, interview, April 13, 2018).

Despite learning computer programming in high school, thereby putting Margaret’s skills ahead of some and on par with other classmates, she explained that her confidence varied throughout her college career. High school came easy for Margaret; she studied little and still received good grades and this led to her feeling highly confident upon entering NCU. In addition, her first computer science course came easy and she described herself as feeling “really confident about everything” (Margaret, interview, April 13, 2018). Things changed during her second year when her coursework started to get more difficult and she started working in the computer lab, where she was hired to tutor students who needed help with their programming assignments. Instead of bolstering her confidence, she explained that it left her feeling like “I can't help anyone. I can't figure out what's wrong and I was so upset” (Margaret, interview, April 13, 2018). She had a difficult time understanding some of the code students brought in, which made her doubt her own abilities. At the same time, Margaret started experiencing some harassment issues with male classmates, which also caused her confidence to plummet. However, in her junior year, after taking more programming courses and continuing her work as a tutor, she began “understanding and like doing really good in the tutor lab” (Margaret, interview, April 13, 2018). She was able to solve other student’s coding problems and Margaret explained that helping others reinforced her own knowledge and made her more confident.

Summary

In this chapter I presented detailed descriptions of the school and classroom contexts, profiles and perceptions of the program directors, and profiles of each of the participants. The contextual data demonstrated the typicality of the NCU computer science offerings and learning environments; thereby indicating the experiences of the women at NCU are likely transferable, or as Stake (1995) refers to it, naturalistically generalizable, to experiences of women in similar contexts at other universities. In the next chapter, I discuss the findings from the thematic analysis of interview and observation data.

CHAPTER 5

FINDINGS

Synthesis combines different things in order to form a new whole, and it is the primary heuristic for qualitative data analysis – specifically, the transition from coding to categorizing (and from categorizing to other analytic syntheses).
Johnny Saldaña (2016, p. 10)

Whereas the previous chapter provided the case's contextual background and introduced the participants, this chapter presents the core thematic case findings that illustrate the richness of the experiences of the women who participated in the study. The chapter is organized by theme and each of the seven resulting themes will be discussed in detail, beginning with duality. The theme of duality is presented first because it is at the heart of the women's experiences and permeates throughout the remaining themes. The next four themes (*Not Being Heard, Just One of the Guys, Overachievement and Perceived Academic Self-Efficacy, Confidence*) tease apart some of the feelings and experiences that occur when opposing cultural demands (*Theme #1: Duality*) are at play. They are presented in no particular order. The theme of exclusion and isolation is presented next because it describes how the experiences related to the prior themes ultimately manifest. Regardless of the decisions the women make, they ultimately find themselves alienated from one cultural group or another leaving them feeling as if they are alone in their pursuits. *Support from Professors* is the final theme. It is presented last because it was a significant type of buffer experienced by the women that counteracted some of the feelings of isolation and exclusion.

The seven themes that emerged from the data are presented below. In several cases sub-themes have been identified and they work to clarify and support the main ideas and concept presented in the parent theme.

1. Duality
2. Not Being Heard
3. Just One of the Guys
    a. Stereotypical male interests
    b. Predominantly Male Friends
4. Overachievement and Perceived Academic Self-Efficacy
    a. Presumptions about men and computing
    b. Impression management
5. Confidence
    a. Imposter syndrome
6. Exclusion and Isolation
    a. Physical isolation
    b. Gendered microaggressions and harassment
    c. Emotional isolation
7. Support from Professors

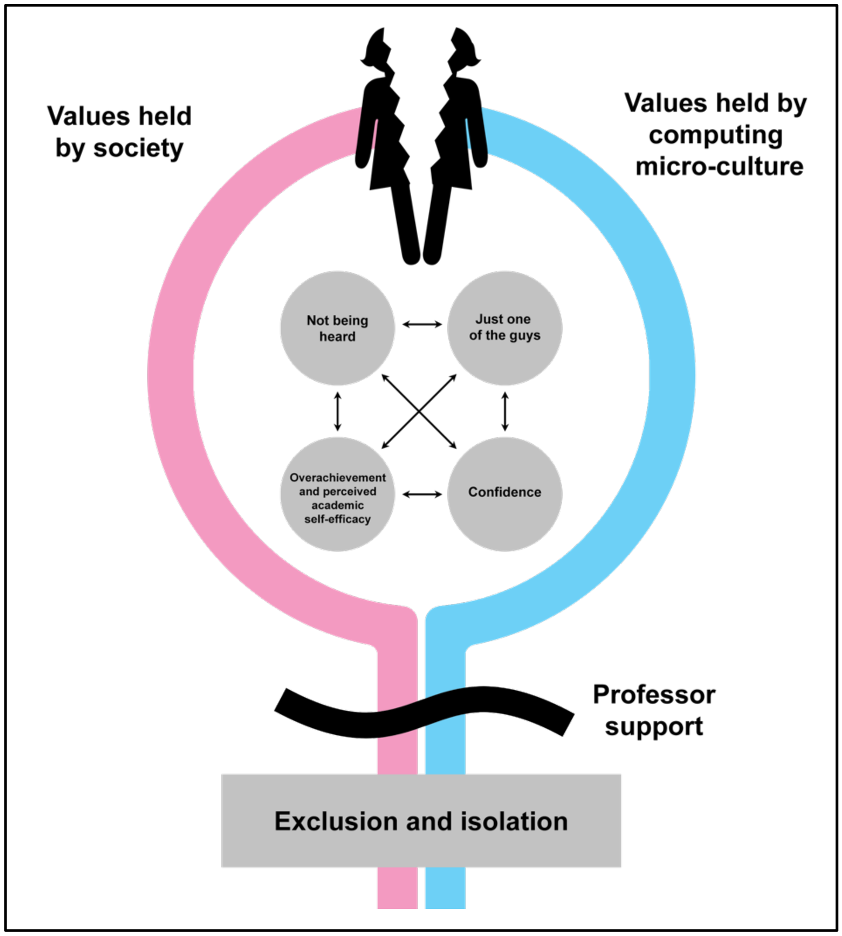

Figure 5.1. Cultural duality of women in computing. Values placed upon women in society differ from those of the computing micro-culture, thus leading to internal conflict.

Theme 1: Duality

Computing and technology have been associated with masculine traits (e.g., being logical and rational) for decades, and in recent years computer expertise has even been recognized as a form of male prowess (Kendall, 2011). Conversely, female traits have been typically defined as being emotional, soft, non-technical, not adept in math and science, and more likely to pursue the humanities and social sciences (Eccles, 2011; Kendall, 2011; Sczesny, Bosak, Neff, & Schyns, 2004). The participants in this study were hyper aware of their gender and as a result found themselves in a sort of internal culture clash. On the one hand they self-identified as female and along with it were aware of all of the associated gendered and cultural assumptions. On the other hand, because of their interests and aptitudes, they were pursing degrees in male-dominated fields that hold different values and attitudes regarding what it means to be female. Their gender was always front-of-mind and ever-present within their academic experiences at NCU.

Men are the dominant gender in computing and technology and, therefore, do not need to think about what it means to be male or how to express their maleness (Kendall, 2011). This is the case because over the course of time, the members have established the rules, values and beliefs of the computing and technology micro-culture (e.g., male, White or Asian, knowledge and skillset, hobbies). However, women, even those who possess some of the requisite values of this particular micro-culture, are seen as outsiders simply because their gender does not fit with one of the tenets of the computing micro-culture — that the members are male.

The women in this study were consciously aware of their femaleness even if their male counterparts did not overtly call attention to it. Anita stated it this way, "It's just constantly being like hyper aware of being the only girl, but then I also try and tell myself, like it doesn't matter. I need to just learn and get what I can get out of it" (interview, March 26, 2018). Unlike their male classmates, the women continuously needed to make choices between remaining *unseen* and therefore being *just one of the guys* or exposing themselves as being *other* to get the most out of their education, regardless of how others may perceive them.

Because their gender was in the minority in the programs at NCU, the women were forced to navigate an extra layer of complexity when working with classmates. Recognizing their outsider status meant the women frequently found themselves questioning whether a misunderstanding, conflict, or sometimes, just a sense of unease, was because they were women or if it would have happened regardless of gender. For example, Mae and a male partner were discussing the work they needed to do on a team project when he instructed her to take on a particular set of tasks. According to Mae, he did not seek her input and "just kind of assigned it" to her (interview, March 28, 2018). She was taken aback and wondered if the encounter would have transpired the way it did if she were a male in the same situation. Mae reflected, "Maybe he would have done that with a guy. I don't know. Maybe that's just how he is" (interview, March 28, 2018). After Margaret experienced a number of confrontations with a male classmate, she found herself asking questions similar to Mae's, "I can still never tell if it's just like they see me as a person, or it's because I'm a girl" (Margaret, interview, April 13, 2018).

Figure 5.1 reveals how this conflict between cultural expectations impacted the experiences of the women in the study. The dissonant cultural demands forced them into continuous cycles of questions, choices, and decisions (e.g., remaining silent or speaking up, being one of the guys or bringing attention to differences) that they must navigate to bridge the cultural chasms, come to know themselves, and determine where and how they fit.

One example of this duality was observed when Mae discussed the challenges she encountered when she wanted to join a computing and technology student organization. She first attended a couple of the general Applied Math Computer Science (AMCS) Club meetings, and described her experience as, it “felt like it's not the club for me because it's a bunch of dudes” (Mae, interview, March 28, 2018). Feeling intimidated, Mae then attended a couple of meetings of the AMCS Women’s Club, thinking that the organization would be similar, but with female members. Instead, she was frustrated when she discovered the focus was on being “cute and girly” and according to Mae, they were “making Valentine’s Day cards for the professors with math jokes” (interview, March 28, 2018). She described her experience with the AMCS Women’s Club, “This is not what I want. I wanted to go program like the AMCS men’s does” (Mae, interview, March 28, 2018). Mae’s choice came down to either being the only woman amongst a group of men but doing the coding that she desired or being with a group of women but focus on feminine activities and not coding. Since interviewing Mae, she has become an officer for the AMCS Women’s Club and has worked to change the scope of the organization to align more closely with the AMCS Club (i.e., men’s club), where the focus is on computer programming and other technology activities.

Another example of cultural duality has to do with the women’s decision to ask or answer questions in class. As the only woman or one of only a few women, asking a question or answering a question in front of a room of men opened them up to judgment by their peers. For instance, Brian, the AMCS program director and Anita’s advisor, described Anita as “the best programmer” in the advanced class he was teaching (Brian, interview, March 20, 2018); yet despite this, Anita explained to me that, “I wouldn’t answer questions [in class] as much because I don’t want to be like, the dumb girl in class” (interview, March 26, 2018). She went on to admit, “I’m fighting that every day because I’m like, I don’t want to like *not* ask a question or answer because this is a learning experience and who cares what [the men in the class] think" (Anita, interview, March 26, 2018). Margaret also summed up this aspect of personal duality well:

> When you do really well, nobody says anything. It's only when you do bad. And yet the guy, it's still funny to me though, because guys don't care if other guys like bomb tests and some of them feel like, 'Oh I did so bad on that.' And I'm like 'Okay, but if I were to do that bad, you would judge me' (interview, April 13, 2018).

Katherine was also concerned about being judged, but it was in part based on her own assumption that "Guys know a lot more than girls do about computer stuff. … They probably took computer science classes in their high school years" (interview, April 18, 2018). Her belief that men were better at computing meant that she was tentative about asking or answering questions in class. Katherine also divulged that she sometimes resisted seeking help if she encountered problems with her homework because she was embarrassed about being behind on her work due to not understanding a given topic. She was concerned that her professors would negatively judge her.

The women also struggled with divergent cultural expectations regarding their role within group situations. Each of the women in this study were quite driven to succeed. They wanted to speak up and make sure that everyone on the team (in most cases all male students) was doing their part to complete an assigned project, but at the same time, they did not want to be perceived as a "nag" or "bitch" by their teammates. Even though Katherine exhibited leadership by determining the work that needed to be done and delegated tasks to team members, and otherwise took charge of the group to ensure that the work was getting done on time, she still did not consider herself the group leader. When asked about times when she was uncomfortable in class, Katherine explained, that it was "Probably when I feel like I have to like pressure someone to make sure that they get the work done or to ask about if they're getting their workload done" (interview, April 18, 2018). This inner struggle between wanting to ensure the team completed their work and the potential for being seen in a negative light for being the taskmaster was very real for Katherine. If one of her male classmates had stepped into the lead position, he would likely not face the same conflict. The requirements of the position and the actions taken would be the same regardless of gender, but the team's perceptions of the leader would presumably be different. Leadership roles tend to shine a spotlight on an individual, but for a woman, claiming a leadership role in an otherwise male group, can also bring attention to her gender, further separating her from the group.

On the other hand, as was the case with Margaret, she stepped in to complete work that was considered menial and feminine by the male members of her group. The artists on Margaret's team (who were predominantly female) needed assistance uploading files and similar tasks that were critical to the success of the team's final video game project, but the task did not require special talents or skills in art. She explained:

> [The guys in the group] didn't want to help the artists even though it was our job. … So, I would volunteer to go when nobody else wanted to go, which kind of sucked. But it wasn't like it was volunteered, but kind of like someone had to do it and none of the guys would do it (Margaret, interview, May 8, 2018).

The type of situation described by Margaret is not uncommon in our society. Women are more likely than men to be relegated to a secretarial role in group situations, where they are expected to take notes and conduct various menial tasks instead of contributing in more substantial ways.

In the previous examples of duality, the women were apprehensive about how they would be judged by their male peers for asserting themselves and exhibiting more masculine traits; however, they were also hyper aware of their gender and stereotypical feminine behaviors. One of the ways in which they were conscious of their femininity was in what clothing they chose to wear to class and how they would be perceived. Anita was aware of striking a balance between dressing in a classically feminine manner and being a "tomboy" (interview, March 26, 2018). She described herself as "I'm not the most feminine wearing person. Like I don't wear dresses and stuff all the time and I'm not overly fond of pink, which is the normal connotation of feminine, but I definitely don't dress like a tomboy" (Anita, interview, March 26, 2018). However, she did go on to say, "The girls that aren't as feminine in their dress and stuff, I think are the ones that definitely I see hanging out with the guys" (Anita, interview, March 26, 2018).

Where Anita was cognizant of what she and other women in her major wore, Katherine expressed more unease; "I sometimes get self-conscious about like what I might be wearing and then like who's behind me and stuff like that. … If it was a whole classroom of girls. I wouldn't be as concerned" (interview, April 18, 2018). Some of Katherine's discomfort was likely based on her desire to be taken seriously as a computer science student and not have her abilities judged based on her experience. Another reason Katherine may have expressed unease about what she wore when attending classes was to avoid sexual overtures or having her requests for help misconstrued as expressions of potential interest or attraction. She explained it this way:

> Because it's easier to connect with women than it is to have a girl chat with a guy and like, just get help and you know, the casual, like, *I just want help please*. Um, yeah, it's less awkward (Katherine, interview, April 18, 2018).

