WOMEN IN COMPUTER SCIENCE: AN INTERPRETATIVE PHENOMENOLOGICAL ANALYSIS EXPLORING COMMON FACTORS CONTRIBUTING TO WOMEN'S SELECTION AND PERSISTENCE IN COMPUTER SCIENCE AS AN ACADEMIC MAJOR

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Abstract

The purpose of this study is to understand the meaning that women make of the social and cultural factors that influence their reasons for entering and remaining in study of computer science. The twenty-first century presents many new challenges in career development and workforce choices for both men and women. Information technology has become the driving force behind many areas of the economy. As this trend continues, it has become essential that U.S. citizens need to pursue a career in technologies, including the computing sciences. Although computer science is a very lucrative profession, many Americans, especially women, are not choosing it as a profession. Recent studies have shown no significant differences in math, technical and science competency between men and women. Therefore, other factors, such as social, cultural, and environmental influences seem to affect women's decisions in choosing an area of study and career choices.

A phenomenological method of qualitative research was used in this study, based on interviews of seven female students who are currently enrolled in a post-secondary computer science program. Their narratives provided meaning into the social and cultural environments that contribute to their persistence in their technical studies, as well as identifying barriers and challenges that are faced by female students who choose to study computer science. It is hoped that the data collected from this study may provide recommendations for the recruiting, retention and support for women in computer science departments of U.S. colleges and universities, and thereby increase the numbers of women computer scientists in industry.

Keywords: gender access, self-efficacy, culture, stereotypes, computer education, diversity

DEDICATION

To my wife, colleague, and most importantly, my life partner. Thank you for your grace, the example that you have set, and for your patience and understanding. I love you with all of my heart and soul.

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Chapter 1: Introduction to the Study

Introduction to the Problem

Computer science is an intellectually stimulating and challenging field. It is a discipline that spans both theory and practice, and combines the need for creativity with the requirement of thinking in both abstract and concrete terms. The practical side of computing can be seen everywhere. It affects many different aspects of life, and creates much of the technology that we have grown accustomed to using on a daily basis.

The history of machine-assisted human computation began long before the modern discipline of computer science sprang into being in the mid-twentieth century. Women are well represented in this history and have played a pivotal role in the development of computer science and computing technology. Yet today, women are vastly underrepresented in the very discipline they helped to create. This study attempts, in a small way, to bring meaning to this phenomenon by giving a voice to women in this study, who despite numerous personal hurdles have chosen and persisted in the study of computer science. The following is a brief history of the beginnings and evolution of computer science, and the contributions that women have made to itIn 1833, a seventeen-year-old woman by the name of Ada Lovelace was introduced to Charles Babbage, the Chair of Mathematics at the University of Cambridge. When the professor demonstrated his new calculating machine to the young woman, he was impressed by her ability to grasp "the most abstract of Science...with a force which few masculine intellects could have exerted over it" (Schwarz, 2002, p. 356). Working with Babbage and his calculating machine, Ada invented a method of saving and reusing instruction sets on, what were later to be called, punch cards. Over two hundred years later, this researcher used Ada's same punch cards in both undergraduate computer science courses and in a professional position as a programmer. This invention has earned Ada Lovelace a spot in computing history as the first computer programmer. Nearly a century and a half later, another woman pioneer, U.S. Navy Rear Admiral and Harvard Professor, Grace Hooper, otherwise known as "Amazing Grace," changed the lives of everyone who would ever use a computer. She invented the first programming language that allowed computers to respond to words rather than numbers (Gürer, 2002). She was also credited for coining the term "bug" when referring to a fault or defect in a computer program (Taylor, Moritz & Stoler, 1984).

Other women luminaries include Edith Clarke, who was the first women to earn a Master of Science degree from MIT. She went on to work for General Electric, and in 1921 filed a patent for a "graphical calculator" which could solve equations, including hyperbolic functions ten times faster than previous methods. Clarke's invention led to the creation of the handheld calculator that is so prevalent today (Gusen, 1994). Margaret Fox, Kay McNulty, Frances Spence and Jean Bartik are other key female contributors to the development of the technologies that we now make up what we call computer science (Gürer, D., & Camp, T., 2002).

Statement of Problem

In the years since Lovelace, Hooper and other women pioneers did their work, the gender imbalance in the computing sciences has become alarmingly wide. At the National Center for Women and Information Technology Summit held in May of 2014, Farnam Jahanian, of the National Science Foundation, spoke of how advances in computing technology have "transformed the way we live, the way we work, play, learn, and communicate" (2014). Yet in the United States, the field of computer science is overwhelmingly male dominated. According to the National Center for Education Statistics, women made up just 18% of undergraduate computer science majors in 2010-2011 (Snyder & Dillow, 2012). Additional studies show that just 27% of master's degrees' recipients in computer science are women (Klawe, Whitney & Simard, 2009) and only 13% of computer science doctorates are awarded to females (Hoffer et al., 2001).

The underrepresentation of women in computer science is a systemic problem in the United States, both at the university level and in the workforce. Every article about women in computer science will be quick to show current statistics, which are indeed alarming. In the year 2010, women comprised 50.8% of the student population of the United States (United States Census, 2011), yet as mentioned, women only received 18% of the bachelor's degrees that were conferred in computer science (National Science Foundation, 2012). Women's attainment of undergraduate degrees in computer science peaked around 1985, when they received 36.9% of the degrees awarded that year (National Science Foundation, 2009). From that time there has been a gradual decline in women's selection of computer science as a course of study. A similar problem exists in the workforce. According to the Bureau of Labor Statistics, in 2013 only 26.1% of the Computer and Mathematical Occupations, which include not only positions in the field of mathematics, but also computer related positions that fall outside the traditional definition of computer science, such as technical project management, quality assurance and systems administration, were held by women.

Apart from ethical concerns of women's lack of participation in computer science, the demographics of the United States show a substantial shortfall of computer professionals unless underrepresented groups increase their participation in computer science or related studies (Othman & Lathih, 2006). Evidence also suggests that a high percentage of women who enter computer science education will either drop out of the academic pipeline altogether, or choose a different course of study. Consequently, women are underrepresented in computer science in both academics and in the computer industry. In light of current U.S. demographics, the participation of women must increase to meet the future demands for trained programmers and computer scientists. Additionally, this current imbalance gives rise to several problems, including staffing challenges, lack of balanced perspectives with regards to technical innovations and other social implications.

The review of the literature show that women are equally capable of succeeding in the computer sciences. What is causing this wide gender gap? Universities, researches, corporations, nonprofits, and even newspaper reporters have been continually investigating this issue for over thirty years. The enrolment, persistence, and retention of women in computer science has been the focus of many studies (Katz et al., 2006; Margolis, 2002; Vesgo, 2005), which have identified a number of issues that preclude women's involvement in computer science. These factors include such things as negative stereotypes about women's abilities (Singh et al, 2007; Sonnert, 1995), a culture of exclusion, and social expectations (Baker & Leary, 1995; Blickenstaff, 2005; Thorne, 1993), demographics (Cole & Espinosa, 2008; Espinosa, 2009; Sax, 2001), early exposure to computing and technology in elementary and high school (Blickenstaff, 2005; Kinzie, 2007), lack of female role models (Marx & Roman, 2000; Jepson & Perl, 2000), and negative stereotypes which influence women's self-efficacy and perception (Cohoon, 2001; Huang & Brainard, 2001; Yasuhara, 2005). As the literature demonstrates, years of research have confirmed the disparity of the numbers of women entering and persisting in computer science programs in the United States, the result being a lack of working female computer science professionals. Many of these studies have produced a variety of suggestions for overcoming these problems. In spite of these efforts, there is still no definitive solution identified, and low numbers of females entering and graduating from computing sciences programs still plagues most colleges and universities.

Yet despite the plethora of problems, some women do persist in computer science. This study proposes that we learn from them. This is not to say that the aforementioned concerns are irrelevant. Indeed, they are extremely relevant. These are some of the issues that women who persist in computer science do encounter and overcome. This is the focus of the study: to understand the phenomena that cause women to persist despite, and in some cases, because of these problems. As the review of literature suggests, additional research is warranted to understand the factors, influences and experiences that are part of the motivation of women who selected and persisted in computer science as a field of study. It is felt that examining the lived experiences and perceptions of women who have made the decision to enter into computer science and have persisted in their studies will enhance the existing body of knowledge in this area.

As the findings identified in the review of literature review and this study suggests, the transformation of our academic and institutional policies and procedures to eliminate gender bias constitutes a significant task that will need to be carried out at the national level. This effort will require committed leadership and continuous attention, evaluation, and accountability. It is felt that this study will be of value to higher education administrators, professors and educations, curriculum designers and researchers who are committed to promoting and improving the educational and professional success of all students regardless of gender.

Positionality Statement

I am currently a member of the computer science faculty at a large public state university located in the Western United States. My path to becoming a professor of computer science was by no means straightforward. I was raised in a sparsely populated area in Northern California where there were fewer than fifty students in my high school graduating class. This was a rural, agricultural area. My family was a part of that agricultural background. My father was a farm worker, as was his father, and his father. I was socialized in this very politically conservative culture. My parents espoused conservative values, including traditional roles of men and women. This was modeled for me in the community, and in the schools I attended. I understand that hegemonic centers never dominate completely (Jupp & Slattery, 2006, p. 203). This was evidenced by the national woman's movement, which was gaining support at the time I was entering junior high school. There was much resistance to this movement from the conservative right, both nationally and at the local level. I did witness firsthand how women who refused to accept a passive role were viewed as being outside of "normality" (Briscoe, 2005, p. 29).

While my parents were not formally educated past high school, they did instill in me the desire for knowledge and leaning, and encouraged me to seek out higher education. I took their advice, somewhat belatedly: I enrolled in college after several years of working various jobs. I was married and had a small child at the time. With the help of my wife, I worked my way through school and graduated five years later with a degree in Design and Computer Engineering. I was the first in my family to earn a college degree.