Aside from dress, the women were also aware of other facets of their femininity, such as being *soft* or *emotional* compared to their male counterparts. When I asked Sally to compare her skills and abilities with one of her male best friends, she said, “On the more technical side of things, I think he has slightly stronger skills than mine and I think my skills lie a lot more on the maybe more softer side” (interview, May 1, 2018). Sally was a skilled programmer; however, she chose to describe her male friend as having stronger coding skills and attributed herself with more female traits. Margaret and Anita both expressed to me their concerns over being considered an emotional girl by their classmates. Anita chose to walk away from potential confrontations as to “not cause any issues in the group” (interview, March 26, 2018), whereas Margaret was more confrontational, even though she admitted to me that she cries easily. Margaret explained that she cries when she is sad, frustrated, or angry and it has caused her to avoid taking certain professors and leaving classrooms during heated disagreements with male classmates.

Much of personal duality is located at the nexus of societal norms and expectations of what it means to be a woman and the rules, beliefs and values associated with the computing and technology micro-culture. As a result, there are separate rules in which the abilities and performances of women and men in the same field are being judged. The women described situations where they encountered the divergent rules and expectations. In each situation they were forced to make a decision as to which cultural paradigm they would adhere to or challenge. The concept of dual and conflicting cultural values that women face in the computing and technology field is a fundamental and significant finding of this study. Dualism, therefore, serves as the cornerstone for the remaining themes discussed in this chapter and each are deeply intertwined with this concept.

Theme 2: Not Being Heard

The participants repeatedly expressed frustration at having to work harder in order to have their contributions recognized as being valid, especially when working on team projects. The experience of not being heard manifested in multiple ways, including being ignored, not being taken seriously, or being pushed out. For example, Sally, who is naturally an outgoing person, felt she needed to "talk just a little bit more or mention [her] idea just slightly more than other people to actually have it be heard as a genuine reality" (interview, April 4, 2018). Unfortunately, being assertive (e.g. "talking a little bit more"), confronting others about being dismissed, or even speaking with an instructor about an issue with a classmate has the potential for creating an even greater chasm and to *other* the women even further from the group. Anita addressed this duality a couple of times in our conversation. She said, "I don't want to be that, like the emotional girl who's like always complaining about not getting enough time to talk" (Anita, March 26, 2018). She later shared, "I felt like I had a valid point and it just got ignored, and I'm like, do I bring it up? And I didn't actually bring it up because I didn't want to cause issues in the group" (Anita, interview, March 26, 2018).

In another instance Mae described how she was regularly ignored by a male group member when she tried to rein in the scope of their mobile game project. Her male teammate came up with the original concept for the game, and according to both Mae and Linda, who teaches the class, the male programmer had really big ideas for the game. Linda, explained:

> She [Mae] works very hard. … And she [Mae] keeps saying, you know, oh, I don't know if we can get all this done. But he [male programmer] just kind of

> brushes that aside and so I have to keep reining them back. You can't get this all done (interview, April 11, 2018).

And in yet another case, Margaret's request for specific tasks on a team project were not being honored. In the GD classes, each team has an electronic task board where the individual members sign up for the particular coding tasks they want to work on. Once a person claims the task, the individual's name appears by the task and it is marked as 'in progress.' Despite signing up and following the process, someone else continually took over Margaret's tasks. It happened so often that Margaret thought about giving up, "Like, first semester, I gave up because this was like a whole year class, and I just gave up. I was like, I'm not going to do any of this anymore" (interview, April 13, 2018). She eventually talked with her instructor who hypothesized that the male student in the group was "just trying to help" (Margaret, interview, April 13, 2018). While Margaret decided to continue both with the class and the major, she remained skeptical about her classmate's intentions. She informed her classmate in as she described it, a kind of "snippy tone," that "I will ask you if I need help, but I got this. … I just need time to work on it" (Margaret, interview, April 13, 2018).

Anita and Margaret both experienced times where their ideas *were* taken up by their teams, but they were ultimately brushed aside and no longer active participants in parts of their own projects. While the initial idea may have been accepted by the group, additional contributions by Anita or Margaret were ignored or dismissed. Anita expressed a couple of instances in the same class where her ideas were accepted and then she was no longer involved in the coding and furtherance of the development. The first experience she described stemmed from simply wanting to bounce an idea off of one of her classmates as she was unsure how to proceed on a coding task. She explained to me during our first interview that she had some ideas on how to accomplish the task but wanted some input. Once she described her idea to her male teammate:

> He started working on it, and then this other guy came in and they started working on it together and then I was like, not in the conversation anymore. … Because I did come up with an idea and they gave credit to a different guy for it" (Anita, interview, March 26, 2018).

She recounted that experience made her feel; "That was just really disempowering" (Anita, interview, March 26, 2018).

The second occurrence where Anita was brushed aside happened when she was helping her younger brother, Caleb, who is also an SD major and was in the same class. He had a question about how to deal with a particular database query. Caleb was not overly familiar with SQL, a database query language, and therefore was unsure how to code that portion of their group project. He asked for Anita's help. Anita began a discussion with the classmate she had worked with to create the original database on ways in which they could create the necessary queries when, "this other guy [on their team] interjected and then they went off and did their own thing and I was left out of the conversation at that point" (interview, March 26, 2018). She had co-created the database the team was using but was pushed out of the conversation completely. Anita did not share with her group how she felt for fear of causing issues within the team, but she expressed her frustration to me:

> I mean, it's not the end of the world to change it, but also, like, you know, I designed it, so it'd be nice if you like included me and asked me about why I chose to do this. Because I actually worked on it with my older brother who is a database professional for IBM. So, it was kind of like, I mean, we choose to do it a certain way because that's how we thought it was going to work (interview, March 26, 2018).

Anita went on to describe how she has become more careful about when she shares her ideas and how much code she has completed before seeking input because of these types of experiences. She explained how she used ask for ideas from others when she was just “pondering over some idea” and did not necessarily have a clear plan, but then “they would just take it away from me” (Anita, interview, March 26, 2018). These types of experiences, where her voice was erased by her male classmates caused her to change her approach to asking for outside contributions. She told me, “I definitely think out my plan much further before I ask for input” (Anita, interview, March 26, 2018).

Margaret had a similar experience in a GD class. The team was working together to create a game where the idea was originally pitched by Margaret. As the development progressed, the game became less and less like Margaret’s vision because, “certain guys in the class, who I had issues with got their little hands on it and took out what I wanted to put in their stuff” (interview, April 13, 2018). Throughout both interviews, Margaret expressed frustration with a couple of male classmates that not only were in her classes, but in some cases, they were all on the same game development team. Margaret disclosed to me that this same male classmate would not share his code with her, so the components they each worked on would not work together; they were incompatible. “He still wasn’t giving us [the team] anything to work on and my code never worked with his because I never got to see his code” (Margaret, interview, April 13, 2018). Margaret is emotionally sensitive, and told me that she cries easily, including when she is angry or frustrated. The exchange between Margaret and her male classmate escalated to point that she was so exasperated she was brought to tears because he was not willing to work cooperatively with her. She described the encounter as him stating, "I don't know why you're so upset. Like why do you keep crying? Why are you upset?" She responded to him by stating, "Because you don't listen" (Margaret, interview, April 13, 2018).

Being ignored or feeling brushed aside presents challenging dilemmas for women in computing majors where they are in the minority. Sally, determined that she needed to be more assertive, even though she is outgoing and appears to already be self-assured in her own abilities. Mustering up the courage to be assertive in order to heard can be difficult for shy or quiet individuals, but that is the case regardless of gender; however, being in the minority presents additional difficulties.

Sense of belonging is accomplished when an individual feels they are valued, their contributions matter, and that they are an integral part of a team (Goodenow, 1993; Good, Rattan, & Dweck, 2012; Hoffman, Richmond, Morrow, & Salomone, 2002; Strayhorn, 2012; Tovar & Simon, 2010; Trujillo & Tanner, 2014). Intentional or not on the part of the male students in the situations described above, their behaviors served to disempower and alienate the female members on the teams, making them feel like outsiders.

Theme 3: Just One of the Guys

> "Generally, it didn't really matter that much [that I was the only girl] because, like in high school, I took AP physics. We had like two other girls. I was used to it."
> — Margaret, first interview, April 13, 2018

Because of the male-dominated nature of their chosen area of study, all five of the women have adapted in some way to being *just one of the guys*. This theme is complex and each of its two sub-themes (stereotypical male interests and predominantly male friends) are heavily intertwined and interrelated with one another. The sub-themes describe the women's nature of being and integral aspects of their experiences because of who they are and what they are interested in. Together, these two sub-themes present the complex circumstances in which the women exist and the decisions they make to rationalize and construct their dual existences as women in a male-dominated field.

Stereotypical male interests. Not only have the women in this case study opted to pursue a degree and ultimately, a career, in male-dominated fields, their academic interests oftentimes are also stereotypically male, including math, science, and robotics. Academic and personal interests in these areas indicate that the pursuit of computing degrees is likely not an isolated interest in topics that are generally considered male. Despite the fact that more women now attend college and university than men (Lopez & Gonzalez-Barrera, 2014), women are still less likely to pursue degrees in engineering, computer science, mathematics, statistics, and physics than their male counterparts (National Science Board, 2018). This means that the "hard" science (e.g., chemistry and mathematics) and engineering fields still tend to be male-dominated. Passion for math and science related fields was expressed repeatedly by four of the five participants. Katherine was the only participant who did not express academic interests in math and science; in contrast to the other women in the study, these were an area of difficulty for her.

Anita was enthusiastic, specifically about math, "I've really liked math. I did well in math. I took AP calculus, like the works" (interview, March 26, 2018). She went on to describe how she sees her interests in math and biology intersecting, "I liked the idea of where mathematics merges with like, other fields of sciences" (Anita, interview, March

26, 2018). This is further evidenced by her lived experiences and future aspirations. For example, Anita already had earned a bachelor's degree in ecology and environmental biology when she began her pursuit of a second bachelor's degree, this time in SD. The team project in her SD senior capstone course was a continuation of a wildflower database project she started while taking a database structures course. The searchable database was being created for one of the biology professors at NCU to use in his courses. When asked what her dream job would be, she explained, "I would prefer to do environmental science and applied math, looking at different environmental problems and seeing if there's ways that we can use machine learning or mathematical modeling to kind of figure out some solutions to those" (Anita, interview, May 2, 2018).

Sally and Mae shared Anita's enthusiasm for math, but their interests also included engineering and robotics. Sally referred to herself as a "huge math and science nerd" (interview, April 4, 2018) and Mae described her how a teacher influenced her, "I love math because of her. I always knew that the logical kind of thinking is something that I should use to my benefit because I'm good at it" (interview, March 28, 2018). During the interviews with Sally and Mae they both expressed interest in pursuing careers in engineering. In Sally's case, she thought she "was going to go into electrical engineering or software engineering" because she was on her school's robotics team for four years and held an office position for two years (interview, April 4, 2018). During her time on the high school robotics team, she was occasionally the only girl and there were at most four females on the team out of 50 people. Sally said that she "spent a lot of my extracurriculars in high school, a lot of my classes in high school surrounded predominantly by men. So, it's kind of become a thing that I'm just kind of used to" (interview, April 4, 2018). Sally acknowledged that her interests in math and science will likely mean that she spends most of her time surrounded by male peers. She viewed her experiences in high school as a sort of preparation for college and her future career. Unlike Sally, Mae explored multiple interests throughout high school. She explained during our first interview that she examined interior design ("I don't art"), architecture, mechanical engineering ("because I wanted to put things together with my hands and then realized that's not what mechanical engineering is"), and electrical engineering, before she landed on SD and GD (interview, March 28, 2018). She explained that "none of the girly careers appealed to me. I knew I wanted to do something science-related or technology-related" (Mae, interview, March 28, 2018).

Margaret became interested in computer programming in high school and was also an active participant in the Science Olympiad, a national organization where teams of students compete to showcase their knowledge in a variety of science topics. Margaret informed me that she took a lot of science electives in high school because she "didn't like any of [the] other electives because they were like, home ec" (interview, April 13, 2018). One of the electives she decided to take was a class introducing students to C++ (a programming language). A friend of hers was taking the class and she thought it was interesting because she liked learning different languages and computer programming is in essence a language. She described it as:

> Learning how to talk to the computer and while some of the words are still in English, I mean no one's going to be like saying those things. … but like no one's going to talk in C++ or Java, but you talk with a computer (Margaret, interview, April 13, 2018).

Margaret joined the Science Olympiad team at her school because her then boyfriend was on the team. In the end, they broke up, her now ex-boyfriend quit, but Margaret stayed on the team because, as she stated, "I love this" (interview, April 13, 2018). Her love of the Science Olympiad is what ultimately led her to NCU and her degree path. NCU hosted the statewide Science Olympiad competition while Margaret was competing in high school. She discovered that she liked the campus and then began exploring degree options, ultimately landing on SD, and then later adding a second major in GD.

The women in the study also enjoyed extracurricular activities that are generally associated with being male, especially playing video and tabletop role-playing games and watching anime. The percentage of women who consider themselves gamers and play video games regularly is on par with men (Duggan, 2015); however, the stereotype remains that the average "video game player is a young, white, heterosexual male" (Romrell, 2014, p. 170). Sally informed me that "as a teenager I played all sorts of different games" and that she's "been playing forever" (interview, April 4, 2018). Katherine summed up the average GD student, "We all like video games, to be honest" (interview, April 18, 2018). It was their love of and passion for playing video games that inspired Sally, Mae, and Katherine to pursue degrees in GD so that they could learn how to create their own games. Sally goes beyond being a game enthusiast. She serves as the Event Coordinator for the student organization, PONG (People's Organization of Network Gaming), where the acronym pays homage to the 1970s video game Pong. As event coordinator, she works with the student center staff to secure a location for the club's LAN (local area network) events and works with campus information technology staff to get the network set up. LANs are computer networks that are often self-contained and connect computers in a relatively small area. The LAN events, or parties, as they are often called, are where a group of people sitting at computers are connected with the purpose of playing the same multiplayer game together. Sally has also participated in two Game Jam sessions where groups of students get together and over a 40-hour period concept, code, and create all of the elements for a game so that it is playable in the end. Katherine and Mae also expressed interest in participating in the Game Jam sessions, but the timing of the event has not worked well with their school and work schedules.

There are some hobbies or interests that are often associated with part of the male, computer geek culture, including tabletop role-playing games (RPGs) and watching anime (a stylized form of animation associated with Japan). According to a market research report, the overwhelming majority (80 percent) of tabletop RPG players are male (Dancey, 2000). Newer data on RPG demographics could not be found but it can be surmised that since tabletop RPGs have historically been male-dominated, it is still perceived to be a male pastime. This would be the case, even if the number of women who play has increased in recent years. While there are different styles of anime that appeal to different genders and tastes, a 2016 report from the International Anime Research Project indicates that anime fans are predominantly white, heterosexual males (Reysen, Plante, Roberts, Gerbasi, & Shaw, 2016). During the first interview with Katherine, she informed me that she and a female friend were going to one of the local game shops, “to go play at the Magic pre-release” (interview, April 18, 2018). She expressed that playing *Magic: The Gathering*, a card-based tabletop RPG, was something she and her friends did often. Anita, who was not interested in video games, did regularly play the tabletop RPG *Dungeon’s & Dragons* with a group of male friends, including her younger brother, Caleb. Finally, while Mae claimed that she was not "super into anime," it came up several times in our conversations, including a particular anime series, that in part inspired her to pursue degrees in GD and SD (interview, March 28, 2018). The anime series prominently featured the use of virtual reality to create a massively multiplayer online game. She described how watching the series impacted her as "I got really excited about making virtual environments and just being able to give people an experience that they can't get in real life. So that has stuck with me" (Mae, interview, March 28, 2018).

Predominantly male friends. While not quantifiably substantiated, I observed that the participants tended to have a high number of male friendships. Common interests provide a foundation for individuals to come together and is one way in which friendships can be formed. If it is assumed that individuals typically tend to partake in societally gender normative interests and hobbies, then it is logical to conclude that under ordinary circumstances women are likely to have more female friends than male friends and vice versa. As discussed in the previous section, the women in this study were interested in careers in the fields of math, science, and engineering and/or participated in video games, RPGs, anime, or other personal pastimes typically associated with being male. Therefore, it is conceivable that because of their academic pursuits and/or personal interests that they were more likely to share common interests with male peers and consequently have a high number of male friends. Mae expressed that she has "never felt like, super girly" and that she has always had more male friends because she "just relate[s] to them better" (interview, March 28, 2018). This sentiment was also shared by Margaret who said, "sometimes I get along better with guys than girls" (interview, April

13, 2018). Katherine's beliefs and experiences aligned with the aforementioned assumptions, but also introduced another possibility of why the women in the study tended to have more male friends than female friends — that of "see[ing] each other around" (interview, April 18, 2018). She summarized her beliefs this way:

> It would go along the fact that guys can bond with guys and girls and guys being friends is something that you either know the person for a very long time and you get along or you have a lot of shared hobbies and so you see each other around and so, you know, you bond in that way (Katherine, interview, April 18, 2018).

The higher likelihood of male friendships may also have been the result of proximity and convenience, meaning that the women were regularly in the minority and the majority of their class and study time was spent with male classmates. Mae talked about having more "guy friends in the field" and intentionally would try to take classes with them (interview, March 28, 2018). This was also the case for Sally and Brendan (a pseudonym), a male classmate she sat next to in one of the classes I observed. The students in this particular course generally worked independently, but Sally and Brendan spent a fair amount of time interacting with one another. They would help each other with class work, talk about interests outside of class, and joke around. In our second interview, I asked her about the relationship. She informed me that Brendan was one of her best friends and she also made it clear that they were platonic friends and that he was not a romantic interest. Sally explained that they originally met at LAN events sponsored by the student organization, PONG. Sally stated:

> We saw each other at LANs and we saw each other in classes, but not like, well not much until that project. And then that project kind of like extended things and then after that we've kind of been like really good friends (interview, May 1, 2018).

The project Sally references was a group project for a class where her and Brendan spent a fair amount of time working together. She went on to tell me that since that class she and Brendan intentionally try to schedule as many of their classes together. During the semester when the interview took place, three of Sally's four classes were with Brendan.

Anita also had many male friends, but she attributed some of that to her younger brother, Caleb also being in the SD program. She explained it to me this way, "I feel like part of it is because I'm in so many classes with my younger brother and so he's friends with the guys in the class and … I've made some male friends because of him" (Anita, March 26, 2018). Because Anita already held a bachelor's degree when she arrived at NCU, she was not enrolled in general education courses where there is a more even distribution of male and female students from which she could form friendships. Instead, Anita established her friendship network through Caleb whose friends were also part of the SD program and male. But even when expanding beyond Caleb's network, Anita's new friends were classmates she knew from the AMCS degree program and therefore, were also more likely to be male.

If in some cases friendships emerge out of convenience, meaning friendships form with the people one is surrounded by on a regular basis, then it is understandable why so many of Anita's friends were male. In one of the classes I observed, Anita was the only woman and in the other class I observed, she was one of four women in a class of approximately 25 students. In the class with multiple woman, Anita did sit near a female student, but she also informed me that the two of them were not friends outside of class. Regardless of whether the friendships came about because Anita was introduced by her brother or whether she sought them out on her own, the majority of people she interfaced with daily were male. Furthermore, Anita informed me that even in classes where there are other female students, she does not "want to be that girl that's only clustering around the other girls" (interview, March 26, 2018). Similarly, Mae shared, "I don't feel comfortable walking up to the only other girl in class and saying, 'Hey, let's be buddies,' just because we're girls" (interview, March 28, 2018). In other words, Anita and Mae made conscious decisions to not necessarily befriend other women in their majors solely based on gender.

Theme 4: Overachievement and Perceived Academic Self-Efficacy

> "I remember reading something about like, women in classes aren't perceived to do as well even when they are doing just as well. They have to do better than most of the men to be perceived as doing just as well."
>
> — Anita, first interview, March 26, 2018

The fourth theme, along with its two sub-themes (presumptions about men and computing, impression management) highlight the perceptions that the women have about their need and desire to demonstrate exceptional mastery of computer science skills. The first sub-theme, men and computing, examines how the commonly held stereotype that men are better at math, science, and working with technology, impacted the women's perceived self-efficacy. Impression management, the second sub-theme delves into how the participants enacted certain behaviors, such as overachieving, to control how others perceived them.

During the interviews, the women explained that the pressure they felt to excel, and in some cases outperform their male classmates, was based on an internalization of societal expectations and therefore, felt it was something they needed to do to prove they were capable. These behaviors were not the result of explicit external pressures made by male classmates or professors; instead, they were a result of what Cyencek et al. (2011) describe as deep-rooted cultural beliefs that seep into unconscious, individual beliefs. An example of how broad cultural beliefs can be internalized is evident in Mae's experiences. Mae recalled her time in high school and claims that she "can't think of a single time that someone approached me and said, 'Hey, you should be a programmer,' or 'You should be an engineer'" (interview, March 28, 2018). Instead, she received more stereotypical feminine messages, "I've had people tell me that I can be a designer or like, 'You're really good at organizing things. You'd be an awesome secretary'" (Mae, interview, March 28, 2018). She also talked about how society places a greater emphasis on women to "be pretty" or "be a good wife," and not on skills in science, technology, engineering or math (Mae, interview, March 28, 2018).

These broader cultural assumptions can lead to the types of beliefs held by the participants that their male classmates and professors were judging them and deciding whether or not they belong in the SD and GD majors. Anita expressed this self-doubt in a series of questions, "Are they judging me for what I'm saying right now or for when I'm asking these questions? And then, maybe, I answered a question wrong are they like, judging me because of this?" (interview, March 26, 2018). Like Anita, Mae found herself thinking about needing to prove she was capable, "It is a constant question in the back of my mind that I just don't know the answer to it. I always know, like maybe I don't need to prove it, but why not?" (interview, March 28, 2018).

The assumptions about how others perceive one's own group is referred to as a metastereotype. If a stereotype is an oversimplified set of beliefs held by one group of individuals about another group, then a metastereotype is the belief or assumption of how one's own group is stereotyped by others outside of the group (Gilrane, 2013). The way the women *think they are perceived* by their male peers in the male-dominated computing and technology field is an example of a metastereotype. Whether intrinsic or extrinsic, explicit or implied, the resulting pressures felt by the women were very real.

Presumptions about men and computing. Before delving into the women's desire to excel and the high standards they set for themselves, it is important to understand their beliefs about and attitudes toward the predominant members of the computing micro-culture. An assumption held by some of the participants is that that their male classmates know more about computing because of their hobbies and interests outside of class. This aligns with the findings of Margolis and Fisher (2002) who said that some women were doubtful of their own skills because they did not "dream in code" like their male counterparts (p. 5). A similar belief is evident in comments made by Anita during our first interview:

> I feel like a lot of the guys already know a lot about computers and programming and stuff because they play video games and like, they just do all this stuff that is foreign to me because I'm not a huge gamer (March 26, 2018).

Likewise, Katherine, who was the least confident in her abilities of the participants in the study, shared that when she began taking GD classes at NCU her mindset was that "guys know a lot more than girls do about computer stuff" and that "this is a major for guys. Like, you know, guys are supposed to be nerdy and know how to work a computer" (interview, April 18, 2018). These types of beliefs demonstrate how strongly held social stereotypes can leak into the beliefs of individuals, regardless of if there is any truth to the stereotype. The internalization of the stereotypes attached to computing led the women to not only question their own skills, but to wonder whether or not their male classmates acknowledged their abilities and contributions. Anita described her feelings about being the only female programmer in her senior practicum class, “Just being the only girl in a class. Like sometimes, I’m like, are they going to trust me because I’m a girl?” (interview, March 26, 2018).

Impression management. The stereotypes and resulting doubts experienced by the women manifested in a form of impression management where they overcompensated by excelling in order to offset the negative stereotypes and to demonstrate their competency of the subject matter. Margaret talked specifically about why she felt it was important to maintain an impression of being an excellent student, even when talking and working with a close male friend, who is also a SD student. She stated:

> I don’t know why, but I felt the need to like, not look dumb in front of him. Like, it was so weird, but I felt like I had to impress him or something or I cared what he thought, and I don’t know why because it was just a weird thing (Margaret, interview, May 8, 2018).

Margaret, Anita and Mae also shared with me that they expended significant effort on their schoolwork to counteract what they felt their male classmates, and to a lesser degree, their professors believed about women in computing. Margaret, who was particularly frustrated, explained, “Even if it’s to prove that you can do it, you shouldn’t have to be a straight A student to prove to these jerks that like, you can do stuff” (interview, April 13, 2018). She went on to share, “There is some pressure to do well because then otherwise people, like guys, might think, ‘Oh, well, see, women shouldn’t be here’” (Margaret, interview, April 13, 2018). Anita described to me how the pressure to succeed, was always in the back of her mind. She said, “I don’t want it to be perceived that women aren’t as good at programming and stuff” (Anita, interview, March 26, 2018). Like Anita and Margaret, Mae's perception was that men, and likely broader society, do not expect women to be as adept at computer programming; therefore, her goal was to dispel that belief by overachieving. She explained, "I like to go above and beyond what people expect. It's a lot easier to be underestimated in this field if you're a girl" (Mae, interview, March 28, 2018).

Technical prowess and aptitude are respected within the computing micro-culture; therefore, the women cultivated an impression where they excel, and sometimes surpass the skills of their male counterparts as a method for counteracting their detrimental femaleness. Thus, according to Servon and Visser (2011), "professional legitimacy is gained by a learned projection of behaviour or competencies" (p. 274) and the women were better able to feel a sense of belonging within their desired culture. One of the ways the women in this study crafted the impression of competency was by holding themselves to high academic standards. For example, Anita shared, "I have stricter goals for myself than I feel everyone else does," (interview, March 26, 2018) and Mae echoed, "I have very high standards for my own work" (interview, March 28, 2018). Establishing high standards meant that the women put in significant effort to understand the course material, submitted top-notch work, and ensured projects were done on time and exemplified excellence.

Achieving a greater degree of success than expected on their coursework and holding higher standards for themselves appears to serve a two-fold purpose; the first is directed inward towards self and the second faces outward towards their peers and professors. By performing better than expected, or even necessary, the women were reassured of their own capacity to learn and of their own self-efficacy in the field of computer science. Overachieving also projects outward to professors and male classmates that they are competent, thereby legitimizing their place within the male-dominated computer science field. The women's high standards for performance served as a sort of coping mechanism in which they project favorable impressions of themselves to others. "Impression management refers to the potential for individuals to adopt certain characteristics in order to create an impression of themselves which they hope will elicit a desired reaction" from others (Servon & Visser, 2011, p. 274). In the case of the participants in this study, their desired reaction not only sought to demonstrate competency, it worked at the same time to counter negative stereotypes of women in computing.

Putting in extra hours on projects to ensure they were done on time and done well was one way in which the women exceeded expectations. Mae let me know that she "spent 80 hours outside of class working on this game, which maybe doesn't seem like a whole lot, but it is when you're taking 17 credits and have two other jobs" (interview, March 28, 2018). Katherine also shared that she had put in nearly 100 hours on her group's game, including staying in the computer lab well past midnight on several occasions.

The women also took it upon themselves to ensure group projects were complete, even if it meant having to take charge or do a significant amount of work on their own. Sally described a game project where there was one other programmer (a male) and an artist in the group. The work was split up and within one week of the major student game expo on campus, when they should be doing final adjustments, they discovered that the game did not work. Sally explained:

> None of this is working and I looked at his coding [and] like half the stuff that I talked about wasn't even there. And I'm like, 'Oh, okay.' So, then I spend the next week trying to fix it and pulled an all-nighter the night before game expo to fix it (interview, April 4, 2018).

Katherine also worked with a group where one of the programmers did not pull his weight. Her team consisted of three programmers (Katherine and two male classmates) and an artist. The one programmer put in a large amount of effort writing code, but the other did not. The programmer who did not fully contribute was responsible for the music and sound effects on the game, but because of his absence and looming deadlines, Katherine took it upon herself to ensure it was done. She described it to me this way:

> I wish that some people like not to be mean, but … I kind of wish he would've done a little bit more because he was working on the music mostly, but it's like, I feel like he could have also done some of the coding." So, then I just kind of put it [the music] all on [the game] (Katherine, interview, May 4, 2018).

In addition, Katherine created "all the burn down charts" (the list of tasks each member of the group is responsible for) for the game, and moreover, she found herself having to fill it out and assign tasks to her group members based on their abilities to ensure the work would get done (interview, May 4, 2018). She also admitted to being a perfectionist about the work that she and her group produced. There was a small animation feature that she was responsible for. The animation rendered, but Katherine had made some minor adjustments to it that did not appear in the game play. She was disappointed and admitted, "It still looks fine without it, but it would have been nicer with it" (Katherine, interview, May 4, 2018).