Since graduation, technology has been a big part of my life. Before moving into academics and teaching, I worked for over 25 years in the software development industry. Fifteen of those years were spent at the senior management level. My career has given me the opportunity to work with many fine people and some very gifted engineers and computer science professionals. I have had the opportunity to manage and interface with several international groups. Through these experiences, I have come to respect and appreciate diversity. However, throughout my entire career there was always one constant: almost without exception, I was surrounded by other men. As a hiring manager, I would routinely receive fifty to a hundred resumes for an open position and oftentimes, there would not be a single female candidate that would apply. The ratios of men to women I see in my classrooms today are an accurate reflection of my experience in software industry. Most of these experiences have taken place in Utah, which has a large conservative population. I am not religious, but I am surrounded by a religious culture. This conservative/religious culture discourages the education of women. A message that is often preached from the pulpit in the dominant religion here in Utah is that a woman's place is in the home (Chadwick & Garret, 1995; Beaman, 2001, p. 71).

As an instructor in higher education, I have seen first had the damage this message has done to many of my students. I have counseled many women, many of which are single mothers who have enrolled in school trying to obtain the skillset necessary to support themselves and their children. These women are starting from ground zero because five, ten or even fifteen years ago they believed some authority figure who said women didn't need an education. These experiences have colored my perception, and in no small part have influenced my course of study. Aside from my personal observations, there is also research that suggests that this religious influence also sways women in their decision on whether to pursue education beyond high school (Madsen, Hanewicz & Thackeray, 2010). These experiences have deeply affected me to the point that I have very little tolerance for conservative and religious dogma that would, in effect, subjugate women to the role of a second-class citizen.

Because of these experiences and observations, during my professional and academic career, I have experienced a constant tension between the conservative environment in which I live in and my beliefs of inclusion and gender equality. I acknowledge this tension, and I do realize that I am predisposed to feel a certain way about this research. I consider myself to have a progressive viewpoint with regards to gender equality, however, because of my conservative background and socialization, I still find myself at odds with some of the hostility displayed by western feminism towards traditional women's roles, such as motherhood (Fennell & Aront, 2008, p. 530).

The disproportional relationship between men and women in post-secondary computer science and technology programs is something that I also observed while in Africa working with the faculty of the Polytechnic of Namibia, located in Windhoek, the capital city of Namibia. The history and culture of the people is patriarchal, more so than in the United States. The early nineteenth century European settlers, who were primarily of German extract, reinforced this traditional, male dominance. Since gaining their independence from South Africa in 1990, Namibia has continued to be progressive in their human rights policies. This is evidenced by the high percentage of female students enrolled at the Polytechnic of Namibia. Yet in the science, technology, engineering and math (STEM) courses, which computer science is a major part, women are still underrepresented, and the differences in enrollment are dramatic. This reinforced, to me, that underrepresentation of women in technology and science disciplines is a worldwide problem.

At times, these observations have caused me to resist or discount any ideologies espoused by conservative, dominant groups of classes. I understand that the personal attachments and preconceptions that I have present both strengths and weaknesses for the research that I am undertaking (Machi and McEvoy, 2012). I acknowledge this is a bias that has the potential to limit the effectiveness of my research. I also feel that our backgrounds, social status and environment do impact any research we undertake. This is especially true if we look at research as a process and not just a product. In qualitative research, the identities of the researcher, with regards to the study and the participants, does have the potential to impact the research process. This is especially true if the researcher is dealing with a subject or problem of practice from his/her own background and experiences. Such is the case with this study. I know this is something that I will have to deal with. I feel a first step is to recognize biases, and then to figure out how to approach this research objectivity.

Research Central Question

What are the common factors and experiences that contribute to women's selection and persistence in computer science as an academic major?

Sub-Questions

The literature review served as a starting point for the creation of the theoretical underpinning of this study. It has also helped frame the research question, and the following sub-questions that are to be investigated in this study. These sub-questions are:

1. What are the experiences that lead female students to choose a computer science major?
2. What are the factors and experiences that influence female students to persist in the study of computer science?
3. Are there factors that are related to the discipline of computer science that discourages female students from participating in the study of computer science?

4. Are there gender related feelings, traits, or experiences which female computer science majors share?

Theoretical Framework

Introduction to Framework

In order to understand the phenomenon outlined in the problem of practice and purpose statements, and to answer the research question, a qualitative research method has been chosen. It is my opinion that a qualitative study would be most effective in gathering culturally specific information about the opinions, values, behaviors, and social contexts surrounding women's selection and persistence in computer science education. In this study, the research of women in computer science is viewed through several theoretical lenses, with cognitive career theory being the primary theory used. This theory takes into account factors that affect the education decision-making intentions of women toward computer science. It is felt that this theory, with its emphasis on cognitive personal variables that enable a person to influence their own career development, and the variables that either enhance or constrain their career choices aligns well with the problem of practice, research questions, and the stated purpose of this research.

In relation to women's academic choices in computer science, current research identified in the literature review suggests that there is evidence that negative and gender stereotypes affect enrollment and persistence of women in computer science. Other studies have been conducted that suggest stereotypes, both positive and negative, influence self-efficacy. There is also a high correlation between self-perceptions and self-awareness and achievement and persistence (Katz et al., 2006). Related theories that help frame this study are the social cognitive theory as it pertained to gender roles, and how women learn though interaction and social context (Bandura, 1997; Hansman, 2001).

It is the intent of this research study to demonstrate how these theories interrelate when applied to women's persistence in a post-secondary computer science program of study.

Social Cognitive Career Theory

The Social Cognition Career Theory (SCCT) is derived from Albert Bandura's social cognitive theory (Lent, Brown, & Hackett, 1994). SCCT is a relatively new theory that makes an effort to understand, and make sense of, the processes with which people make choices, form interests and achieve varying levels of success in educational and career pursuits. It also attempts to address issues of culture, gender and self-perceptions.

One of the major tenets of SCCT is that individuals have a tendency to eliminate possible occupation and educational choices due to faulty self-efficacy perceptions and outcome expectations. SCCT states that the greater the perceived barriers are to an occupation, the less likely it is for individuals to pursue those careers. The theory argues that modifying outcome expectations and faulty self-efficacy can help individuals create positive experiences that will adjust their views and expectations toward new career occupations. These tenets have been adapted to include education choices, and research has been conducted on how these choices are turned into actions (Gibbons, 2004). With this adjustment to include educational choices, there is strong alignment with my research question: what are the common factors that contribute to women's selection and persistence in computer science as an academic major.

SCCT focuses on three building blocks of career development, which are: self-efficacy, outcome expectations and personal goals. This theory proposes that career choices are influenced through four main sources: social persuasion, physiological states and reactions, and vicarious learning (Lent, et. al, 1994). These themes recurred many times in my review of the literature on women's selection and persistence in computer science.

Self-efficacy is a belief about one's own ability to succeed, and refers to the belief that a person has about their ability to understand and successfully complete the processes required for a given task. A person develops a sense of self-efficacy from their personal performance, learning by examples and interactions, both culturally and socially, and how comfortable they perceive themselves in a given situation. Primary sources of self-efficacy include personal performance and accomplishments, social persuasion and environmental pressures (Gibbons, 2004).

Outcome expectations are the beliefs about the outcome of performing particular behaviors. These expectations are formed by past experiences of the individual, which could be either vicarious (observed) or direct experiences, and the perceived results of these experiences (Gibbons, 2004).

Personal goals are viewed through the SCCT lens as the determination to engage in a particular activity or task, and to affect a particular outcome (Lent, 2005). A goal is defined as the decision to begin a particular activity or work toward a future plan. Gibbons (2004) states, goals are seen as playing a primary behavior role.

The constructs of this theory include the interest development model, with a premise that people are attracted to tasks and activities that they feel they are competent at, and what they feel they will be successful in. Attitudes and values are another construct that is tied very closely to self-efficacy and the persons' outcome expectations. Gender and Race or ethnicity is another construct of SCCT that factors closely into the purpose of this study, as the focus is women's participation in computer science. These constructs are supported in the review of literature.

SCCT acknowledges that gender bias and negative peer pressure can be linked to decisions, such as not persisting in pursuing goals associated with a computer science major. Additional constructs include a choice model that helps frame the career or educational choice process. This includes the establishment of a goal, the actions taken to achieve the goal, and the measurement of the level of performance that will determine the direction of future careers or educational behaviors. Related to this is the SCCT performance model construct, which deals with the quality and persistence of behavior.

Both the choice model and the performance model have a direct alignment with the problem of practice and have been identified in the review of literature as lenses to be used to frame, and perhaps measure, the decision of female students to persist, or not to persist, in computer science.

Social Cognitive Theory

This theory, as it pertains to gender roles, is used to frame this research. The Social Cognitive Theory (SCT) is based on the social learning theory, and assumes that a person works through his/her individual cognition to interact with and alter the environment, and that this interaction will influence the person's behavior. This theory advances the notion that an interaction between a person and their environment will influence decision-making. The social cognitive theory also considers the fact that socialization is not constant, but a dynamic process, and thereby has changing influences on self-concepts and behavior throughout life (Bandura, 1978).

Definition of Terms

Computer Science

Computer science is the study of computers and computational systems and technologies. This includes both computing hardware and software. It is a discipline that spans both the theory and practice (Denning, 2005).

Culture

In this study the use of the term culture refers to the complex and broad set of relationships, attitudes, behaviors and values that bind a specific community together either consciously or unconsciously.

Gender

A cultural term that "describes characteristics we ascribe to people because of their sex—the ways we believe they behave or the characteristics we believe they possess, based on our cultural expectations of what is male and what is female" (Shakeshaft, Nowell, & Perry, 1991).

Persistence

For the purpose of this study persistence is defined as students remaining enrolled in the academic institution and are in good academic standing.

Science, technology, engineering, and mathematics occupations (STEM)

STEM occupations as discussed in this study include computer programmers, computer analysts, computer technicians, network technicians, technical project managers.

Social Environment

For this study, social environment is defined as the physical and social setting in which people live, and includes a set of beliefs and behaviors that exists within the culture that the participant was socialized in.

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Assumptions and Limitations

This research was conducted using an inductive lens, that examined participants' experiences that were specific to their decision to select and then to persist in the study of computer science. This study has revealed factors that lead to the participants' decisions to enter a computer science course of study, and then to persist in that study. An assumption is made that the factors identified in this study will likely be similar to those of other female students who have chosen computer science as their area of study.