The impression of computer science competence also extended beyond the classroom. Not only did the women put in a tremendous amount of work on individual and group homework assignments, they also were employed in math and computer science-related jobs on campus and/or participated in technical student organizations. Margaret and Mae were employed as math and computer science teaching assistants, which meant working with students during class lab times and answering student questions. Margaret also worked in the computer science tutoring lab and was taking an independent study with one of the AMCS professors to assist him on a research project. Sally served as the event coordinator for the networked games student organization, PONG and Mae became an officer for the AMCS Women's club.

Linda, a GD professor and director of the GD program, said in our interview that the females are "usually the better students" and receive "typically better scores" than their male classmates (interview, April 11, 2018). She also said that "the females are always the ones that I know will pass their assignments. They will do a good job" (Linda, interview, April 11, 2018). Linda's statements what the women said in their interviews and what I observed in the classrooms.

Theme 5: Confidence

> "I think a lot of it is confidence because the guys seem to think they are so wonderful at this stuff [programming] and so the girls kind of don't, simply because they think it's such a guy thing."
> — Linda, GD program director, interview, April 11, 2018

Confidence is complex and layered. I asked direct questions of the participants about their confidence in their own abilities to do well in their computer science courses as well as questions about what kinds of things or experiences caused them to lose confidence. In general, the women felt that they were confident in their abilities. For example, Sally stated, "I'm pretty confident in my math" and "I feel confident in writing code" (interview, April 4, 2018). Likewise, Anita described herself as being "confident in those areas [math and coding]" (interview, March 26, 2018). However, their responses to other questions in the interviews as well as comments made by the program directors indicate self-doubt is more pervasive than they let on. This theme includes one sub-theme that investigates imposter syndrome, which is defined as "a collection of feelings of inadequacy that persist despite evident success" (Corkindale, 2008, para. 3).

Margaret shared experiences in her first couple of years at NCU that illustrate inner struggles with confidence and its variable nature. Margaret described how she taken several coding classes while in high school, was busy with a variety of extracurricular activities, and "got As in everything" despite not having to put much effort into her classes. After high school she took a year off before matriculating at NCU and "got really excited about school" (Margaret, interview, April 13, 2018). She described her self-esteem in her first year at NCU as being "way up there" (Margaret, interview, April 13, 2018). Margaret described her first year as follows:

> I know math and I'm starting in Calc 2 … and I'm going to take all these classes. I have this awesome plan and I was just like, I was on the Honors floor [of the residence hall] and I got to meet a lot of cool people through that and I just kind of felt really confident about everything (interview, April 13, 2018).

At the beginning of Margaret's second year her confidence started to wane and eventually it got so bad that she contemplated leaving the major. She said she began experiencing "issues with other students [in her classes], just being kind of jerks about stuff," some of which is described in more detail in gendered microaggressions and harassment sub-theme of exclusion and isolation (Margaret, interview, April 13, 2018). She began working as a teaching assistant (TA) in the AMCS department, where she thought, "I can't help anyone. I can't figure out what's wrong and I was so upset"

(Margaret, interview, April 13, 2018). She persisted in both her classes and as a TA and eventually, she "got more used to it [coding] and stuff" (Margaret, interview, April 13, 2018). Margaret went on to say that her work as a TA, especially tutoring other students, "really upped my coding ability" (Margaret, interview, April 13, 2018). During that second year Margaret also experienced self-doubt in her abilities because she was not coding outside of class or "dream[ing] in code" as Margolis and Fisher (2002) describe it, which is what she saw many of her male classmates doing (p. 5). She then came to the realization that between her full-time course load and working two jobs (one of which was the TA job where she worked with code) did not afford her time to work on independent coding projects. She recognized that coding outside of class did not mean that she was incapable of coding or that it was somehow a reflection of her abilities.

Linda, the GD program director, substantiated what I learned about Margaret's experiences. She explained that, "it takes them [female students] several classes before they are confident, and some of them, it takes longer" (Linda, interview, April 11, 2018). She went on to say that it is not uncommon for female students from the SD or GD programs to underestimate their own capabilities when she suggests that they should work as one of the tutors in lab.

Despite Margaret's purported confidence, Linda witnessed first-hand that Margaret's confidence was still shaky. Because Margaret was planning to graduate in May 2018, she had been working to secure a job in the field. Linda stated that Margaret was "not confident [about] getting a full-time job" (interview, April 11, 2018). Throughout the job-hunting process, Margaret would ask Linda, "why should they hire me?" (Linda, interview, April 11, 2018). Even though Linda offered words of encouragement, she said Margaret would come out of interviews “so down on herself” (interview, April 11, 2018). Margaret finally secured a position in the field of computer science.

Imposter syndrome. Even the most confident participants in the study experienced occasional self-doubt about their own abilities as well as other characteristics commonly associated with imposter syndrome. In the previous theme, *Overachievement and Perceived Academic Self-Efficacy*, I discussed some of the misconceptions that the women held about the men’s computing abilities and ways in which the compensated for their perceived inadequacies by holding themselves to exceptionally high academic standards. Imposter syndrome is an intermingling of the previous theme (*Theme #4: Overachievement and Perceived Academic Self-Efficacy*) and confidence. The participants felt that they did not possess the perceived high levels of understanding and expertise of their male classmates, despite working extra hard to learn the subject matter. According to Corkindale (2008), those who experience imposter syndrome “suffer from chronic self-doubt and a sense of intellectual fraudulence that override[s] any feelings of success or external proof of their competence” (para. 3). For instance, Mae, who was an honors student and held multiple merit-based scholarships still experienced the aforementioned sense of intellectual fraudulence. During our first interview, when asked if she ever experienced times when she doubted her ability to succeed in computer science, Mae explained:

> I used to, especially last semester, doubt that I would succeed in this field. But um, I had a meeting with Dr. Hamilton [the program director of GD and Mae’s advisor], who said literally everybody feels that way at some point. Fake it till you make it. I've been living off those words (interview, March 28, 2018).

Brian, the program director for AMCS, also noted, “The thing I noticed the most is the lack of confidence in the females compared to their ability. They don't recognize how good they are, even if they're incredible” (Brian, interview, March 20, 2018). He went on to speculate that the women likely felt the men knew more because they were more likely to “holler out answers confidently” in class, even if they did not know the answer, whereas the women were more subdued (Brian, interview, March 20, 2018). I witnessed the phenomenon described by Brian myself when I observed Margaret in a lecture-based advanced web programming class. When the instructor would stop to ask a question, there were a couple of male students who would regularly respond, even though their answers were frequently incorrect. Being incorrect did not seem to assuage them from continuing to attempt to answer the questions. Conversely, Margaret either spoke so quietly that others even a row or two away could not hear her responses or she said them quietly to the male student who sat next to her and he would respond to the instructor.

> The instructor asks the class about some data types of components. Margaret quietly (I can’t hear her) responds. The instructor is standing near her and acknowledges that the answer is correct (field notes, classroom observation, April 30, 2018).

In the follow-up interview with Margaret I asked her about why she would not speak up when answering questions or sometimes let her male classmate answer for her. She explained, “I don't like asking questions out loud or answering. I don't know if you heard any of my answers” (Margaret, interview, May 8, 2018). When asked why she did not like to ask or answer questions, Margaret elaborated:

> I never answer anything, because I think I'm getting it wrong, but usually I'll like mutter it, like and mumble it and then [the instructor] will occasionally pick up on it or the guy sitting next to me, will say it, which I don't care. I'm like, fine. I knew I had to right answer (interview, May 8, 2018).

When pushed she went on to say that she was concerned about being judged if she provided an incorrect answer. Margaret's fear of being judged circles back to the theme of duality. The men in the class can provide incorrect answers to questions asked in front of the entire class without jeopardizing their position within the computing micro-culture, whereas, as a woman, Margaret was afraid of being ejected from the group over a perceived lack of competence. Her sense of belonging within the computing micro-culture is much more tenuous than that of her male classmates because her gender is not dominant.

Theme 6: Exclusion and Isolation

This theme, and its sub-themes (physical isolation, gendered microaggressions and harassment, emotional isolation), often appeared as the physical and/or emotional outcomes of the previous themes. The physical isolation sub-theme examines the participants' experiences directly related to being in the minority in their classrooms and chosen field of study. The second sub-theme investigates how subtle and/or unintentional forms of discrimination (unconscious bias) as well as outright harassment undermined the participants' confidence and resulted in feelings of emotional isolation. The final sub-theme is that of emotional isolation, which can be a result of being on the receiving end of microaggressions, harassment, and is also directly related to their internal struggles between disparate cultures and gender role expectations (broader society versus computing micro-culture).

According to the *New Oxford American Dictionary* (n.d.), the word 'exclude' means to "deny [someone] access to or bar [someone] from a place, group, or privilege."

Similarly, ‘isolate’ is defined as “to cause [a person or place] to be or remain alone or apart from others” (*New Oxford American Dictionary,* n.d.). Generally speaking, the participants appeared to be happy, well-adjusted students, but they have all experienced varying degrees of feeling excluded or isolated at different points in their college career. Three sub-themes related to exclusion and isolation emerged from the data: a) physical isolation, b) harassment, and c) emotional isolation.

This theme is closely intertwined with the concept and theme of duality. The cultures in which these women are part of espouse contrasting values, meaning that virtually every decision they make is likely to align them more closely with one culture and further from the other. The possibility of alienation is very real. By contrast, for men in the NCU computer science programs, the cultural expectations posited by broader society and the computing micro-culture align closely with one another, thereby they do not need to be as concerned about how their decisions may impact their status or sense of belonging with the group. For example, male computer science students who fail a test or answer a question incorrectly in front of the class are not likely to jeopardize their member status within the group. By comparison, Margaret shared her concerns about doing poorly on exams, “Guys don't care if other guys like bomb tests and some of them feel like, ‘Oh I did so bad on that.’ And I'm like ‘Okay, but if I were to do that bad, you would judge me’” (interview, April 13, 2018).

Another example of how interwoven the themes are with one another is the frequent co-occurrence of the exclusion and isolation code with the not being heard code. Of the 51 times the *Theme #2: Not Being Heard* code was present in the data, nearly half of those times (21) co-occurred with the presence of the exclusion and isolation code. An example of how the two codes are interrelated was evident when Anita revealed her concern about how her actions may have an impact on her inclusion on a team project where all of the other members were male. She stated, “I felt like I had a valid point and it just got ignored and I’m like, ‘Do I bring it up?’ And I didn’t actually bring it up because I didn’t want to cause issues in our group” (Anita, interview, March 26, 2018). In other words, Anita was concerned with what she said and how she reacted to certain situations as she did not want to cause any rifts between herself and her male team members. As the only woman in her class, she was put in the difficult position of trying to strike a balance between ensuring her needs were met (e.g., being heard and respected) and not isolating herself from the group.

Physical isolation. The easiest form of exclusion and isolation to observe is that of physical isolation. I asked each of the women during the first interview how many other women were typically in their computer science related courses. The responses ranged from one to around three or four others. Each of the women acknowledged that there were more women in their first- and second-year courses, and as they progressed to the higher-level classes, the number of female students dropped. Anita imparted her surprise upon entering her senior practicum on the first day of class, “It’s definitely shocking to look around. Like I didn’t realize the first week of Software that I was the only girl in there and then like, I’m, ‘Oh wait a minute, there’s no one else’” (interview, March 26, 2018). As seniors, both Margaret and Anita had experiences where they were the only woman in some of their classes. Mae claimed that she was fine having her gender ignored by her male classmates and that, “I’m not one to really care” (interview, March 28, 2018). However, she also admitted to feeling “isolated” when I asked her about being one of a couple women or sometimes the only woman in class and she described it as “there’s kind of an internal barrier of like, going to go walk into a room full of guys” (Mae, interview, March 28, 2018).

Mae and Katherine both expressed sometimes feeling excluded when trying to find someone to study with outside of class. They felt uncomfortable approaching other women that may be part of the class simply based on gender, because as Mae put it, “I don’t feel comfortable walking up to the only other girl in class and saying ‘Hey, let’s be buddies just because we’re girls’” (interview, March 28, 2018). They also conveyed concerns about various social intricacies related to approaching male classmates, such as having the request to study together be misconstrued as a romantic overture or opening themselves up for scrutiny if they do not understand some of the content. Katherine, who is quite introverted and shy described it this way, “[It] just seemed like I was surrounded by guys and I’m like, ‘Oh well’” (interview, April 18, 2018). She went on to say:

> Because it's easier to connect with women than it is to have a girl chat with a guy and like, just get help and you know, the casual, like, *I just want help please*. Um, yeah, it's less awkward (Katherine, interview, April 18, 2018).

The low proportion of female students was confirmed by the NCU student data (Table 4.1), in my own observations of the classes, as well as accounts conveyed by the AMCS and GD program directors. Brian, the AMCS program director, recounted an instance at an orientation session where first-year students came to campus to get to know the university and to register for their first semester of classes. Brian had pictures of each of the students and asked them to each write down something memorable about themselves as a form of icebreaker and as a way for him to remember them when they arrived on campus in the fall. A female student’s mother instructed her daughter to “just put female!" as a form of unique identifier because she was the only female student in the room (Brian, interview, March 20, 2018).

Gendered microaggressions and harassment. Physical or verbal harassment are often quite easy to identify and can result in painful feelings of isolation. While most of the participants did not feel they experienced any overt harassment, they all had experienced forms of microaggression where they were not sure if the behavior directed at them from some of the men in their classes was because they were women or if it would have happened regardless of their gender. In addition, the students, as well as the program directors, knew of women who had suffered harassment.

During the interviews with the participants, when asked if they had ever been harassed for being female, it was not uncommon for them to question some confrontational experiences with male classmates. They were unsure if the confrontation happened because of their gender or if it was something that would have happened even if they had been male. Anita talked about a time when a male classmate took the credit for one of her ideas for their group project:

> I'm not sure if like they just forgot that it wasn't him that came up with it. He's the one that ultimately was working on it. So, I think they maybe got confused. I'm hoping they got confused. … So, I don't know that there's a lot of instances like that where I like question if it's like real and I don't know if like they're intending it to be. And I definitely don't have any reason to say it's because I'm a woman or if that's just like how they treat everyone. So, uh, yeah, it's hard to navigate that I think (interview, March 26, 2018).

Anita's experience, and her reaction to it, was similar to the one Mae described earlier when discussing duality and the conflicting values and demands women face that their male counterparts do not. In Mae's case, her male partner assigned her tasks without her input about what she might like to work on. In both cases, the women were taken aback and at the same time wondered if the male behavior was an unconscious microaggression related to gender or if it was normal behavior that would have occurred regardless of gender. Mae speculated, “Maybe he would have done that with a guy. I don’t know” (interview, March 28, 2018).