Limitations

My educational and professional background is in computer science. Working as a professional in the high technology industry, and more recently as a faculty member in the college of computing and technology at a large public university has played an important role in the selection of this research topic. This information must be noted as all data in this study is interpreted through the lens of the researcher. As Stanley and Wise (2002) have noted, not only does the researcher shape the interpretation of the data, but the researcher also has an impact on the production of the data.

Unchecked, my experiences might have rendered the me as an insider and might have shaped the interview questions and influenced data interpretation. It was essential for me to separate or bracket my assumptions prior to collecting data to ensure any assumptions that had did not unduly cloud my ability to collect and analyze study participant responses. The data collection plans allocated time for the me to do so.

With regards to the scope of this study, seven participants, even though they hale from all regions of the United States, are not likely to report experiences that are completely generalizable to all female students. Likewise, the three Western universities that comprised the pool from which the participants were chosen may not be representative of the academic environment of other regions in the United States. While diverse, these women's work experiences may differ from women in the workforce from other geographical areas of the country.

These limitations along with the limited number of participates need to be taken into consideration when reviewing the results and implications of this study. However, research on this specific and limited population is counterbalanced by the richness of the data taken from the personal narratives.

Summary

This research focused on understanding the socially constructed lived experiences that triggered underrepresented students to enter and to persist in university level computer science programs. A better understanding of underrepresented student experiences that led to student selection of computer science as a program of study and factors that have influenced those who have persisted in the program may assist in producing best practices to alter the current underproduction of computer science degree graduates.

Chapter 2: Literature Review

Introduction

The following is a review of literature that details the research concerning the issues associated with the gender gap in computer science education. The question that was used in this research to filter, select and organize existing research was: how has existing studies sought to understand the phenomena of the underrepresentation of women in the computing sciences. With this question in mind, a number of themes have emerged from the literature review that support and inform the problem of practice.

Literature Review

This review is divided into multiple streams of literature organized along these themes, with the first section of this review being in an overview of the current state of women in computer science research. The second section reviews research that identifies gender-based barriers that limit access to computer resources and knowledge. This is followed by a review of literature that examines the effects gender related stereotypes, perceptions, self-efficacy, and the effects the culture and attitudes have on female participation in computer science.

Current State of Women in Computer Science Education

The review of literature confirms that low entrance numbers and the rate of persistence of women in college level computer courses have resulted in a critically low level of female penetration into technical careers, involving or related to computer science and information technology (McIlwee & Robinson, 1992; Powell, Bagilhole, & Dainty, 2009). A study conducted by the American Association of University Women (AAUW, 2015) presents clear evidence that women lag behind men in interest and participation in computer science and technical fields. The study also states that women's low participation in the culture of computer science is of increasing concern from the viewpoint of economics, education, and culture (2015). Figures released by the National Science Foundation (2015) reported that women obtaining Bachelor's degrees in computer science are less than one third that of men. Unfortunately, the number of women choosing a computer science major is in steady decline. In 1980, 4.7% of female college freshmen chose to major in computer science, while thirty years later in 2010, only 0.7% of women selected computer science as their major. (Astin, King & Richardson, 1981; Pryor, Hurtado, DeAngelo, Palucki & Tran, 2011).

The underrepresentation of women in computer science is a systemic problem in the United States, both in college and in the workforce. It is a recurring theme: the number of computer science graduates is not keeping up with the demands of industry. Technology companies widely lament unfilled industry demand for computer science positions. This gender gap is present throughout all computer disciplines, is present in all age groups, and across all cultures. (Li & Kirkup, 2007; Papastergiou, M., & Solomonidou, 2005; Whitley, 1997); Colley & Comber 2003). Due to a lack of domestically available workers, many technology companies are becoming more dependent on imported foreign workers with H-1B visas. Companies such as Facebook, Microsoft, and Google have recently endorsed legislation to increase the number of H-1B visas (McCullagh, 2013). Offshoring computer science jobs is also becoming a widespread practice, with Alan Blinder of Princeton University (2007) suggesting that computer programming has become the number one offshored position.

These trends have not gone unnoticed by the U.S. government. In the January 2012 State of the Union address, President Obama remarked, “Growing industries in science and technology have twice as many openings as we have workers who can do the job” (Executive Office of the President, 2012). Though this speech suggests an overall shortage of science, technology, engineering and math (STEM) jobs, it is important to recognize that computer science positions accounts for 51% of all STEM jobs (Carnevale, Smith, & Melton, 2011).

These disparities result in not only missed opportunities for women to become involved in a lucrative and professional field, but society in general may be deprived of the benefits that diverse perspectives can offer (Hong & Page, 2004). The following literature identifies a number of studies that have been conducted with the goal to achieve a better understanding of the issues surrounding female participation within computer science.

Barriers in Access

Research conducted by Sanders and Nelson (2004) shows that over the past twenty years, women made progress in the disciplines of engineering, physics, chemistry and other sciences, while at the same time participation in computer science dropped by nearly thirty percent. The Sanders and Nelson paper reviews early work on gender in computer science and identifies issues that at one time were well founded, but now seem to be less relevant. This includes concerns about women's access to computers, concerns about the close association of computer science and mathematics, and the physical safety going to and from campus computer labs at night. This study concludes that there are no longer significant barriers in physical access for any population.

Other studies support the conclusion that gender differences in computer usage, including mobile computing devices, have substantially decreased over the past decade (Cooper, 2006; Cooper & Weaver, 2003; Todman, 2000). There are several studies that insist there is no longer any evidence of physical barriers to computers and computing resources. (Wasserman & Richmond-Abbott, 2005).

Barriers in Ability

An issue that is often discussed is possible differences in cognitive abilities between men and women in the field of computer science. This topic emerged as a significant theme in the review of literature because this is an area that has spawned stereotypes that women have less natural ability in computing sciences. The fact is that once you move past the stereotypes, there is little evidence to actually suggest this. Several studies have confirmed, when examining actual underlying cognitive abilities, there seemed to be minimal gender differences between men and women, and that women are as successful as men in completing technical tasks associated with computer science (Werth, 1986; Clarke & Chambers, 1989).

One such study, conducted by Marx and Roman (2002) argues that no physical or cognitive obstacles exist that might create disadvantages been one gender group over the other. This study posits that men and women should be equally suited for excelling in computer science education and obtaining computer related professional skills within the computer domain. This finding was supported by research conducted on gender differences in computers in distance delivered education (Atan, Sulaiman, Rahman, & Idrus, 2002), where no gender differences in terms of technical competencies were seen in usage types of computer software. According to the authors, both male and female subjects had access to and utilized the computing and networking software to support their digital learning environment without any observable differences between genders. My observations are in alignment with these findings. In reviewing personal data that has been gathered from over five years of teaching university level computer science courses, it was found that in the courses this instructor taught, female students routinely scored in the top one third of the class, in both assignments and finial grades.

If there are no discernable gender related differences in ability, then the imbalances must be socially constructed and related to culture, perceptions, attitude and expectations about computers and the computing sciences. The following sections explore literature that suggests possible ways in which gender differences in computing and computer technology could be socially constructed and perpetuated.

Self-efficacy

Belief in one's ability to perform well in a specific field or at a certain task is referred to as self-efficacy. (Bandura, 1997; Pajares, 2005; Zimmerman, 2000). There is a wide body of research on self-efficacy, its sources, the cognitive processes surrounding it, and its effects on goal setting and persistence. Perceived self-efficacy is at the core of Bandura's Social Cognitive Theory (1977). Bandura contends that self-efficacy reflects individuals' beliefs about whether they can achieve a certain level of success at a particular task (Bandura, 1997). In an academic setting, it has been observed that students with greater self-efficacy are more confident in their abilities to be successful when compared to students with lower perceived self-efficacy. In this regard, self-efficacy has proven useful for understanding students' motivation and achievement within academic settings. In support of this, a study by Pajares (1996) found that higher levels of perceived self-efficacy were directly associated with greater goal choice, persistence and successful obtainment of those goals, and with more effective strategy used to obtain the goals. (Pajares, 1996).

Goal setting and choices are other tenants of the Social Cognitive Theory (Schunk, 1990). Goal choices made by individuals are significantly influenced by their self-efficacy, as is the amount of effort expended, and level of persistence used to reach these goals (Pajares, 2005; Bandura, 1997). This and other studies suggest that self-efficacy is a significant predictor of the level of motivation toward a particular task and ultimately of performance of the task itself (Bandura & Locke, 2003). Another critical component to goal setting and goal (or task) achievement is motivation. Ryan and Deci (2000) define motivation as being "energized or activated toward an end" (p.54). In a study conducted by Dale Schunk, it was found that motivation and self-efficacy are enhanced when people perceive they are performing a task skillfully or during the performance of the task they perceive they are becoming more competent (1989). Motivation also leads to increased effort and energy that is expended toward a goal. In an academic setting Csikszentmihalyi and Nakamura (1989) found that students expended an increased amount of effort and energy in activities directly related to their needs and goals.

With regards to the study of computer science and computer technology, there is a theme of research that has emerged from the literature that suggests a person's computer behaviors are largely influenced by how they perceive their computer self-efficacy (Compeau & Higgins, 1995). In one study, researchers Jun He and Lee Freeman (2010) investigated mechanisms through which gender affects the development of general computer self-efficacy. Over 280 undergraduate students were surveyed and data comprising four categories was collected and analyzed: computer knowledge, current computing experience, computer anxiety, and general computer self-efficacy. The results of this study suggest that women feel less confident with computers and computing tasks because they have less experience when entering undergraduate courses in terms of computer learning and computer practice. As a result of the perception of having learned less than men, women feel more anxious when engaging in computer tasks when compared with male students (2010).

In a related study that was designed to investigate the attitudes of high school students towards computers, Lily Shashaani (1993) surveyed approximately 1,750 high school students from five different school districts in Pittsburgh, Pennsylvania. Significant differences in attitudes towards computers were observed between male and females. These differences were mainly realized with respect to self-efficacy with regards to computer use. While the study showed that females generally have equal competencies, women reported fear of using computers and feeling helpless around computers at much higher rates than the male subjects did.

These findings are very telling, as self-efficacy has been tied to the positive aspects of engagement and interest in a program of study (Schunk & Pajares, 2002). Self-efficacy also predicts the effort level of the initial engagement of the task, and task performance itself. This process is often reciprocal, as initial success at a task leads to greater interest, which improves the likelihood of engaging in that task, or a similar task in the future.

Other studies have noted that individuals with high self-efficacy move onto more challenging tasks, and in the case of education, more challenging courses, than do individuals with low self-efficacy. Individuals with a high self-efficacy usually see demanding tasks as new challenges rather than threats (Watt, 2006). Nash and Kallenbach (2000) found that subjects who showed persistence in challenging tasks were more successful in their academic preparation. Specific to engineering and technical disciplines, this research has shown that women in nontraditional careers tend to have perceived self-efficacy that enables them to believe in themselves and achieve success in areas such as science and engineering (Whitmarsh, et al., 2007).

These studies support the results that found a positive relationship between self-efficacy and career choice, particularly in science and engineering. Additionally, research shows that interest is a larger factor in determining self-efficacy than actual ability (Bandura, 1991). These findings seem to highlight the importance of perceptions of abilities rather than actual abilities themselves for influencing task motivation, which helps to explain why many female students lose interest in computer science and technology courses even though they do not lack in abilities. Some studies suggest that what is lacking is a belief that women are capable of attaining success in technical areas of study, which leads to decreased interest in computing and technical education (Eccles, 1994; Seymour, 1995). A limited perception of computer science is often a contributing factor in women's beliefs about their technical capabilities. A common view is that computer science consists of software development, or computer programming. In fact, the field of computer science contains many more aspects beyond just programming. When given a more expanded definition of computer science, it was found that student's attitudes became more positive (Dempsey, Richard, Kishi, & Titcomb, 2015).

Given the emerging importance of self-efficacy with relation to academics, there have been numerous programs implemented to increase female achievement in computing sciences. However, these programs have primarily been focused on achievement, and are not designed to specifically increase self-efficacy. What research that has been done suggests that instructors and professors of computer science and information technologies (IT) should pay as much attention to a student's self-efficacy as they would to their ability (Zeldin & Pajares, 2000). It is my opinion that more study is needed in the areas of self-efficacy, particularly with female students in computing science disciplines. One of the goals of this study is to explore with the participants their own perceptions of self-efficacy with regard to persisting in a computer science program.

Stereotypes

Stereotypes are generalized characteristics assigned to certain social groups based on race, gender, age, class, etc. Stereotypes can be positive or negative, and can be true or untrue. Stereotypes can also over generalize a group or certain population, which would have the effect of taking away from individuality within that group. Negative stereotypes have often been found to be at the root of discrimination, and denial of opportunities. This usually takes the form of stereotype threat, which is a fear of confirming a negative stereotype, such as a woman's lesser abilities in technical tasks (Steele 1997).

Gender stereotypes often affect the social cultural roles and expectations of social groups and can over generalize the group as a whole. This is the case with computer science. There are positions categorized within computer science that involve hands on technical skills such as networking, quality assurance testing and software architecture, and programming. There are also management, marketing and technical sales positions that require the so called "soft skills of written and verbal communications and teamwork. In the real world, diversity of skills is important. As the review of literature suggests, stereotypes are a significant barrier to recruiting more women into the study of computer science. There is also evidence suggesting that common negative stereotypes are a factor in the persistence of women in the study of computer science (Beyer, Rynes, Perrault, Hay & Haller, 2003). The following is a review of current studies on stereotypes as they relate to women in computer science.

In research exploring gender differences, Jeff Butterfield and Thad Crews (2012) present data from a study of undergraduate students where differences between male and female students were examined. Different perspectives were uncovered regarding attitudes toward technology, timing of exposure to computers, and experiences with technology. This research was conducted between the years of 2003 and 2010, and supports prior research that suggests stereotypes associated with individuals in computing and computer science are one of the reasons why women may choose to pursue different fields of study and work (Carter, 2006). However, older stereotypes, such as images of people, mostly men, with a poor sense of fashion, introverted personalities, and weak interpersonal skills that were common in popular culture of the 1980s and 1990s. These perceptions are now generally regarded as outdated. As computer ownership, including hand held computer devices, has become widespread, such stereotypical images are much less common (Cheryan, Plaut, Davies & Steele, 2009).

Current studies suggest that while negative stereotypes may have been a larger factor some years ago, perceptions of society in general are evolving, and the image of computer science professionals are seen as more positive. This does not mean that gender stereotypes in computer science have disappeared. There is much research arguing that negative gender computer science stereotypes are still with us. One study presented by Sapna Cheryan, Victoria Plaut, Caitlin Handron and Lauren Hudson (2013) suggests that while progress has been made, gender stereotypes of computer scientists persists as a significant factor in the underrepresentation of women in the study and as professors of computer science. Particularly, the predominately masculine image of computer scientists is one of the persisting stereotypes that may deter women from becoming interested in computer science education (2013). Smith, Morgan, and White (2005) suggest that there exists a number of stereotypes that paint women as less competent than men with regard to computer related skills, even though there is no evidence to support this, and much evidence to refute these notions.

Steele, Steele and Aronson (1995) identify these stereotypes as threat paradigms. They argue individuals belonging to minority groups, such as women, suffer from performance impairments when performing a task in a threat paradigm influenced environment. In other words, when minority group members perform a challenging technical task in which the group they associate with is considered weak, they feel at risk of confirming the negative stereotype, which usually leads to under performance. This finding is supported by a recent study that examines common stereotypes held by students in computer science, and what effect these stereotypes have on the enrolment, persistence and retention of women in computer science education (Cheryan et al., 2013). The findings suggest that stereotypes about the people in a particular field of study can powerfully influence their academic decisions.

While the review of literature on stereotypes informs this study, as an educator part of my responsibility is to motivate, encourage, and recruit more women into computer science. It is a goal of this dissertation to identify factors that will improve female retention and recruitment. For this reason, the awareness of gender and computer science stereotypes and individual perceptions were explored with the study participants, with the focus being on how negative stereotypes were perceived and overcome, and identifying the positive stereotypes and aspects of computer science that contributed to persistence.

Role Models

In research that focused on vicarious experiences, which refers to learning through the observation of others, it was found that role models were especially influential when they are perceived as similar to the student. This suggests that female students that have an interaction with successful role models, such as female faculty members, mentors, industry leaders, and advanced female students would positively affect their self-efficacy (Seymour, 1995; Zeldin & Pajares, 2000). Additional studies indicated that many women are positively influenced by male family members, especially fathers who were engineers or computer scientists (McIlwee & Robinson, 1992; Haber, 1980). Ware and Lee (1988) also noted that in the process of choosing a scientific major, women reported being influenced by high school teachers and guidance counselors while making plans for college.

Additionally, related research has also shown that a role model's affect on the self-efficacy of a woman as it relates to science, technology and computing courses was greater when the role model addressed gender inequities that are usually associated within these fields of study (Weisgram & Bigler, 2007). Other studies mentioned that women lack awareness of what computer scientists and technical engineers do, and the lack of women as technical role models has a negative effect on other women pursuing engineering or even considering it a field suitable for them (Mattis, 2007).

With that said, a number of studies support the need for female role models and suggest that in higher education, more female academics are needed to for role models and mentors (Gruman, 1990, Pearl et al, 1990). One study found that the lack of role models was the primary reason female students were less likely to pursue computing technology careers (Jepson & Perl, 2000). The findings of a study conducted by Marx and Roman (2000) indicate that female role models can buffer women's self-appraisal abilities, which can lead to successful performance in testing.

Related to this, a study of female faculty and graduate students in two U.S. universities confirmed that the lack of female role models in computer science programs contributed to low enrollment numbers of women entering undergraduate computer science programs (Etzkowitz , Kemelgor, et al., 1992). Conversely, twelve successful women in computing technology careers credited role models in part for their career choice of computer science (Smith, Rainie, & Zickuhr, 2011). Female faculty serving as role models help to combat the negative stereotypes women hold about the nature of computer science and information technologies. Female role models also serve as evidence to women students that achieving successful careers in computer science is possible.

Female representation in the technical disciplines of education is an important aspect of gender equity since colleges and universities are the training ground for the future generations of professional engineers and scientists. In these traditionally male dominated fields of study, the presence of female faculty members can provide support, encouragement, and mentorship to female students.

Culture

The cultural factors that influence a woman's educational and career decisions are often felt very early in life. Numerous studies were found that recognized how gender influences within family, particularly influences of parents and educators, affect women's future career decisions (Ayiah-Mensah, Mettle and Ayimah, 2015; Murphy & Steele, 2007). In relation to family values and potential career choices, a study by Ware and Lee (1988) found that women who were attending a college and who were enrolled in a baccalaureate program, who reported having been influenced by family and high school teachers and guidance counselors, and who placed a high priority upon aspects of their future family and personal lives, were less likely to major in science than their female peers. One study, conducted by Lori Carter found that social encouragement, meaning positive reinforcement from family and peers, accounts for up to twenty-eight percent of explainable factors that influence a young woman's decision to pursue Computer Science (2006).

It has also been noted in several studies that part of the low representation of women in computer science at the undergraduate level is inherited from the secondary school level, where women do not participate in entry-level computer science courses and related activities as much male students (Sanders,1995). This gap between male and female enrollment in high school computer science courses continues to increase as the students' progress into more advanced computer science courses (Schofield, 1995). Based on this gender gap in pre-college computing experience, it is not surprising to find a difference in the confidence levels of male and female first-year college students.

A related study found that women in female dominant careers, such as teaching, nursing, administrative and paralegal, are recommended by their parents and primary and secondary teachers and advisors to choose these careers because they are considered "family friendly" in terms of shorter work hours (Whittock, Edwards, McLaren & Robinson, 2002). Additional studies found women who chose a more traditionally male gendered career, such as technology, science, business or law, were more influenced by their fathers. It was also found that these career decisions were made later in women's career paths in comparison to women who chose female dominated occupations (Whitmarsh, Brown, Cooper, Hawkins-Rodgers, & Wentworth, 2007). McIlwee and Robinson noted that women who make STEM career choices tend to be more influenced by males, including their fathers, professors, husbands or boyfriends (McIlwee & Robinson, 1992; Mattis, 2007).