Margaret was the only participant who experienced overt harassment because of her gender. She described a number of instances where she endured harassment in her GD classes, particularly with one male classmate. Todd (pseudonym), according to Margaret, was overbearing, pushy, did not trust her abilities, and inserted himself into conversations and situations where he was not invited. She observed that “he was being very, very pushy with me and he didn’t do that with my friend who’s a guy” (Margaret, interview, April 13, 2018). At the same time, she also “noticed he also did similar things to some of the other girls in the class where he would be kind of talking down to them” (Margaret, interview, April 13, 2018). Margaret informed me that he would demand to see her code for team projects without giving her adequate time to work on it. He also began following her, first in class, and then later to office hours with one of the professors. Margaret described what was happening and how it made her feel this way:

> It was to the point where I felt so uncomfortable because I would try to go ask the professor a question and he would follow me. He would stand right there, and I would like, I was in line and … there’s a person behind me and a person in front of me trying to talk to the professor. And then Todd like slowly walks up and comes up there. And then he followed me, and I was just like, I just, I can’t take this anymore (interview, April 13, 2018).

She went on to describe how Todd started showing up at office hours when she did and would invite himself into the professor’s office without being invited or waiting his turn. The professor took note of Margaret’s discomfort and asked Todd to leave and to come back at a later time. Margaret’s confrontations with Todd caused her to cry during class on more than one occasion. When she would cry, he would accuse her of being an emotional girl or try to excuse his behavior by saying, “Just kidding” (Margaret, interview, April 13, 2018).

In her frustration, Margaret nearly quit pursuing the entire GD major because of the perpetual harassment she faced. A significant reason for her choosing to persist was because the professor for that class took notice of Todd’s behavior. Margaret stated, “I just kept working with him [the professor] to like, get through it” (interview, April 13, 2018). The professor moved Margaret to a different team that was “a bunch of guys” and he also monitored the situation to ensure that Todd did not continue to harass her and that she was doing okay on the new team (interview, April 13, 2018). She said that her professor “tried to help with that and that helped me get through the class” (Margaret, interview, April 13, 2018). Margaret persisted through to graduation despite the flagrant harassment from one of her male classmates. The physical isolation, direct and indirect harassment, along with a number of other reasons, such as lack of support and/or role models, can leave women in the male hegemonic culture, feeling emotionally isolated.

Emotional isolation. The participants were not consciously aware of their sense of emotional isolation until we went through the interview process and they heard themselves using words like “isolated” and “excluded” to describe some of their experiences. While physical isolation is visible (e.g., only woman in class of men), emotional isolation is more subtle. It is the result of balancing between two sets of paradigms — societal norms and expectations of women versus masculine traits and beliefs associated with computing — and not completely fitting in with either one. Some examples seen in the female students included being hyperaware of what they wore (e.g. feminine or tomboy), not having many close female friends, or not wanting to bring up issues or concerns with male classmates for fear of bringing negative attention to themselves. Because of the lack of female classmates, especially those they were close enough with to call friends, the women lacked opportunity to share their experiences of being female in a male-dominated environment.

Emotional isolation is the potential outcome of decisions made by the women (consciously or unconsciously) when forced to choose between contrasting values. One of the ways in which the women chose to fit in with the masculine micro-computing culture was to surpass expectations on class projects and tests (*Theme #3: Overachievement and Perceived Academic Self-Efficacy*). The women's choice to do exemplary work was a metaphorical double-edged sword. On the one hand the participants felt compelled to achieve, to demonstrate that they knew what they were doing and belonged in computer science. On the other hand, being the smart woman in a class full of men may make them seem unapproachable. Anita said that her classmates knew she received good grades but she also stated, "I don't like being the person that everyone always comes to, because then they expect you to be right all the time and, like, if I'm not right that one time, it's like a 'Gotcha!' kind of thing" (interview, March 26, 2018). Even though she was an excellent student, Anita still felt that her male classmates were waiting for her to fail. At the same time, she felt that when her male classmates did seek her out with questions, they were not about computer programming. In Anita's senior practicum class where her group was programming a searchable wildflower database, she explained that "they [her classmates] would come to me for questions about the wildflower guide, but then when it was coding it, they'd always ask somebody else and then I'm just, like a side conversation" (interview, March 26, 2018).

The women also admitted to how their own perceptions about what it means to "do" computer science led to the creation of invisible walls or barriers between them and the men in their classes. Mae described it as "not so much intentional oppression" on the part of her male classmates, "but there's kind of an inside like, internal barrier of going to walk into a room full of guys" (interview, March 28, 2018). Anita described her sense of anxiety as being somewhat self-induced, "I think in terms of my classmates, that I definitely saw a lot of walls that aren't really there" (interview, March 26, 2018). These "internal barriers" stemmed from not knowing how they would be perceived by their male classmates and ultimately how or if they would be accepted as respected and contributing members of the computing micro-culture.

Regardless of whether the walls were crafted by internalized pressures or were exerted by outside forces, the impact on their lived experiences were very real. Katherine explained, "I feel like it's harder to connect with other people around you and to ask for assistance, especially outside of class" (interview, April 18, 2018). This relates to Mae's comment about being fine with being an outsider, "except for when I need a study buddy and I can't find anybody" (interview, March 28, 2018). This sometimes meant not being able to find someone to study with and struggling through homework on their own. The invisible barriers also meant that the women sometimes felt excluded from fully participating in conversations with classmates. Anita described it as being "boxed out of the conversation" (interview, March 26, 2018) and Katherine said, "I just kind of felt I was kind of out of luck in trying to talk to someone" (interview, April 18, 2018). This was especially true when the women did not share common interests with their male classmates. Anita was not an avid video gamer, and she said her classmates were "very into video games and I'm not so much into video games. … And so, I feel like a lot of the surrounding discussions of like classroom pursuits, I'm excluded from" (interview, May 2, 2018).

As the researcher and as a woman who has worked in computing and technology for approximately 20 years, I feel it is imperative that I share my own experiences with emotional isolation. As students, the women were almost continually surrounded by friends, both male and female. All of the participants except Anita lived in the residence halls, which meant that in addition to classmates, they also had friends they lived with and spent large amounts of time with. Easy access to a wide range of people at almost any time of day or night can help assuage some of the effects of emotional isolation. However, after graduation, it can be difficult to find and form deep friendships with like-minded women who work with technology. For example, my interests, much like some of the women I interviewed, align with attributes that are typically considered more masculine, such as computer programming, a variety of technology topics, tabletop role-playing games, and an interest in sci-fi and fantasy novels, television shows, and movies. While I also partake in more feminine pastimes such as fiber arts, fashion, and jewelry, when getting together with friends I find that I have more in common with and can more easily relate to the husbands and men in the group. This means that I have significantly more male friends (many of which are in technology) than female friends (none of which are in technology), and it can be difficult to find someone who I feel comfortable confiding in when in need of emotional support from someone who can relate from the female perspective.

Theme 7: Support from Professors

The final theme is an important finding in that it reveals the critical role that instructors play, especially female professors, in establishing a sense of belonging in the female students. The sense of belonging that is created goes beyond the walls of the classroom and demonstrated to the students that a larger community of women in technology exists. The women in this study indicated that they looked to the female professors in their major programs as mentors and role models. Support from male instructors was also perceived as valuable in that it demonstrated to the women that their opinions, ideas, and contributions were valuable. The support of professors, regardless of gender, helped offset the feelings of isolation, bolstered confidence in their own abilities, and instilled in them a sense of conviction that it was possible to succeed in a male-dominated field.

The women who participated in this research described the professors in their majors as approachable, supportive, and caring about their success. The class sizes at NCU are relatively small at around 25 students and large lecture hall classes of 100 students or more are non-existent. This means, as Mae describes, "there's 20, 30 people in your class and the professor knows you by name every time. It's great! And it's consistent in this major" (interview, March 28, 2018). In addition to the small class sizes, the major programs at NCU are also relatively small by comparison to similar programs on much larger campuses. For example, the combined enrollment in the AMCS and GD majors at NCU is 438 students, which is about one-third the number of students enrolled in computer science alone at a large tier one research university about 70 miles away. The relatively small number of students in the major and in turn smaller class sizes are conducive to the students and professors building strong relationships because, as Sally described it, “You get to know each one [professor] really well because you’ll see each one probably two or three times” (interview, April 4, 2018). This seemed to be particularly valuable to the female students in the SD and GD programs.

Not only did their professors know their names, the women felt supported in their academic endeavors. Anita and Margaret had opportunities to work with professors on research projects, which was one way in which the women felt that their abilities were acknowledged and respected. In addition, I asked each of the women what they thought of their professors during the first round of interviews. Anita responded, “I feel like they just care right off the bat. So, it’s really helpful to just be encouraged right away to do well” (interview, March 26, 2018). Mae echoed this same sentiment when she stated, “I really like my professors. A lot of them are very inspiring and you can tell that they care and that just means so much” (interview, March 28, 2018). Katherine also reiterated the feelings of support, “It seems like most teachers care about you doing well in their course as a student” (interview, April 18, 2018).

The participants also described how important is was to feel that their professors listened, were empathetic, and acknowledged their struggles and concerns as real. Katherine summarized the experience when she stated, “they [the professors] obviously care about you as a human being” (interview, April 18, 2018). Margaret, who experienced bouts of depression, shared her experiences with a particular professor, whom she was comfortable talking to about her mental health. She described her interaction with the professor this way, "He's super understanding. … I've cried in front of [Professor A] multiple times" (Margaret, interview, April 13, 2018). In most cases, the gender of the professor was not imperative to the female participants feeling supported; however, Sally explained that having a female professor (and advisor) was beneficial because "she understands" (interview, April 4, 2018). Sally felt that a female professor, especially one who had worked in industry prior to teaching, could relate to her own feelings of occasional inadequacy and isolation of being a woman in a male-dominated field.

Having role models and mentors of the same gender were also a powerful form of support experienced by the female participants that encouraged and inspired them to persist in their chosen majors. The need for female mentorship could be clearly seen when Margaret stated, "It's kind of hard to see yourself in a position where it's all guys" (interview, April 13, 2018). While still in the minority, there are several female professors who teach the computer science classes at NCU. When speaking with the participants, they enthusiastically spoke about how impressed they were with the accomplishments of their female professors and how inspiring it was to their own career pursuits. Anita explained, "It was really cool to have them [women professors] teach our classes because they'd both been in the field working" (interview, March 26, 2018). Similarly, Katherine went on to state:

> I think it's super cool that Linda, you know, is our director, and she is actively working like both as a teacher and she does have time on games. I think that's super cool that we have a woman like showing that she's being successful out in her field (interview, April 18, 2018).

Sally also looked up to her female professors:

> A lot of my GD classes have been taught by a female and it makes a difference because I'm like, 'Oh look, you've done x, y, or z that's also in this field as well as like what you're doing now.' And that's cool and you can actually look up to them (interview, April, 4, 2018).

Sally, in particular, seemed to be significantly and positively impacted by having a female advisor and professors. In two different instances during our first interview, Sally shared how transformative it was to her college experience and professional goals. In the first instance she stated, "It honestly was college career changing for me because my advisor's female" (Sally, interview, April 4, 2018). Later in the interview Sally reiterated the feeling when she declared, "It was a life changing moment for me when I had a female instructor in my game design. … I never thought it would be this impactful, but it was" (interview, April 4, 2018).

Summary

In this chapter I described the data analysis process used to derive seven themes and eight sub-themes, which were deeply interconnected and illustrated multiple facets of the women's experiences as students in the North Central University (NCU) Software Development (SD) and Game Development (GD) programs. The concept of duality, where the women were caught up in a continuous cycle of divergent cultural demands, was determined to be the most pivotal theme insomuch that it interacted with the remaining themes and shaped the women's overall experiences. In the final chapter, I discuss conclusions, implications, and limitations of this dissertation and its findings. Finally, based on the insights from this study, I make recommendations to colleges and universities on how to counter the negative experiences with the end goal of bolstering confidence (and hopefully persistence) of female computer science students.

CHAPTER 6
CONCLUSIONS and IMPLICATIONS

I hope that girls are strong enough to be like, this doesn't matter and I'm passionate about this. I'm just going to keep doing it because that's how I currently feel.
Anita (2018, first interview, March 26, 2018)

In this chapter, I discuss the insights gained from examining the experiences of women pursuing computer science degrees in face-to-face classrooms at a mid-size university. The chapter begins with a brief overview of the research study and a summary of the findings as they relate to the research questions that guided the inquiry. This overview is followed by sharing conclusions and a review of the limitations of the study. Finally, I close with a discussion of the significance and implications of this research, including how these findings can inform colleges and universities in ways to improve the experiences of women pursuing degrees (and careers) in computing and technology.

Summary of Research Study

Women are significantly underrepresented in the technology sector, not just as employees in industry, but also as students pursuing degrees at colleges and universities. Using the conceptual frameworks of sociocultural theory and sense of belonging, this dissertation sought to understand the experiences of women who had declared majors in the field of computing and technology. Five females, who were studying Software Development (SD) and/or Game Development (GD) at North Central University (NCU) were investigated in order to understand the women (their personalities, backgrounds, and interests) and how they described their experiences within their chosen academic program using their own words. The following research questions guided this inquiry:

RQ1. How do women who are pursuing computing-focused degrees in a face-to-face, on-campus environment at a four-year university describe their experiences?

RQ2. What impact does sense of belonging have on how women perceive their experiences?

Summary of Research Findings

Research findings were presented in a variety of ways to holistically capture contexts surrounding the case and revealing the experiences of women in computer science programs at NCU from multiple perspectives. University data, interviews with program directors, and classroom observations were used to understand the context and learning environments in which the women existed. The data demonstrated the typicality of the environment and thereby the transferability of the experiences to similar contexts (Merriam, 2009; Stake, 1995). Interviews with the program directors also revealed that they were aware of the low ratio of women pursing computer science at NCU as well as the faculty in their programs. Unfortunately, the program directors at NCU do not have the time or financial resources for recruitment and retention in general, much less to specifically focus their efforts on female students. Some effort was made to retain female students including pairing them with female advisors and ensuring they were given priority for scholarships. The profiles of the women presented in Chapter 4 provided more detailed insights into each of their backgrounds, values, and attitudes, while the themes that were discussed in Chapter 5 exposed the underlying homogeneity of their experiences.

Seven themes were identified, with the concept of duality being at the center. Five of the remaining themes manifested out of the contradictory and dichotomous value and belief systems between broader society and the computing micro-culture. The final theme (support from professors) demonstrated the necessity for academic support and mentorship, especially as it relates to sense of belonging. Collectively, the themes work to answer the two research questions (RQ1, RQ2) that guided this study.