One study found that mothers often provided their daughters with positive reinforcement regarding their interest in pursuing technical careers, which in effect is encouragement for them to pursue a computer science or information technology field of study (Spertus, 1991). In addition to general parental support, several studies of women in STEM fields found that other family members were also supportive in their career choice.

Related research shows that there is evidence that women who have selected a STEM field of study perceive that they receive more support from their parents or guardians than women in other non-technical or non-science fields of study (Adelman, 1998; Ciccocioppo, 2002). There are also studies that suggest females who chose STEM majors had parents who were more highly educated than the parents of women who had chosen other fields of study (Graham, 1997; McNeal, 1999).

In one study conducted by Ware, Steckler and Leseman (1985), findings suggested factors that significantly predict a decision for a woman to major in a technical or science area were (1) having highly educated parents; (2) achieving outstanding mathematics scores on the SAT or ACT; (3) having a strong desire for control, prestige and influence and (4) a desire for positive interaction with others (p. 75). The correlation between having highly educated parents and choosing a technical area of study may be explained in part by the expectations more highly educated parents place on their children, and the examples they presumably set (Anderson & Minke, 2007). From these and other studies, it can be assumed that more highly educated parents are more likely to be early adopters of technology, such as computers and are able to afford computers for their family and children (Baruch and Nagy, 1977). Additionally, it is likely that a woman who was raised by highly educated parents will have been exposed to less conventional ideas about what constitutes appropriate behavior for women and will consequently be more willing to explore nontraditional educational avenues. (Ware, Steckler & Leserman, 1985).

It should also be noted that the influence of peers can play a decisive role in the selection of academic goals and areas of study (Azmitia & Cooper, 2001). In a study conducted by Thomas Kindermann (2007) findings suggested that peers play a role in steering women away from STEM areas. Examples of this can be found in research by Rachael Robnett and Campbell Leaper (2005): high school girls tend to rate their peers as being less supportive of their interests in STEM related subjects than boys. These trends also extend into technical undergraduate and graduate programs where women report receiving low levels of support from their peers (Herzig, 2002; Zeldin & Pajares, 2000). With computer science majors, it was found that social isolation influenced many female students to believe that they were the only ones who might be struggling with their coursework (Margolis, Fisher & Miller, 2000). As a result, many women left their major to pursue different fields of study. These studies are important as they identify a correlation between women who selected STEM related careers, such as computer science and the positive support they received from parents, family members, teachers, peers, husbands or boyfriends.

In a study designed to investigate whether gender, group composition, or self-efficacy in computer science programs has any impact on collaboration in computer related tasks, it was observed that groups comprised of a majority of women experienced greater cooperation than with other categories (Busch, 1996). Other studies have suggested that environments that are dominated by men, as many computer science departments are, have been found to be a deterrent to female inclusion. Studies have also found that women who were exposed to stereotypical objects in computer learning settings such as classrooms and computer labs expressed less interest in computer science than women exposed to non-stereotypical objects in the same settings. One study suggests that the presences of male stereotypical objects served as a reminder to women that computer science is a male dominated field. The results suggested a student's choice of a field of study can be shaped simply by the observations of stereotypical objects in the classrooms and labs (Cheryan, Plaut, Handron, & Hudson, 2013).

Oftentimes, these stereotypical objects, such as Star Trek posters, video games, empty soda cans, and assorted science fiction memorabilia do not reflect the reality of the profession's workplace. They serve to perpetuate the negative stereotype of the male computer "geeks" who stay up all night coding and have no social life. This stereotype does not appeal to many, including women who do not like the portrait of masculinity that it evokes. These objects help create what Sapna Cheryan, a University of Washington professor of psychology calls "ambient belonging," or the feeling that you do or do not fit in somewhere (Cheryan, Plaut, Handron, & Hudson (2013).

In addition to hearing encouraging words from faculty and counselors, women need to be exposed to positive reinforcement, such as posters, videos and career events that accurately depict women actually working in computer science professions and disciplines (Levin & Gordon, 1989). Materials should be inclusive, and should depict both men and women in a variety of task related activities. In order to avoid enforcing negative stereotypes, these materials should portray women as the integral members of the technical organization, and avoid any messages and images that reinforce negative stereotypes. This includes ensuring that all computer department and recruitment literature includes a representation of successful women whose lives and professional careers do not reinforce the standard stereotypes (Cuny & Aspray, 2002).

Summary of Literature

The literature confirms that the under representation of women in computer science education is well documented. This imbalance creates challenges for staffing as well as problems such as lack of balanced perspective involving innovation. The research presented in this paper suggests that a significant factor in the underrepresentation of women in computer science is the gendered nature of stereotypes of computer scientists (Cheryan, Plaut, Handron, & Hudson, 2013), and that computer behaviors are largely influenced by how a subject perceives their computer self-efficacy (Compeau & Higgins, 1995; Jun He & Lee Freeman, 2010).

Research has been presented that suggests that women role models in the form of faculty and mentors have been shown to increase female enrollment and retention while the absence of female faculty has been cited as a reason for low enrolment of women in technology and computing. Lack of female faculty in the computing sciences may also reinforce negative stereotypes. The absence of female faculty in computer science classrooms also creates a negative condition that resists change. Universities and colleges seeking to increase the number of women enrolled in computer science should be aware of the effects of these gender-natured stereotypes on female's self-efficacy and motivation, and seek to increase the numbers of female faculty and tailor their marketing and curriculum accordingly.

Added to the diversity of opinions, it should be noted that many of the studies that examined gender issues in computer science were conducted over ten years ago. Technology and computing has evolved rapidly over the last two decades, and thanks to the internet, computers and computer usage has become much more ubiquitous. Thus, these earlier findings may not be as valid as they once were. Current college aged students grew up during a period when personal computers, mobile devices, such as smart phones and tablets, and Internet access have been widely available (Marc, 2001). Ownership of personal computers among students is over 88% (Smith, Rainie, & Zickuhr, 2011). A recent survey suggests that older stereotypes of computer science and computer professionals have changed (Sieverding & Koch, 2009). This suggests that there has been a recent shift in perceptions, and that more research is needed in this area.

Related to this, is the fact that SCCT is a relatively new theory, and has not been widely used in studies on the prediction of science interest as educational goals (Mills, 2009).

In light of the lack of consensus of causation, and the rapidly changing nature of computing technology and the perceptions associated with computers, there is a need for additional avenues of research and study on current college age subjects with regard to gender differences. It is essential that our institutions of higher education promote the educational and professional success of all people without regard for gender, race, or ethnicity. Any career impediments for women must be identified and resolved. As the literature identified in this review suggests, the transforming of our academic and institutional policies and procedures to eliminate gender bias constitutes a significant task that will need to be carried out at the national level. This effort will require committed leadership and continuous attention, evaluation, and accountability. Because the obstacles are both substantial and systemic, there will be no quick fixes, but as referenced in this review, there are many practices that have been developed and carried out by a number of universities that have proven effective in increasing both the participation and the retention of women in computer science.

Research on the gender gap in computer science education should be an ongoing initiative for universities. As technology and computers continue to become more integrated into mainstream society, and as new technologies emerge, current research will be needed to evaluate gender issues and universities will need to adapt to make their programs as relevant and appealing as possible.

Chapter 3: Research Methodology

Introduction

In the United States the field of computer science is overwhelmingly male dominated. Women made up just 18% of undergraduate computer science majors in 2010-2011. Studies show that just 27% of master's degrees recipients in computer science are women, and only 13% of computer science doctorates are awarded to females. The underrepresentation of women in computer science is a systemic problem in the United States, both at the university level and in the workforce.

A number of studies conducted have identified possible causes of the gender gap in computer science. Many of these studies have produced a variety of suggestions for overcoming these issues. In spite of these efforts, there is still no definitive solution identified, and a low numbers of females entering and graduating from computing sciences programs still plagues most Colleges and Universities.

It should be noted that even with the plethora of problems identified from numerous studies, some women do persist in computer science. This study suggests that we learn from them. The focus of this research is to understand the phenomena that cause women to persist despite, and in some cases, because of these problems.

Though the phenomenon of too few women selecting and persisting in computer science is quantitatively discernable, quantitative methods cannot fully describe the complexities of this phenomenon. In order to understand the phenomenon outlined in the problem and purpose statements, and to answer the research question, the qualitative research method of Interpretative Phenomenology Analysis (IPA) was chosen for this study. I feel that research focused on the lived experiences of female college students who have made the decision to enter into computer science and have persisted in their studies will enhance the existing body of knowledge in this area.

Interpretive Phenomenological Analysis

Overview

The methodology of IPA is one of the newer approaches that have been added to the qualitative research options for data analysis. Jonathan Smith introduced IPA during the 1990's. In his seminal paper, Smith (1996) positions IPA as an alternative, but complementary approach to most of the established qualitative methodologies, such as narrative and grounded theory. IPA started in psychology, and much of the original work done using IPA was in health psychology (Larkin et al., 2006). Since then, Smith and others have refined the theoretical underpinnings of IPA, and it has gained in popularity within clinical and counseling psychology, as well as in educational and social psychology (Smith, Flowers & Larkin, 2009). IPA is an approach to research which focuses on attempting to understand the experiences of the individual participant and what meaning these experiences hold (Smith, 2004).

Interviews are commonly used to gather data, with the questions being exploratory and semi structured. While this is the main data collection method of IPA, it should be noted that IPA should be considered a complete methodology rather than simply a means of gathering and analyzing data. Through interviews of participants, this study aimed to find the essence of meaning of each participant's experience (Creswell, 2007). In this study, phenomenology applies to the experience of what it is like to be a female in the male dominated field of computer science. It is my opinion that a study of the lived experiences of women who selected and persisted in computer science can provide insights into why there are so few women who choose and then persist in the field.

Philosophy of IPA

One of the main aims of IPA is to provide a framework that allows the exploration in depth of how participants view and make sense of their personal world and the social environment in which they live. In other words, IPA is concerned with trying to understand lived experiences of the study participants and how the participants make sense of their experiences with regards to the focus of the study. Therefore, the central concern in IPA is within the meanings those personal experiences hold for the participants. This means that IPA can be used to explore an individual's personal perception or account of an event or a social state that is being experienced by the individual, as opposed to attempting to produce an objective record of the event or phenomena itself. This first personal point of view is an important theoretical underpinning of IPA (Zalta, 2003).