RQ1: How do women pursuing computing-focused degrees in a face-to-face, on-campus environment at a four-year university describe their experiences? The participants' experiences navigating the male hegemony of computer science suggest that women are continually forced to choose between two often conflicting value and belief systems. Traditional values associated with femininity were at odds with the stereotypical male characteristics that are firmly entrenched in the computing micro-culture. The female participants were competent and skillful computer scientists and, overall, they also appeared to be well-adjusted, happy, and for the most part, confident in their abilities. In addition to this underlying duality (*Theme #1: Duality*), and dichotomous cultural expectations permeated through the entirety of their experiences and often resulted in periods of self-doubt (*Theme #5: Confidence*), overcompensation for perceived deficiencies (*Theme #4: Overachievement and perceived academic self-efficacy*), and feelings of isolation (*Theme #6: Exclusion and isolation*). They were also not immune to sexual harassment, unconscious bias, and microagressions. At one point or another, each of the women expressed concerns about whether certain negative interactions with male classmates were because of gender. Similarly, each of the women also recognized that their gender made them outsiders within their chosen major. This was especially evident on the first day of each semester when they would walk into class and immediately observe that they were the either the only woman or maybe one of a few, and the rest of the class was made up of men. These kinds of experiences and self-doubt about belonging are not something that individuals who are in the majority — in this case male students — are likely to experience. As a majority member of the group or micro-culture, their position is secure.

The women also found that their gender complicated matters when trying to solicit help or to find someone to study with. While they indicated that they were more comfortable approaching and interacting with female classmates, they also did not want to seek out females solely based on gender. At the same time, they were also concerned about how the men in their classes would perceive them if they reached out to them for help. For example, they did not want the request for help to be misinterpreted as a potential overture of sexual/dating interest.

Without consciously setting out to be overachievers, the participants shared that they felt a sort of internalized social pressure to succeed. The women recognized that their gender immediately meant they were seen as outsiders within the micro-culture. As a result, the participants worked hard to overcompensate for the perceived inadequacies based on their gender. This was done to demonstrate to the larger micro-culture that despite their not fitting the gender criteria associated with the micro-culture, they still deserved a place within the group. Unlike their male classmates, the female participants felt that any level of failure might reflect negatively on their abilities as computer scientists, and therefore potentially jeopardize their membership within the group or culture.

RQ2: What impact does sense of belonging have on how women perceive their experiences? Just as the duality experienced by the participants made the concepts of culture and identity complex, sense of belonging was also a multi-layered and intricate concept and experience for the women in the study. There were a number of facets within the women's experiences that worked to erode their confidence and their sense of acceptance and belonging within their desired group, such as cultural duality (*Theme #1: Duality*), not being heard (*Theme #2: Not Being Heard*), perceptions of men and computing (*Theme #3: Just One of the Guys*), and unconscious bias (*Theme 6: Exclusion and Isolation*). These experiences can lead to doubting one's own knowledge and abilities, especially if it happens repeatedly.

In most instances the sense of isolation and exclusion was a manifestation of a variety of systemic beliefs, microagressions, and unconscious biases related to what it means to be a computer scientist. Not only were the women subjected to societal stereotypes that computing is the domain of White or Asian, heterosexual men, they also internalized those beliefs which in turn revealed themselves through metastereotypes — the assumption of how one's own group is perceived or stereotyped (Gilrane, 2013). In other words, the women felt that they were perceived by the men in their degree programs as less capable of understanding and learning the principles of computer science such as logic, algorithms, and programming. This form of stereotype threat can be detrimental to a woman's confidence in her own abilities, capacity and desire to learn, and ultimately in her sense of belonging within the computing culture.

The women curated a number of behaviors to control or manage the perceptions others with regard to their abilities and knowledge about computer science in the attempt of demonstrating fit within the culture. The participants feared that any sort of failure on their part, even on trivial matters, would make them appear less competent in the eyes of their male classmates, and to some degree their professors as well. One of the ways they worked to counteract the metastereotype was by placing high standards on themselves to excel in their coursework. Outside of the classroom, the women often found a sense of belonging through shared interests in commonly considered male pastimes, such as watching anime and playing tabletop role playing games and video games. These behaviors are all a form of impression management, which can sometimes perpetuate, instead of alleviate, gender barriers.

Finally, the female participants maintained certain levels of confidence in their abilities and persisted in their programs in part because of the support from their professors — both female and male. While individual experiences varied, they each communicated the important role that their professors played in contributing to persistence and their sense of belonging while simultaneously offsetting feelings of isolation, exclusion, imposter syndrome, and lack of confidence. Furthermore, the deliberate decision on the part of the SD and GD program directors to assign female advisors to female students did not go unnoticed by the participants in this study. The participants looked to their female advisors as mentors who had not only persisted in a male-dominated industry but were also successful and active contributors to the field (e.g. technology patents, active game development). The support and encouragement of the professors enabled the women to feel like they had a place within the computing micro-culture, despite other difficulties they may face.

Conclusions

To staunch the leaks in the computer science pipeline and to achieve gender parity and inclusion in the field of computer science, it is important to first understand the experiences of the women who are currently in the proverbial pipeline. Girls and young women are increasingly participating in computer science related activities in elementary through high school both inside and outside the classroom (Trapiani & Hale, 2019). Despite the growing number of women who are opting to pursue degrees in computing and technology, men have been flocking to the field at disproportionately higher numbers, thus negating any gains that may have been made to improve the ratio of women (Trapiani & Hale, 2019). Therefore, the findings of this study are timely, relevant, and significant to identifying ways in which educators, and more broadly, industry, can improve the experiences of women in computing.

This research explored the experiences of five women pursuing degrees in Software Development (SD) and/or Game Development (GD) at a mid-size university in the upper Midwest through multiple lenses — first-hand student accounts (interviews), classroom observations, and interviews with program directors. Each of the participants in this study brought with them unique histories, interests, and personality traits; however, they shared common experiences as female computer science students NCU. College/university educators and leaders in the technology sector must acknowledge the negative impact that the pervasive belief that computing is masculine has on women entering the field. The predominant effect is one of a dual nature, where women are forced to choose between the societal and cultural expectations of femininity and masculine expectations of the computing micro-culture. This dichotomy of cultural beliefs and values immediately casts women who pursue computer science as outsiders in both broader society and within the micro-culture of computing. The alienation is further compounded by unconscious biases that can be experienced in a number of ways, such as not being acknowledged as an intelligent, capable contributor of ideas, that failures are judged harshly, and successes are not recognized. Continual exposure to these forms of microagressions can ultimately result in feelings of isolation, exclusion, and self-doubt.

One approach that women might take to counter the negative experiences is a form of impression management. In this research, one type of impression management took the form of academic overcompensation, meaning that the women strived to excel in all things related to computer science to demonstrate that they possessed the requisite skills to be a member of the computing micro-culture. Another example of impression management was evident in the awareness the participants had as to how their clothing could potentially affect how others saw them. It was perceived that dressing in a feminine manner may convey a message of incompetence whereas dressing in a more masculine fashion communicated competence. This was observed by me outside of the boundaries of this study but within the NCU context, when a female computer networking student described to me how she changed the way she dressed over time to be less feminine, especially when she was the only woman in a class. She quit wearing skirts and dresses and was conscious about the necklines of her tops. She began wearing sweatshirts and similar styled clothing to, in essence, disguise her femininity.

Unfortunately, some research indicates that impression management can sometimes perpetuate gender barriers or result in a form of backlash (Gilrane, 2013; Rhoton, 2011), thus further alienating women in STEM fields. Gilrane (2013) suggests that women who "engag[e] in strategies to enhance perceptions of competence" may do so at "the expense of being seen as likeable" (p. 3). Furthermore, Rhoton (2011) argues that women who use impression management to distance themselves from traditionally feminine traits and work to maintain hegemonic male values actually sustain the gendered cultures found in many STEM fields. Women in computing careers consequently face the difficult task of navigating the divergent gender expectations placed on them by society and their chosen major and ultimately profession. Women who choose to participate in this form of impression management may be at risk of distancing themselves from both male and female students/colleagues as well as from themselves.

The research also found that encouragement and support from both male and female professors, specifically in the areas of math and computing, can be a critical factor for improving perceived sense of belonging and persistence of women pursuing these types of degrees. Regardless of the gender of the instructor, the participants expressed how feeling supported in their academic and professional endeavors, as well as feeling that their success was important to their professors made them feel more valued overall. This support goes a long way toward improving sense of belonging, even when facing other obstacles. In addition, the women found it particularly impactful to have female professors and advisors. Therefore, colleges and universities that offer degrees in computing and technology should strongly consider improving gender parity of their own faculty. It would also be beneficial for all faculty to undergo training to recognize and mitigate microaggression behaviors and communications (in themselves as well as students) in their classrooms and institution as well as professional development in the practices of inclusive pedagogy.

Limitations

Even though this research contributes to the expanding collection of literature that examines ways in which to increase the number of girls and women who pursue computing, as well as how to retain them once they enter the field, this study does have limitations that must be acknowledged. The most significant weakness in this study is the non-inclusion of Separator participants (those women who initially declared some form of computing major and subsequently changed to a non-technical major) due to my inability to successfully recruit them for participation. The initial goal of this study was to investigate the experiences of both Persister and Separator participants and then perform a cross-case analysis to compare the experiences, attitudes, and beliefs of the two sub-units. While the findings and conclusions of this dissertation provide valuable insights, the lack of Separators means that a truly holistic understanding of why women choose to persist or leave could not be achieved. In future inquiries, it will be important to determine better ways of identifying and reaching Separators.

A second limitation of this study was the homogeneity of the participants. Even though the participant recruitment and selection criteria were inclusive and any individuals who identified as female were welcome, the makeup of the student body at NCU is predominantly 86 percent White across the university and closer to 90 percent in SD and GD regardless of gender. This study was not specifically investigating racial and ethnic diversity; however, having at least one female of color would have provided another perspective and made the findings that much richer. As is, the findings convey the experiences of five female White students, predominantly from small, rural communities in the upper Midwest.

One final limitation is that this study examined only the experiences of women in a face-to-face campus environment. Online education has grown exponentially in recent years, including a number of degree offerings in computer science and game development. Because of the nature of online learning, individuals can often participate with some anonymity (e.g., name only, no images), thus reducing stereotyping based on gender, age, or race (Kramarae, 2003). Unfortunately, online gaming culture, which was shown in Chapter 4 to be a common interest among these female SD and GD students, tends to be hyper-masculine and oftentimes misogynistic (Shaw, 2015). Therefore, when their gender is exposed, women in online gaming communities may face a barrage of sexist and sometimes violent comments making them feel unwelcome in that community, and thus wanting to hide their gender in order to participate (Shaw, 2015). Based at the vastly different experiences women undergo in online learning and online gaming environments, it is difficult to know what their experiences might be like in an online computer science or game development program and merits further investigation.

Despite these limitations, this research contributes valuable insights about the experiences of college women pursuing four-year degrees in the male-dominated field of computer science. Since the U.S. Department of Labor (2019a) is predicting a significant shortfall of people qualified to fill nearly half a million tech jobs over the next decade, finding ways to retain women in the computer science pipeline is critical. It is, therefore, my hope that these findings resonate with instructors and leaders at similar institutions of higher learning and can be used to improve the experiences and retain not only women but to create inclusive and beneficial learning environments for all students who pursue degrees in computer science.

Future Research

Perhaps the most significant (and challenging) change that needs to occur in order to bring about gender parity in the tech industry is society's perception of computing and gender. Women played a pivotal part in the early decades of the computing industry. It was a handful of intelligent women in the 1940s and 1950s who invented the concept of sub-routines, created the first compiler, and developed one of the most prevalent business computing languages in history (COBOL) (Isaacson, 2014; Thompson, 2019). As computers began to shrink and the need for software became more prominent, men began to systematically push women out of the tech industry (Hicks, 2017; Isaacson, 2014). Beginning in the 1980s computing has been associated with men and masculinity. History has demonstrated that women are not only capable of working in the computing and technology industry, but that there is no discernable difference in aptitude based solely on gender. In other words, computer science and the skills necessary to be successful in the technology sector are not gendered.

Because the field of computing has been dominated by men for several decades, society has come to associate masculinity with technology; therefore, implying that women, as the binary opposite to men, are not suited to work with technology. This assumption about gender and technology immediately imposes dual and opposing cultural forces on women who choose to pursue a degree/career in computing. As this research illustrates, it means these women must continually decide the identity to which they want to align themselves and, regardless of the identity they select, in any given circumstance they will be alienated from the alternate identity. Unlike women who pursue degrees/careers in technology, men are not forced to choose between two divergent identities because computing and masculinity share similar cultural expectations.

Working to systemically shift attitudes about computing away from being associated with masculinity to one of gender neutrality will improve the experiences of women and move the industry closer to gender parity. Changing the face (literally and figuratively) of computing will be achieved through deliberate and collaborative efforts, many of which are already happening. Introducing girls to computer science, computational thinking, and coding through programs like Girls Who Code will continue to spark interest. Conceivably more important than generating initial interest is establishing a network of support and mentorship encouraging girls to go into computing majors, to help them persist through to graduation, and ultimately enter the workforce. The significance of support and enabling girls and young women to see themselves as computer scientists cannot be stressed enough. This notion was supported by the women in this study as they shared how critical it was for their success to have female professors and advisors to serve as mentors and role models. They also expressed their desire for an increased sense of community that might consist of peer support (juniors and seniors mentoring younger students), faculty and industry mentors, and career guidance.

The initial intent of this dissertation research was to compare the experiences of those women who persist in computing majors (Persisters) with those who left to pursue non-technology types of degrees (Separators). As I was unable to recruit Separators, this is an area in which this research could be extended. I recently attended conference session discussing the retention of women and underrepresented populations seeking computer science degrees. In that session I learned that most universities do not track prior majors declared by students and only track the student's current major (Camp, Lewis, Richardson, & Zweben, 2019); I know firsthand that this is the case at NCU. It further indicates that this is a significant gap in the literature regarding the retention of women in computing majors. Why are they choosing to leave technology? Was there a specific event or experience that influenced their decision? Understanding the experiences and motivations of Separators could provide invaluable insights on additional actions that could be taken to retain talented women in computing and technology-related majors.

Finally, proponents of inclusive pedagogy, particularly in the STEM fields, argue that educators must recognize multiple ways in which different populations conceive computing and technology (Eccles, 2011; Lemke, 2001; Margolis & Fisher, 2002; White & Massiha, 2016). Some research suggests that the act of programming or working with technology is frequently the primary motivation for men, whereas women want to learn how to use technology to solve larger social problems (Gorson & O'Rourke, 2019). Is this indeed the case? Are the motivations to pursue computer science different for men and women? What about people of color; what are their motivations? The women who participated in this study indicated some of their reasons for pursing software development and/or game development included wanting to contribute to something bigger than themselves and the ability to give others joy. Institutions like Carnegie Mellon University and Harvey Mudd College have made curriculum changes to address these different ways of thinking, particularly in their introductory computer science courses (Alvarado et al., 2012; "CMU's proportion of undergraduate women," 2016; Corbett & Hill, 2017; Margolis & Fisher, 2002). However, after the introductory courses, the curriculum often reverts back to more traditional approaches to teaching computer science (DeNisco Rayome, 2017). This transition from an inclusive to exclusive pedagogical approach likely has a negative impact on retention, particularly for women and other underrepresented populations in computer science. I theorize that this might be the case because the graduation rates at institutions who have made these types of changes are not significantly higher than schools that have made no such change to their curriculum or teaching (DeNisco Rayome, 2017). Therefore, it merits further investigation into the motivations that drive different populations to pursue degrees in computing and technology in the first place. Furthermore, additional research might explore how adjustments to curriculum and pedagogy at all course levels impacts retention of various populations from matriculation to graduation.

What Would Grace Hopper Do?

Circling back to the early history of computing, it becomes obvious that the role women played in building the foundations for modern computer science was significant. A paramount example of this can be seen in the development of the COBOL programming language. In 1959 the emerging computing industry sought to develop a new computer language, COBOL, that could be run on a variety of computers regardless of manufacturer ("COBOL," n.d.; Isaacson, 2014; Thompson, 2019). In part because of her experience leading the team to develop the FLOW-MATIC language for UNIVAC, Grace Hopper was selected to the direct the team of computer scientists to create the COBOL language ("COBOL," n.d.; Isaacson, 2014; Thompson, 2019). "The COBOL project brought together a diverse group—men, women, African Americans, and Asian Americans," some of which can be seen in Figure 6.1 ("COBOL," n.d., para. 2). While the COBOL developers represented only one team, it established a powerful precedent and serves as a positive model for the computing industry of the twenty-first century.

Figure 6.1. Programmers working on the COBOL computer language. Grace Hopper (center in the white dress) works with a diverse team of developers (“COBOL,” n.d.).

Informed by the experiences of the participants in this study, I have devised multiple recommendations to improve the sense of belonging and ultimately retention of women in computing and technology degree programs. Research has illustrated that there is little to no difference in science and math aptitudes between the genders (Corbett, Hill, & St. Rose, 2008; “Digest of Education Statistics,” 2018; Riegle-Crumb, King, Grodsky, & Muller, 2012); instead, retention must be focused on building communities, providing support, and ensuring women have role models. In the absence of a women-in-technology type of student organization or other form of community at NCU, the participants in this study looked to their professors for support; furthermore, these students looked to their female professors as role models. My first recommendation is that academic departments, particularly in the areas of computing and technology (e.g., computer science, computer networking, computer engineering), need to ensure that their faculty are prepared to nurture and support female students. Demonstrating empathy and providing encouragement to female students is critical for all faculty, not just female faculty. Access to emotional support, recognition of skills, aptitudes, contributions by someone viewed as an expert in the field can go a long way in offsetting feelings of exclusion and isolation that may ultimately result in women abandoning their aspirations in computing.

In addition to faculty support, the second recommendation is that colleges and universities must work towards establishing communities of women pursuing computing and technology. For example, Mae desired to find a computer science student organization at NCU where she could hone her skills and connect with peers. Mae first attended the AMCS student organization but was intimidated by being the only woman at the meeting. Hoping to find a community of like-minded women pursing computer science, Mae also attended an AMCS Women's club meeting. She was disappointed to discover that the AMCS Women's Club did not focus on events and activities designed to improve programming skills or career preparation, and instead was, as she described "cute girly" (Mae, interview, March 28, 2018). Student organizations comprised of women pursuing computing and technology can work to stave off feelings of isolation and exclusion by creating a sense of community that is a safe place to explore and expand skills. In addition, these types of student organizations can provide access to study partners and peer mentors, expand personal and professional networks, and share experiences.

The final recommendation is for computing and technology departments to provide role models for the female students; this means hiring more female faculty. The participants in this study expressed how impactful and inspiring it was to have female professors and moreover, that those professors were active contributors to the school and industry. According to a recent study, only about 15 percent of tenure-track computer science faculty in the United States are female (Callier, 2016). This means not only are female students in computing and technology programs in the minority among their peers, they also lack female role models that may aid in offsetting feelings of self-doubt, imposter syndrome, and isolation. Having access to women role models can also foster aspirational career goals in young women, knowing that they too can make valuable contributions and have a place in computer science.

Ada Lovelace, the women of the ENIAC, Grace Hopper, and countless other women in computer science have paved the way, but they have often been overlooked by history. The spotlight is beginning to shine on their stories and accomplishments. The findings of this dissertation research indicate that there is hope, that there are women who persist in computing degrees, and that concerted efforts to make the computing micro-culture more inclusive show promise for bringing about gender equity. The findings also indicate that more research and much work is still needed to bring about gender parity in the field of computer science.

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Appendix A
University of Minnesota IRB Approval

University of Minnesota

Twin Cities Campus

Human Research Protection Program
Office of the Vice President for Research

D528 Mayo Memorial Building
420 Delaware Street S.E.
MMC 820
Minneapolis, MN 55455

Phone: 612-626-5654
Fax: 612-626-6061
Email: irb@umn.edu
http://www.research.umn.edu/subjects/

EXEMPTION DETERMINATION

February 26, 2018

Cassandra Scharber

612-625-6607
scharber@umn.edu

Dear Cassandra Scharber:

On 2/26/2018, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	What would Grace Hopper do? Reclaiming women's place in computer science education
Investigator:	Cassandra Scharber
IRB ID:	STUDY00002703
Sponsored Funding:	None
Grant ID/Con Number:	None
Internal UMN Funding:	None
Fund Management Outside University:	None
IND, IDE, or HDE:	None
Documents Reviewed with this Submission:	• Program Director Interview Protocol, Category: Other; • Persister First Interview Protocol, Category: Other; • ISAACSON-HRP-580 - SOCIAL TEMPLATE PROTOCOL 012917.docx, Category: IRB Protocol; • Non-participant waiver, Category: Consent Form; • Persister Recruitment Survey, Category: Recruitment Materials; • Persister Consent Form, Category: Consent Form; • Separator Consent Form, Category: Consent Form; • Program Director Consent Form, Category: Consent Form; • Separator Recruitment Survey, Category:

Driven to Discover℠

	Recruitment Materials; • Separator Interview Protocol, Category: Other; • Persister Second Interview Protocol, Category: Other;

The IRB determined that this study meets the criteria for exemption from IRB review. To arrive at this determination, the IRB used “WORKSHEET: Exemption (HRP-312).” If you have any questions about this determination, please review that Worksheet in the HRPP Toolkit Library and contact the IRB office if needed.

This study met the following category for exemption:

• (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that Human Subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the Human Subjects responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects financial standing, employability, or reputation

Ongoing IRB review and approval for this study is not required; however, this determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit a Modification to the IRB for a determination.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the HRPP Toolkit Library on the IRB website.

For grant certification purposes, you will need these dates and the Assurance of Compliance number which is FWA00000312 (Fairview Health Systems Research FWA00000325, Gillette Children's Specialty Healthcare FWA00004003).

Sincerely,

Jeffery P Perkey, CIP, MLS

IRB Analyst

We value feedback from the research community and would like to hear about your experience. The link below will take you to a brief survey that will take a minute or two to complete. The questions are basic, but your responses will help us better understand what we are doing well and areas that may require improvement. Thank you in advance for completing the survey.

Appendix B
Persister Recruitment Survey Questions

I am asking you to participate in my research project. I am trying to learn more about the experiences of female university students who are enrolled in computer science and technology-related majors.

Please answer the following question(s).

Do you identify as female? (Yes/No)

If answer is no:

Thank you for responding to this brief survey.

If answer is yes:

I am trying to understand of the experiences of women enrolled in computing related degrees, such as Computer Science, Computer Networking or Information and Communication Technologies at University of Wisconsin-Stout. Understanding your experiences may provide me with more information about why women choose to pursue technology degrees or why some women choose to leave.

If you agree to participate:

- We will meet two times during the spring semester where I will ask you a variety of questions about your experiences
- I will also observe some of your classes
- You will receive a $50 gift card for your participation
- There is little to no risk to you and you may change your mind at any time

By answering yes to the following question you are not agreeing to participate in the study, instead you are only agreeing to allow me to contact you with more information.

Are you interested in learning more about participating in this research? (Yes/No)

If answer is no:

Thank you for your consideration.

If answer is yes:

Thank you for your interest in participating in my research. I will reach out to you at a later date where I will provide you with more information about the study and ask you to sign a consent form. In order to contact you I need the following:

Email address: ______________________
Phone number: ______________________

Appendix C
Separator Recruitment Survey Questions

I am asking you to participate in my research project. I am trying to learn more about the experiences of female university students who are or were enrolled in computer science and technology-related majors.

Please answer the following question(s).

Do you identify as female? (Yes/No)

If answer is no:

Thank you for responding to this brief survey.

If answer is yes:

I am trying to understand of the experiences of women who are or were enrolled in computing related degrees, such as Computer Science, Computer Networking or Information and Communication Technologies at University of Wisconsin-Stout. Understanding your experiences and why you decided to change majors may provide me with more information about why women choose to pursue technology degrees or why some women choose to leave.

If you agree to participate:

- We will meet once during the spring semester where I will ask you a variety of questions about your experiences
- You will receive a $25 gift card for your participation
- There is little to no risk to you and you may change your mind at any time

By answering yes to the following question you are not agreeing to participate in the study, instead you are only agreeing to allow me to contact you with more information.

Are you interested in learning more about participating in this research? (Yes/No)

If answer is no:

Thank you for your consideration.

If answer is yes:

Thank you for your interest in participating in my research. I will reach out to you at a later date where I will provide you with more information about the study and ask you to sign a consent form. In order to contact you I need the following:

Email address: ______________________
Phone number: ______________________

Appendix D
Participant Consent Letters/Forms

Persister Consent Letter

[Student's Name]:

I am asking you to participate in my dissertation research project where I am trying to learn more about the experiences of female university students who are enrolled in computing and technology-related majors.

You are being asked to participate because you have self-identified as being a woman. You are also enrolled in a computing related course and are pursuing a computing related degree at the North Central University. I am hoping to learn more about how your experiences and interactions in the classroom support or inhibit your passion, participation, learning, and career aspirations regarding technology.

As a participant, please expect to do the following in 2018 spring semester:

1) Participate in two semi-structured interviews that will last approximately 45-60 minutes. The interviews will be video recorded.
2) Allow me to observe and audio and video record classroom discussions and activities (approximately 3 observations).
3) Occasionally engage in informal conversations with me during breaks or brief moments between activities as time permits.

Here are a few more things you should know before deciding to participate.

Purpose of Video-Recording
Video recording of small group and classroom discussions and activities will be conducted in ways that will not be intrusive to classroom activities or your learning. The purposes for the video recordings are to provide:

1) A record of the activity or discussion that may help me understand the dynamics of the classroom or activity
2) A record of the interviews that I may refer back to in the analysis of the study data
3) Specific examples of the classroom environment and/or from the interviews may be used in my dissertation presentation and other academic presentations.

Compensation
As a token of my appreciation, you will receive a $50 Visa gift card upon the completion of the final interview.

Risks and Benefits of Being in the Study
This study has very little risk. The risk is possible loss of privacy. Careful measures will be taken to insure your confidentiality and reduce this risk. There is no physical danger to this research. There is no direct benefit for your participation in this study.

Confidentiality
If you choose, your name will remain private; I am the only one who will know your real name. The use of any real names that occur in video clips will either be distorted or not used. Your real name will not be used in any presentations, reports, or publications that are written about this research unless you give me permission.

The master code list with your name will be stored in a password-protected digital file accessible only by me. The link between you and research information will be retained for two years. Digital files, such as interview transcripts, video data, discussion transcripts, field notes will be stored on a password-protected device and saved for no longer than 5 years from the completion of this study and then they will be destroyed. Any paper data generated during this study will be kept in a file cabinet in a locked office, accessible only by me.

Voluntary Nature of the Study
Your decision to participate or not participate in this study will not in any way affect your grade for your class, your relationship with your instructor, or any future relations with the researcher or any department at the North Central University. You are free to withdraw at any time without affecting those relationships.

Contact and Questions
If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, please contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

As required by the University of Minnesota and the North Central University, I am seeking your consent to participate in the study. Attached is a consent form. **If you agree to participate in the study, please sign the form**.

Keep this letter for your records.

I look forward to your participation in this project.

Sincerely,

Kris Isaacson
Ph.D. Candidate, University of Minnesota

STATEMENT OF CONSENT

Findings for this research will be used in Kris Isaacson's dissertation defense. The information will likely also be used in academic publications and presentations. In order to respect your privacy, please indicate your preferences to the following items.

Participant Name:

- ❑ It is okay to use my real name.
- ❑ I do not want my real name to be used. I would prefer a pseudonym.

Use of video clips

- ❑ It is okay to use short video clips from interviews and/or classroom settings in academic presentations.
- ❑ I prefer that you do not share video clips of me.

I have read the information provided to me about the study. I have asked questions and have received answers. I acknowledge that I am at least 18 years of age and agree to participate in the study.

Signature: _______________________________________ Date: __________________

Print your name here: ____

Separator Consent Letter/Form

[Student's Name]:

I am asking you to participate in my dissertation research project where I am trying to learn more about the experiences of female university students who are enrolled or were enrolled in computing- and technology-related majors.

You are being asked to participate because you have self-identified as being a woman. You also were enrolled in a computing related course and were pursuing a computing related degree at the North Central University I am hoping to learn more about how your experiences and interactions in the classroom support or inhibit your passion, participation, learning, and career aspirations regarding technology.

As a participant, please expect to do the following in 2018 spring semester:

1) Participate in one semi-structured interview that will last approximately 45-60 minutes. The interview will be video recorded.

Here are a few more things you should know before deciding to participate.

Purpose of Video-Recording
The purposes for the video recordings are to provide:

1) A record of the interview that I may refer back to in the analysis of the study data
2) Specific examples from the interview may be used in my dissertation presentation and other research presentations.

Compensation
As a token of my appreciation, you will receive a $25 Visa gift card upon the completion of the interview.

Risks and Benefits of Being in the Study
This study has very little risk. The risk is possible loss of privacy. Careful measures will be taken to insure your confidentiality and reduce this risk. There is no physical danger to this research. There is no direct benefit for your participation in this study.

Confidentiality
If you choose, your name will remain private; I am the only one who will know your real name. The use of any real names that occur in video clips will either be distorted or not used. Your real name will not be used in any presentations, reports, or publications that are written about this research unless you give me permission.