When using IPA as a process to understand and to get close to a participant's personal experiences and perceptions, it is important to know that this cannot be accomplished directly, as access is dependent on the researcher's own positionality and conceptions which are used to make sense of participant's personal world through a process of interpretative activities. The attempt by a person to make sense of what is happening to them is an interpretative endeavor. Because of this, IPA relies on hermeneutics, or the theory of interpretation (Larkin, Watts and Clifton, 2006). In fact, Smith called this the second major theoretical axis of IPA. In what is considered the seminal paper on IPA (2006), Smith makes the case that research could be both experimental and experiential. To accomplish this, Smith combined theoretical ideas from hermeneutics and phenomenology (Shinebourne, 2011). IPA is also influenced by idiographic inquiry, with its concern on the particular and distinct experiences o participants and the contexts in which those experiences occur (Eatough & Smith, 2008). Smith (2004) goes on to describe IPA as an approach to qualitative, experiential and psychological research which has been informed by concepts and debates from three key areas of philosophy of knowledge: phenomenology, hermeneutics and idiography (p. 43). Interpretative Phenomenological Analysis draws on each of these theoretical approaches to inform a distinctive framework and research methodology.

IPA also emphasizes that the research exercise is a dynamic process, which requires the researcher to take on an active role in the IPA process and to attempt to get close to the participant's world, or in Conrad's (1987) words, achieve a "insider's perspective." It is dedicated to the examinations of a particular event or case in a participant's world, and attempts to uncover the details of what the experience for this person is like and what sense this person is making of this experience. Because of this, IPA is idiographic, and IPA studies tend to have a small number of participants. The aim of these studies is to reveal something of the experience from each of the participants. Data collection is usually in the form of semi-structured interviews where the interview schedule is flexible and the participants have an important stake in what is covered (Smith, Fowers & Larkin, 2009).

Additionally, IPA is committed to the examination of how people make sense of their life experiences as they unfold, and specifically supports the telling of a story that has yet to be told in its entirety (Smith & Flowers, 2009). A main requirement of IPA is to understand and "give voice" to the lived experiences and the concerns of the study participants, and to contextualize and make sense of these concerns (Finlay, 2011).

It is my belief that a phenomenological methodology best addresses the research questions of this study by exploring the lived experiences and personal views of female computer science students. By using the qualitative approach, I was to catalog the students' lived meanings and then, through interpretation, define the essential structure of the students' experience of the phenomenon (Brocki & Wearden, 2006; Moustakas, 1994).

Setting and Participants

A qualitative Interpretative Phenomenology Analysis study of seven female computer science students selected from three universities in the Western Region of the United States was the focus of this research. The criteria for participation ensured that individuals must be female and be currently enrolled in a 4-year post-secondary college or university in the study of computer science, or a closely related computing technology field. The participants who were selected had successfully completed over four semesters, or eight quarters (two academic years), in a computer science or computing technology field of study.

Targeted recruitment was conducted by posting a Call for Participants (Appendix A) flyer on student bulletin boards in the computer science buildings at several regional universities. Additionally, colleagues were contacted at several universities and asked to distribute Call for Participant flyers to possible candidates. Candidates were selected though initial intake calls (Appendix B), where an overview of the project was given to the candidate interviewed to determine if they met the above mentioned study criteria. The successful candidates were sent a consent form (Appendix C) via their e-mail address along with an invitation to participate in the study.

While specific site access was not sought, participates did come from three Utah based campuses consisting of a state university, and two private, non-profit universities. This type of selection is typical of qualitative research and is often used to select both the research sites and the participants (Coyne, 1997). Maxwell identifies this type of sampling, *purposeful selection*

(Maxwell, 2005, p. 97), with *purposive sampling* being another term that is used by scholars (Tongco, 2007; Palys, 2008). In this strategy, research sites and participants are deliberately selected to provide data that is relevant to the goals of the research that would not be readily available through other choices (Teddlie & Yu, 2007).

Seven individuals were chosen to participate in the study (see table 1). This sampling size is consistent with the goals of IPA research. A distinctive feature of IPA is its commitment to a detailed interpretative account of the subjects' experiences. It aims to explore, in detail, how participants are making sense of their personal and social world. Many researchers recognize this can only be realistically accomplished on a small scale (Smith, 2004). In other words, most IPA studies sacrifice breadth for depth (Smith, Flowers and Osborn, 1997).

The participants were interested in sharing their stories and were very generous with their time and information. Their responses revealed remarkable strength, confidence and tenacity in terms of their belief in their ability achieve their educational aspirations and goals. Overall, all of the participants expressed a high regard for the discipline of computer science, and the situations that shaped and gave direction to their journey, as well as their experiences as university students in the study of computer science.

Table 1 Participant Demographics

Participant Pseudonym	Age	Marital Status	Ethnicity	Area of Origin	Major
Deena	62	Single with children	African American	South Carolina	Computer Science/web development

Melissa	29	Single, no children	White	Utah	Computer Science/Software Engineering
Kimberly	47	Single with children	white	Idaho	Computer Science
LaTosha	25	Married with children	African American	Texas	Computer Science
Nancy	23	Single, no children	Hispanic	Colorado	Computer Science
Pam	61	Married	white	Iowa	Computer Science/Graphic Arts
Mary	22	Married with children	White	Virginia	Computer Engineering

Research Methods

Instrument

An interview protocol (Appendix D) containing standardized open-ended questions was used as the foundation for the semi-structured interviews. The protocol questions formed the basis of the interviews, and further, probing questions helped me to gain insights and better descriptions. Individual interviews with the participants were conducted at a mutually agreed upon time and location, not on a college campus, and scheduled for one hour. Several of the interviews were conducted online via 'Skype®' or 'Zoom®' (an online program which allows people to converse remotely, similar to a telephone conversation, but also offering the ability for individuals to see one another). These interviews focused on the participant's life history and present day experiences in relation to the topic, and participants were encouraged to reflect upon the meaning of these experiences. The goal of this approach was to elicit as much information as possible that the respondents found relevant without tainting the responses by the researcher's preconceptions or bias.

I utilized the observation protocol form (see Appendix B) to take notes during interviews and to document observations such as non-verbal cues or specifics about the interview location, if relevant to the discourse. I also utilized the observation protocol form post-interview for reflective notes when additional context was available upon reflection.

Data Collection

IPA employs a qualitative methodology. Data in IPA research is usually conducted by using in depth semi structured interviews, which enable the participant to provide fully detailed accounts and allows the researcher great flexibility during the interview process to drill down on interesting areas that might emerge. The focus of the interview process is on understanding the lived experiences of the participants within a specified phenomenon (Smith, 2004). A semi structured interview process is required for this type of flexibility. This form of interviewing allows the researcher to engage with the participant in a dialogue where initial questions could be modified depending on the participants' response. It also allows the researcher to probe important areas that might arise in the interview (Smith & Osborn, 2008). The semi-structured nature of these interviews gave me the freedom to move the conversation in any direction of interest that may come up during the interview session. While this might pose some difficulty in analyzing the interview data, my background as a subject matter expert in computer science was beneficial in building a rapport with the participants and guiding the interview.

Smith notes (2009) that IPA requires a verbatim record of data that is collected (p. 73). This means that all interviews and interactions with the participant must be recorded. All interviews with participants in this study were recorded using redundant audio devices. All recorded interviews were transcribed by me, and were coded and subjected to a detailed analysis with the goal of identifying key experiential themes in the participant's narrative.

Data Analysis

Data analysis in qualitative research consists of preparing and organizing data, and processing the data in themes, identifying patterns, then summarizing and attempting to find meaning. According to John Creswell (2012), data analysis is something that the researcher custom builds for the study. The data analysis phase can be further broken down into three main elements, which are: data reduction, data organization, and data explanation and verification (Miles & Huberman, 1994). These elements are common to most types of qualitative analysis, including IPA.

With the IPA methodology, the researcher is focused on the participants' attempts to make sense of their experiences. This involves the investigator engaging in an interpretative relationship with the transcript. Smith, Flowers and Larkin (2009) put forward a structure for analysis that consists of several phases. The first phase consists of reading and re-reading the interview text, followed by making initial notes of areas of interest. During this phase, note taking may include the recording of key phrases and descriptive and conceptual comments (p. 90). The next phase involves working directly with the notes and comments to identify and develop emerging themes. In the final phase, themes should be extracted from the data and listed, and then compared across participants, looking for patterns that emerge across all study cases.

These authors further note that this process in not prescriptive, and there are many ways of working with the data (Smith, Flowers & Larkin, 2009). However, at the end of this stage it should be possible to map how the emergent themes have been constructed, and there should be a format that allows for the analyzed data to be traced though the process from the initial transcripts to the final structure of themes (p. 80).

This study followed the above mentioned IPA methodology, with the first step of the data analysis was a close reading of the textural narratives of raw interview data detailing participants' experiences and writing analytic memos (Saldaña, 2012). Open coding and associating the reduction of the information into themes followed. The final step was a focused coding to determine which in the research are dominant (Boeije, 2009). This collection method resulted in a collection of data representing the subjective compilation of experiences and recollections of the subjects.

It should be noted that I cannot be removed from the analysis of an Interpretive Phenomenological study entirely. In fact, the researcher's role in an IPA study is essential. Researcher Sharan Merriam (2014) noted that the researcher's role in any qualitative study is essential. In a qualitative study, the data is mediated though the researcher, and in fact the researcher is the instrument of data collection (Denzin & Lincoln, 2003).

Ethical Considerations

To ensure adherence to ethical procedures, I sought permission to proceed from the Northeastern University Institutional Review Board, and I followed the guidelines of the IRB to ensure the all participant's rights were respected and that no participant was put at risk through participation in this study. All study participants received a consent form (Appendix C) outlining their rights as voluntary participants. To protect privacy, participants remained anonymous and responses and information identifying the schools they were attending were generalized to ensure confidentiality. In this study, all participants were assigned pseudonyms to further protect identities. Findings were aggregated by themes for presentation to prevent identification of any individuals. Every effort was made to ensure findings could not be linked directly to individuals or specific universities.

Chapter 4: Data Analysis and Findings

Introduction

This study is an exploration of the experiences of women who have selected and successfully persisted in the study of a university level computer science major. Computer science is a discipline where women, who comprise just eighteen percent of the student population, are considered an underrepresented population (Snyder & Dillow, 2012).

This is an Interpretative Phenomenology study that was designed to explore answers to the following research questions:

1. What are the common factors and experiences that contribute to women's selection and persistence in computer science as an academic major?
2. What are the experiences that lead female students to choose a computer science major?
3. What are the factors and experiences that influence female students to persist in the study of computer science?

4. Are there factors that are related to the discipline of computer science that discourages female student from participating in the study of computer science?
5. Are there gender related feelings, traits, or experiences which female computer science computer science majors' share?

This chapter contains the findings, results, and interpretations of the research. Data was gathered through an analysis of semi-structured, in-depth personal interviews (Appendix D) of females currently enrolled in a university level computer science program. All participants had successfully completed at least two academic years of their program, and were in good standing within their department.

The participants of this study are a diverse group of people. The sample size of seven women represents seven different U.S. states. Six of the seven students were attending college outside of their home state. In addition to geographic diversity, there is significant age diversity among the participants. Three of the women were of average college senior age at the time of their participation in this study. Four of the students were older; two of those four being between thirty and thirty-five years old. Two of the students were over fifty years old, with one being a sixty-two-year-old grandmother.

The marital status is also diverse, with three participants being single with no children, one participant being single with children, three study participants were married with children, and one divorced grandmother who is the primary caregiver for her three grandchildren.

It is interesting to note that the military played a role in preparing two of the seven study participants for college. Both participants received computer training while in the military, and both reported that this training and their experiences in the military were positive influences on both their decision to enter college and their choice of college majors.

While the participants interviewed in this study were indeed self-selected, and thus might not be entirely representative of women in a university level computer science major in general, there were at least two participants who informally stated that they felt their perceptions, observations and experiences were typical of most of the women in the computer science department with whom they have interfaced with.

Participants

The women who participated in this study were pursuing one of two degrees: computer science or computer engineering. The former is geared toward the design and development of software systems, while the latter is focused on computer system architecture. All three intuitions offered both majors as a baccalaureate of science degree. Two of the universities also have a computer science Master's degree program.

All participants considered computer science or computer engineering their primary major. The computer science degree programs offered by the three universities that the participants were drawn from did not require a minor. This is typical of computer science programs in the United States (Director, Khosla, Rohrer, and Rutenbar, 1995).

Study participants came from either a working class or lower middle class background, and all were products of the U.S. public school system. This is consistent with the student populations at the universities where the participants were drawn from. All three schools have solid academic credentials that are consistent with regional level universities with a focus on undergraduate level and masters level education.

The participants' exposure to technology and computers varied widely. The main factors that determined exposer to computers were the age of the participants, parents' and family members' professions, and the level of technology that was available at their primary and secondary schools.

Coding Themes

In accordance with the methodology discussed in Chapter Three regarding IPA, each participant was interviewed individually and privately to protect their anonymity. The transcription followed immediately after the interviews were completed. During this process, portions of the students' narratives were repeatedly reviewed in order to capture their responses word-for-word. This process enabled me to hear the participants' stories more than once, which facilitated greater understanding of the meanings that were conveyed through the words, pitches, and tones of the participants' voices. Responses to certain questions were noted and grouped into what became same, similar, or opposing categories among the interviews. This gave credence to emerging themes. As these themes were recognized, they were recorded in my journal for further evaluation.

The interviews were transcribed; the data was reviewed multiple times, and compared to the raw recordings. This effort was meant to ensure that all relevant data was recoded, and that there were no inconsistencies. The first cycle of coding was done manually using printed copies of the transcripts. Later cycles, including Evaluation Coding and Axial Coding were done using professional data analysis software by MAXQDA. This software allowed for the color-coding of responses that were eventually formulated into themes. This process included color-coding answers to particular questions, which allowed me to group responses using the data analysis software.

This process provided me with a general knowledge of how each interview question was answered. As a result, several themes thus emerged and were noted. Sub-themes were also identified that fit within the major themes. The color-coding also enabled the me to separate out information that did not fit within any of the themes. Using the narratives that represented responses for each interview question, I was able to group certain responses under the main themes of “pre-college experiences” and “college experiences” in order to place relevant data within each theme. From this information structural descriptions that added context were taken into account. This information, along with the analysis of the themes, resulted in a composite description of the experiences of being a woman who has persisted and has been successful in a computer science major.

The following sections contain the analysis of the data gathered from the seven female student participants, and the themes of the study.

Social and Cultural Influences Regarding Women’s Career Choices

According to the reviewed literature, several studies recognized how gender influences within the family and society, particularly influences of parents, educators, and school counselors, affect women’s career decisions in both conventional and non-conventional areas (Ware & Lee, 1988; McIlwee & Robinson, 1992; Mattis, 2007, Mau, Domnick, & Ellsworth, 1995). The results of this study were in general agreement with the literature: parents and siblings, along with interactions within the community and peers influence a person’s educational and career decisions. For example, from the literature, several studies report that women who selected computer science or engineering careers had support from parents, teachers, counselors, and spouses (McIlwee & Robinson, 1992; Mattis, 2007).

Six of the seven participants of this study reported being supported by parents. However, this support could best be described as passive, as it was more in the way of a general support for whatever career path their daughters chose to pursue, and not a direct support or encouragement toward technology or computer science. One of the possible reasons for this is that the participants of this study were drawn from social settings that could be described as lower middle class and working class. As a result, most of the parents and family members of the participants were engaged in semi-skilled occupations of a blue-collar nature. This meant that none of the participant's parents served as direct role models of a working computer scientist or technical professional, nor were parents in a position to offer guidance in how to pursue STEM educational experiences.

Past studies indicate parental role modeling of a technical profession to be a major influence in the career decision making process (Haber, 1980), and that many women are positively influenced by male family members, especially fathers who were engineers or computer scientists (McIlwee & Robinson, 1992). As mentioned above, the participants of this study did find support for their technical career choice, but most of this support came later, after they had left home. This finding supports current research which suggest that women, who had or found support for their technical career choice, tended to made their decisions later in their lives in comparison to women in female dominated occupations, such as teaching, office administrative, and paralegal fields (Whitmarsh, Brown, Cooper, Hawkins-Rodgers, & Wentworth, 2007).

It is important to understand how education, family, and environment influenced the process of selecting computer science as an area of study for the participants in this study. The influences which emerged as important themes in this study, and are grouped with within the two main themes of pre-college characteristics, and college experiences, which is discussed in detail in the following sections.

Pre-college Characteristics and Influences

The review of literature identifies numerous studies that recognize how gender influences within family and society, particularly those parents, educators, friends and peers affect women's career decisions in both conventional and non-conventional career areas (Ware & Lee, 1988; McIlwee & Robinson, 1992; Mattis, 2007; Murphy & Steele, 2007).

In at least one study, social encouragement, or positive reinforcement, accounts for up to 28% of explainable factors that influence a woman's decision to pursue an education in computer science (Carter, 2006). The research summarized in this paper does lend support to studies that posit social support and encouragement as an important factor in female selection of STEM fields of study, particularly computer science. However, the analysis of the collected student experiences of this study suggests that while early social encouragement was a factor in their decision to select computer science, it was not a deciding factor. Additionally, my findings are not in complete alignment with current research on where this support usually comes from. Particularly with findings in the literature that place an overall importance on family, teachers, and peer influence on the career selection process. The students in this study received minimal family and early peer support when compared to the findings of current research.

With that said,I do concur with the review of literature that it is important to understand how early education, family, peers and community influence women's selection process. The following section details the seven participant's pre-college experiences, and attempts to identify the main influences on their selection processes. These influences have been grouped into the basic categories of parents and family, teachers and counselors, peers and community, and self-efficacy.

Parents and Family

The research of McIlwee and Robinson (1992), Mattis (2007), and Mau (2003) found that parents, particularly fathers, were influential in the decision about college and career choices made by their daughters. These findings are supported in a study conducted by Ayiah-Mensah, Mettle and Ayimah (2015), where they concluded that, "the influence of parents in the development of students' interest in vocational/technical subjects cannot be over emphasized. This is because parents seem to have much influence on children's choice of educational career" (p.64). The findings of a study conducted by Wigfield, Bymes and Eccles (2006) support this, and suggest that family is the most important setting outside of the school experience in shaping a student's motivational beliefs.

Additional studies suggest that highly educated and high earning parents are more likely to have the social capital to provide greater learning opportunities and better quality educational interactions at home and at the student's school. Examples of this are found in research conducted by Mulkey, Catsambis and Steelman (2005) where it was observed that higher educated parents were better at communicating with teachers, and maneuvering within the educational system, negotiating their child's education track, and getting their child into high ability math and science groupings (Useem, 1992).

Unlike much of the current body of research suggests, parents of the participants in this study played a supporting role only. Most of the students in this study reported that their parents only nominally supported their career and schooling decisions. The idea of higher education was encouraged, but the participants' parents were not actively involved in college selection, nor in the career decision process. None of the participants of this study reportedly received advice, direction, or encouragement that would steer them into a technical career.

There was also no evidence from the data gathered in this study that would suggest any of the participants' parents had interceded on their behalf in obtaining greater learning opportunities, or even focused learning opportunities for their daughters. Perhaps this is due to the fact of the seven participants, only two reported that their parents had attended college. None of the students in this study had parents who worked as computer scientist or information technology professionals, or for that matter were working in any type of technical or science field. Not only does this preclude any type of parental role modeling in any of the computer science or engineering professions, but it also suggests that there was not a framework of support within the family to encourage the development of technical skills, with any of the participants, that could have possibly led to a stronger involvement in computing and greater technical self-efficacy.