The master code list with your name will be stored in a password-protected digital file accessible only by me. The link between you and research information will be retained for two years. Digital files, such as interview transcripts, video data, discussion transcripts, field notes will be stored on a password-protected device and saved for no longer than 5 years from the completion of this study and then they will be destroyed. Any paper data generated during this study will be kept in a file cabinet in a locked office, accessible only by me.

Voluntary Nature of the Study
Your decision to participate or not participate in this study will not in any way affect your grade for your class, your relationship with your instructor, or any future relations with the researcher or any department at the North Central University You are free to withdraw at any time without affecting those relationships.

Contact and Questions
If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, please contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

As required by the University of Minnesota and the North Central University, I am seeking your consent to participate in the study. Attached is a consent form. **If you agree to participate in the study, please sign the form**.

Keep this letter for your records.

I look forward to your participation in this project.

Sincerely,

Kris Isaacson
Ph.D. Candidate, University of Minnesota

STATEMENT OF CONSENT

Findings for this research will be used in Kris Isaacson's dissertation defense. The information will likely also be used in academic publications and presentations. In order to respect your privacy, please indicate your preferences to the following items.

Participant Name:

- ❑ It is okay to use my real name.

- ❑ I do not want my real name to be used. I would prefer a pseudonym.

Use of video clips

- ❑ It is okay to use short video clips from interviews in academic presentations.

- ❑ I prefer that you do not share video clips of me.

I have read the information provided to me about the study. I have asked questions and have received answers. I acknowledge that I am at least 18 years of age and agree to participate in the study.

Signature: ____ Date: __________________

Print your name here: ____

Program Director Consent Letter/Form

[Faculty Member's Name]:

I am asking you to participate in my dissertation research project where I am trying to learn more about the experiences of female university students who are enrolled or were enrolled in computing- and technology-related majors.

You are being asked to participate because you are a Program Director in one of the programs included in the study. Your insights will aid in producing a holistic understanding of the case by providing information about the program and its history, alternative perspectives, and any efforts that may (or may not) have happened to improve gender inclusivity.

As a participant, please expect to do the following in 2018 spring semester:

1) Participate in one semi-structured interview that will last approximately 45-60 minutes. The interview will be video recorded.

Here are a few more things you should know before deciding to participate.

Purpose of Video-Recording
The purposes for the video recordings are to provide:
1) A record of the interview that I may refer back to in the analysis of the study data
2) Specific examples from the interview may be used in my dissertation defense presentation and other research presentations.

Risks and Benefits of Being in the Study
This study has very little risk. The risk is possible loss of privacy. Careful measures will be taken to insure your confidentiality and reduce this risk. There is no physical danger to this research. There is no direct benefit for your participation in this study.

Confidentiality
If you choose, your name will remain private; I am the only one who will know your real name. The use of any real names that occur in video clips will either be distorted or not used. Your real name will not be used in any presentations, reports, or publications that are written about this research unless you give me permission.

The master code list with your name will be stored in a password-protected digital file accessible only by me. The link between you and research information will be retained for two years. Digital files, such as interview transcripts, video data, discussion transcripts, field notes will be stored on a password-protected device and saved for no longer than 5 years from the completion of this study and then they will be destroyed. Any paper data generated during this study will be kept in a file cabinet in a locked office, accessible only by me.

Voluntary Nature of the Study
Your decision to participate or not participate in this study will not in any way affect your performance evaluation, your relationship with your department or supervisor, or any future relations with the researcher or any department at the North Central University You are free to withdraw at any time without affecting those relationships.

Contact and Questions
If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, please contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

As required by the University of Minnesota and the North Central University, I am seeking your consent to participate in the study. Attached is a consent form. **If you agree to participate in the study, please sign the form**.

Keep this letter for your records.

I look forward to your participation in this project.

Sincerely,

Kris Isaacson
Ph.D. Candidate, University of Minnesota

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❑ It is okay to use short video clips from interviews in academic presentations.

❑ I prefer that you do not share video clips of me.

I have read the information provided to me about the study. I have asked questions and have received answers. I acknowledge that I am at least 18 years of age and agree to participate in the study.

Signature: ____ Date: __________________

Print your name here: ____

Appendix E
First Persister Interview Protocol

Warm-up

1. What year in school are you?

2. How are things going?

3. How much time do you spend on the computer? What kinds of activities do you do?

4. How many major classes have you taken so far? How many are you in right now?

Program, Learning, and Aspirations:

5. Can you tell me about why you chose this major?
    - What experiences or people were particularly influential?

6. What interests you most about [name of program]?

7. What do you least like about [name of program]?

8. Do you think [name of program] is the right program for you? Why or why not?

9. How confident are you in your ability to do well in your major classes this semester?

10. What do you think are the qualities or characteristics of someone who is good in your major and/or the field you want to go into?
    - Which of those qualities do you think you possess?

Being a Woman in the Program:

11. How many other women are in your major classes?
    - How does that make you feel?

12. Talk about what it means to be a woman in your program.

13. Are there any incidents of discrimination or harassment that come to mind related to being a woman in [name of program]?

14. Have you ever felt excluded in the classroom or other activities related to your major because of your gender?

15. Do you interact socially with the other women in your major? Why or why not?

Experiences at North Central University

Environment:

16. How would you describe your major to someone considering the program?
17. Do you feel like you belong in [name of major]? Why or why not?
    - Describe any examples that make you feel like you fit in.
    - Examples of when you don't feel like you fit it.

Classes:

18. What has been your favorite in-major class? Why is it your favorite?
19. What has been your least favorite in-major class? Why?
20. Do you feel comfortable asking questions in class? Why or why not?

Professors:

21. What do you think about the professors in your major?
22. Do you feel supported by your professors? Provide examples.
23. Do you feel comfortable going to your professors outside of class to ask for help or guidance? Why or why not?

Peers:

24. How would you describe your fellow [name of program] classmates?
25. Do you feel comfortable asking your classmates for help?
26. Do you feel your classmates respect your abilities? Why or why not? Provide examples.
27. Do you spend time with your classmates or people in your major outside of class? What kinds of things do you like to do?

Final thoughts

28. Why do you feel there are so few women in computer and technology programs/jobs?

29. What kinds of ideas do you have that might attract more women to the field? To the program?

30. Do you have anything else that you would like to share?

31. Do you have any questions for me?

Appendix F
Second Persister Interview Protocol

These are possible questions. The questions need to remain open enough to discuss anything specific that was observed while observing the classroom.

Warm-up

1. How is the semester going?

Reaction to Classroom Observations:

2. Tell me more about the class that I observed.

3. What do you think about this class? (e.g. like, dislike, difficult, easy)

4. When do you feel most comfortable in class? Least comfortable?

5. How are you doing in the class?

6. How do you think you're doing compared to your classmates?

7. How would you describe your confidence in your ability to do well in this class? Your major?

Classroom Environment

8. How would you compare this class to other classes you've had in your major?

9. How comfortable are you at asking questions or contributing to the class in other ways? (e.g. discussions, presentations, etc.)

10. Have you ever felt excluded in the classroom or other activities related to your major because of your gender?

11. Do you feel that your contributions in class are valued?

The Instructor

12. What do you think about the instructor for this class?

13. What is your relationship with him/her like?

14. Do you feel he/she supports your learning? Provide examples.

15. Are you comfortable going to his/her office outside of class to ask for help or guidance? Why or why not?

16. How often have you gone to this instructor for help?

Peers

17. Do you have group work in this class? (If observed then just go to the follow up question)

18. What is your role in group activities? (e.g. leader, note-taker, etc.)

19. Are you comfortable asking your classmates for help?

20. Do you feel your classmates respect your abilities? Why or why not? Provide examples.

Future

1. Do you think you will finish your degree in [name of program]?

2. What do you want to do when you graduate from North Central University

3. What is your ideal career?

Final thoughts

4. Do you have anything else that you would like to share?

5. Do you have any questions for me?

Appendix G
Program Director Interview Protocol

Background

1. How long have you been program director?

2. How long have you been teaching at NCU?

3. What can you tell me about the program? Just trying to get a little background.

4. What kinds of courses do you teach?

Women in the Program

5. On average how many women are in the classes you teach?

6. Why do you feel there are so few women in computer and technology programs/jobs?

7. When there is more than one woman in a class, do you notice if they tend to self-segregate? (e.g. sitting next to each other, work together in groups, etc.)

8. How would you describe the participation level of the women in your classes?
   - Do you feel the level of participation is any different than their male counterparts?
   - How about roles in group work? (e.g. leader, spokesperson, note taker, etc.)
   - How about participation in clubs, organizations, or competitions?

9. Do you think women in the program are treated differently than the male students?

10. From your perspective, how would you describe the relationships between the male and female students in the classes you teach and the program in general?
    - Do they socialize?
    - Do they voluntarily work together on projects and/or homework?

11. Have you observed, or have you been made aware of statements or behaviors of male students that could make women uncomfortable? Some may be overt, but others less obvious. (e.g. sexist language, direct comments about ability, isolation)

12. Have any of your female students expressed concerns about being a woman in the program (e.g. different treatment, inclusion, etc.)?

13. What qualities or characteristics should students possess to be successful in [name of program] and in the workforce after they graduate?

Discussions on Gender

14. What are your thoughts about the gender parity issue in your field?

15. What conversations about gender have happened with faculty in your program or department?

16. What has been done in your program to attract and/or keep more female students?
    - What kind of successes have you had?
    - If things didn't go well, what changes could be made?

17. What are some ideas that you have for the program, department, or University to attract and retain more women in computing and technology fields?

Final thoughts

18. Do you have anything else that you would like to share?

19. Do you have any questions for me?

Appendix H
Code Mapping

First iteration of codes (and sub-codes) in alphabetical order

- Ability to get help
- Academic support from peers
- Attitude toward major/program
- Attitudes towards other women in major classes
- Attitudes/Feelings about being in a minority in major classes
- Being a woman in the major
    - Feminism
    - Imposter Syndrome
    - Perception about guys and computing
- Class participation
- Class size info
- Classmates respect abilities
- Code outside of class/school
- Coding comes easy
- Concerns about femininity
- Concerns about perceptions of male classmates
- Confidence
    - High confidence
    - Low confidence
    - Questioning confidence
- Confusion/Not understanding topic
- Connection with peers
- Creativity
- Disempowering
- Don't interact with women in major outside of class
- Empowering
- "Fit" with major
- Gender and social/dating complications
- Get to know professor
- Girls seek each other out
- Harassment, Discrimination, Different Treatment
    - Harassment
    - Exclusion
    - Discrimination
    - No overt discrimination
- High standards/expectations of self
- I really like math
- Intimidated by professor
- Just one of the guys

- Knowing professor expectations
- Lack of "fit"
- Lifelong learner
- Men taking over
- Negative – lack of interest in topic
- Negative peer interaction
- Negative professor interaction
- No computing experience
- Not being heard
- Not taken seriously
- Other majors considered
- Overachieve
- Passion for technology
- Passion to persist
- Positive interactions with professors
- Positive about degree/career path
- Pre-college influencers
    - High school teachers
    - Friend(s)
    - Family member
    - Technology
- Problem solving/puzzles/logic
- Programming is learned – growth mindset
- Qualities needed to succeed
    - Organization
    - Curiosity
    - Enthusiasm
    - Good communication skills
    - Accept criticism
    - Passion for computer science
    - Passion for math
    - Patience/attention to detail
    - Team player
- Questioning experience based on gender
- Real-world application of learning
- Reasons for pursuing major
    - Make money/decent living
    - Creating virtual environments
    - Give joy to others
    - Contribute to something bigger than me
    - Possibilities
    - Share stories/experience
- Science interests
- Self-reliant

- Socialize with people in major
- Societal gender pressures
- Stereotypical Geek interests
- Teamwork frustrations
- Trailblazers for improvement
- Validations of knowledge/skills
- Welcoming environment
- What students like about the major
- Why don't women pursue computing
    - News of harassment
    - Experiential opportunities
    - Lack of support
    - Early exposure
    - Role models
    - So much to learn – intimidating
    - Unaware of careers

First Iteration: Initial Categorization

Category 1: Not Being Heard

- Men taking over
- Not being heard
- Not taken seriously

Category 2: Peer Relationships

- Classmates respect abilities
- Socialize with people in major
- Teamwork frustrations

Category 3: Women and Femininity

- Attitudes towards other women in major classes*
- Being a woman in the major*
    - Feminism
- Concerns about femininity*
- Don't interact with women in major outside of class
- Girls seek each other out*

Category 4: Men and Masculinity

- Gender and social/dating complications*
- Just one of the guys
- Perception about guys and computing*

Category 5: Stereotypically Male Interests

- Coding comes easy
- Code outside of class/school
- I really like math
- Passion for technology
- Science interests
- Stereotypical Geek interests

Category 6: Harassment, Isolation, Exclusion

- Attitudes/Feelings about being in a minority in major classes
- Class participation
- Connection with peers
- Disempowering
- "Fit" with major*
- Harassment, Discrimination, Different Treatment
    - Discrimination
    - Exclusion
    - Harassment
    - No overt discrimination
- Lack of "fit"*
- Negative peer interaction
- Passion to persist
- Questioning experience based on gender*

Category 7: Overachievement

- High standards/expectations of self
- Overachieve
- Self-reliant
- Societal gender pressures*
- Validations of knowledge/skills

Category 8: Confidence

- Concerns about perceptions of male classmates*
- Confidence
    - High confidence
    - Low confidence
    - Questioning confidence
- Imposter Syndrome*

Category 9: Support

- Academic support from peers
- Ability to get help
- Empowering
- Get to know professor
- Intimidated by professor
- Knowing professor expectations
- Negative professor interaction
- Positive interactions with professors
- Pre-college influencers
    - Family member
    - Friend(s)
    - High school teachers
    - Technology
- Welcoming environment

Category 10: Qualities to succeed in computing major

- Creativity
- Problem solving/puzzles/logic
- Qualities needed to succeed
    - Accept criticism
    - Curiosity
    - Enthusiasm
    - Good communication skills
    - Organization
    - Passion for computer science
    - Passion for math
    - Patience/attention to detail
    - Team player
- Real-world application of learning

* Indicates an area of possible duality/conflict

Second Iteration: Research Themes

Theme 1: Duality

Theme 2: Not Being Heard

Theme 3: Just One of the Guys: You Get Used to It

Subcategories:

- Stereotypical male interests
- Predominantly male friends

Theme 4: Overachievement and perceived academic self-efficacy

Subcategories:

- Perceptions of men and computing
- Impression Management

Theme 5: Exclusion and Isolation

Subcategories:

- Physical isolation
- Harassment
- Emotional isolation

Theme 6: Confidence

Subcategories:

- Imposter Syndrome

Theme 7: Support from Professors