As mentioned, of the seven participants, only two reported having parents that had attended college. This is significant as some studies suggest (Ceci & Williams, 2010a) social class differences reflect differences in parental beliefs and behaviors toward education. In particular, the level of parent education exerts an influence on child achievement through parent attainment expectations. Not surprisingly, highly educated parents value education and tend to pass on to their children their value systems, along with higher educational attainment expectations (Davis-Kean, Malanchuk, peck, & Eccles, 2003). Additional support for this claim is found in a study conducted by Hyde, Else-Quest, Alibali and Romberg (2006), who found that parents with more math preparation and more math self-confidence are more effective at scaffolding their children in math-learning, both in the home and at their children's schools. Conversely, high poverty, high unemployment, and low-education families tend to employ fewer education-oriented practices and provide less educational support for their children (Greenman, Bodvoski, & Reed, 2011).

Furthermore, the review of literature supports an indirect positive influence of parents' education on their children's perceptions of educational attainment and choice of careers. This suggests the possibility that highly educated parents have fewer conventional beliefs about appropriate career choices for females, and are consequently more willing to encourage their daughters in nontraditional pursuits (Ware, Stecler & Leserman, 1985).

Because of their ages and the social-economic status of their families, few of the participants in this study benefitted from the above-mentioned conditions. All of the participants stated that their parents did not use a computer as part of their employment, or in the home, and were generally considered by their children as not technically savvy.

However, it is interesting and significant to note that four of the seven participants reported having access to a computer in the home. This does suggest that while not familiar with technology, parents did indirectly support the introduction of technology within the home, even though the parents, with one exception, were not active users of home computers. Several of the participants of this study who had home access to computers stated that they, or siblings, were the primary users of the home computers.

Mary, a 22-year-old computer science student from the Washington D.C. area was the only participant who stated that both parents attended college. Though neither parent worked in the computer industry, or used computers in their professions. With that said, Mary was also the only one in the study who reported any use of the home computer by her parents. She recalls that her family had one of the first home computers.

> It was a phenomenon. It had a traditional T.V. that sat on the floor and you had to use the dials to turn the channels, and we used it for the computer. I was only two or three at the time… It was an early system that was used mostly for gaming.

Mary did state that while her father did use the computer at times, she was by far the primary user. Outside of this early exposure in the home, Mary did not interface with, or have access to, other computers until she reached high school where she had several classes that used computers. But she was quick to state that she received no encouragement from parents or family towards technology or computing as a field of study.

In reflecting on her early experiences with computers, Nancy, a 23-year-old computer science student from Colorado stated that she also grew up with a computer in the home. It was considered the whole family's desktop, though she went on to say that she and her siblings were the main users of the computer. Of her parent's interaction with computers and technology, she reflects:

> My parents are not very computer savvy. They are still stuck in the old days. We [children] did try to teach them. And they know how to use a computer, but it is not something that they use daily.

Nancy was also exposed to computers in a school setting because of the influence and role modeling of her siblings. Of her initial exposure to computer technology in school, she says:

> I was in first grade I believe, first or second grade. I went to one of my sibling's classrooms. I am the youngest, so they were in higher grades, in higher levels. And I went to their class that they were having after school, and they were being taught how to use a computer. I thought that was the most amazing thing ever.

Additionally, Nancy does attribute later support and direction from her brother, who was working in the information technology and networking field at the time Nancy was contemplating career and education choices. She recalls that her brother was helpful and supportive in her college major decision-making process:

> My bother started school before me. I never really gave it much thought until I saw that he took the jump to actually start computer networking. I was talking to him, and asked him saying, I wanted to go to school but I didn't know what to go for, and I didn't want to waste years in college without having a major to follow. And I was speaking to him about it, and he said why don't you try programming? You are really good at computers. You are better at computers than I am, so why don't you it. I think you can do it. That is what gave me the push to actually pursue this career.

Pam, who grew up in Iowa in the 1970's, is one of two older, non-traditional students in this study. She disclosed that she had no exposure to computers or computing prior to her first year at a community college. She stated, "I grew up before personal computers were really available." She did not have access to a computer neither in her home, nor in her primary and secondary schooling. Pam comes from a working class family, with neither of her parents having graduated high school.

> My dad quit school at the age of nine, and my mother didn't graduate from high school. She quit in her last year. So, I mean they had other obligations.

While Pam received general support and encouragement in pursuing her education, her parents and siblings did not have the education or social capital to assist in selecting and applying for college, or to help with the decision process when it came to what field of study to pursue. Pam was a first generation college student in every sense of the phrase. Her parents and family, including extended family, did not factor into any of her educational decisions.

LaTosha, a married 34-year-old student from Texas, was another participant that did not have access to a computer in the home. Her parents did not attend college and were non-technical with regards to computers and computing. Because of this, LaTosha was ambivalent about computers and computing through her early family and schooling years.

Kimberly, who is originally from Idaho, was one of the study participants who was exposed to computers at an early age. She felt she had been "led into" computer literacy through her family's example even though her parents were not computer users:

> My family was very supportive of technology and my parents bought me, my brother and sister a computer for Christmas. This was back in the early days, and I think it was something like a Radio Shack or a TI 80 or something. We had to hook it up to the T.V. It didn't come with a monitor.

Kimberly was quick to state that while her parents did not use their home computer themselves, they did allow her and her siblings full access. Kimberly also stated that out of her siblings, she was the most interested exploring computing, and was the primary user of the family computer.

Kimberly used the computer for games and entertainment, but also explored programming, using the BASIC language, which was popular at the time. She is the only one in this study that reports using a computer for programming prior to moving into the workforce.

Deena, another non-traditional student is the oldest participant at 63. She is also a first generation college student, and perhaps because of the generation she was raised, the 1970's, she reported experiencing gender stereotypes, some of which were experienced within her home. She is the only participant that does not credit her parents or family for supporting her decision to peruse the study of computer science. Typical of these stereotypes was the idea that a women's principle role was that of a stay at home mother (Rudman, Greenwald & McGhee, 2001; Paré, Dillaway, 2005). When asked about family support of career selection and pursuing higher education, Deena shares her feelings:

> When I was coming up through my family, I was the first one to go into the military, the first one to into the field of technology, and I was the first one in my family, the first female, to become independent. Because the mindset in my family was that you grow up, you know, sweet little girl, you go to school, you go to college, then you come home and you get married, you become someone's wife, you be at home, (sic) you have some babies and you raise children. And I broke the mold.

In addition to having no support for a technical education, Deena had no access to a computer in her home, or at the primary and secondary schools that she attended.

Melissa, 28, is in her final year of a Computer Science program with the specialization in programming languages. She is originally from Salt Lake City Utah, and is a first generation college student. Growing up, Melissa was indifferent towards computers and technology.

Neither parent was computer literate, and both of her brothers work in construction and do not use computers. Melissa's family did purchase a computer when Melissa was sixteen, which she used for homework assignments. It was not until much later, after she had left home and was in the workforce, that Melissa became interested in computing as a possible career option.

Teachers and Counselors

It should be hardly surprising that the older study participants had the least exposure to technology and computing in their early educational experiences. Computers started to make their way into primary and high school classrooms during the mid-1980s (Mouza, 1008). Most school classrooms did not include computers or computer learning until after the adoption of the Educate America Act and the Improving America's School's Act (IASA) of 1994 (Short & Talley, 1997). This legislation authorized funding for state and federal technical education (Coley, Richard, Cradler, and Penelope, 1997).

Two of the participant's high school experiences predated this act, and both stated that they had no exposer to computers or technology in their homes, or during their primary and secondary school years.

When asked to describe her early experiences with computing, Deena, the oldest participant, stated that that she did not have any exposure to computers, "because they were not available then." She went on to say that when she was in high school in the 1970's, we were "still typing on typewriters." Again, this can be attributed in part to the time she was raised, as personal computer use was very limited in the 1970's (Allan, 2001).

While computers were not available, other subjects such as math, science, and other technologies, which would later be grouped into a category call STEM, were available. Deena remembers that she and the other girls in her school, while not necessary discouraged from pursuing math and science, were not encouraged either. The home economics movement, which had its genesis in the 1970's, served as a form of gender discrimination.

Women were encouraged to take home economics courses, which at the time were geared toward women who would not be going to college but would be getting married and starting a family (Stage, 1997; Almquist &Shirley, 1971). Home economics was recognized as a science in most high schools, which meant that girls would receive science credit for it. Which oftentimes meant that home economics became a substitution for classic science and math courses (Harding, 1986, p. 62; Gybers & Gust, 1968; Mayberry & Rose, 1999). As Deena put it:

> In high school it would have been great to have women introduced to technology instead of home economics, cooking and sewing.

Pam, who also came of age during the 1970's and 1980's, transferred into a university computer science program from a Community College in Iowa. Pam's choice to pursue computer science, and to attend college for that matter, was her own decision. According to Pam, her parents and family, including extended family, did not factor into any of her educational decisions. She had no exposure computers or computing in High School, and the possibilities of having a career working with technology was not part of her conscious thought. It wasn't until she was introduced to computing in the workforce that Pam began to consider computer science as a possible career choice.

Younger students interviewed were exposed to computers much earlier. Nancy, the twenty-three-year-old from Colorado, had her first interaction with a computer while in the first grade. As the youngest of the family she profited from having older siblings who were interesting in computing, and continued to seek out opportunities to use computers throughout her primary and secondary education.

> In elementary school, it was kind of a luxury to have a computer back in those days in our family. And usually when I used a computer in elementary school, it was between classes or when I had some free time during class.

By the time she entered high school, Nancy felt that computers had become a necessity in her coursework, "We had to do research and essays and so on and all of this was expected to be done on a computer." Nancy also made it clear that she had full access to computers at her school, and that she did not experience overt discrimination to computer access because of her gender:

> I didn't really notice any difference. We all had to do the same amount of research and work on the same assignments. I don't know what it was like after school when I went home. But we all had a certain time frame given to us to work on an assignment during class.

However, she does feel that there was an implied stigma associated with regards to the profession of computer science or technology. She never received guidance or support to pursue a technical field of study from her teachers or councilors.

Mary was also one of the participants who had access to computers and computer instruction in high school. As part of her high school coursework, she took basic computer literacy courses. Mary recalls her first exposer to a computer as "phenomenal." When asked if she had the same level of access as males did, she stated unequivocally that she did, and that she did not experience any inequities because of her gender, in access to computer labs or in the basic literacy courses. However, she does remember that with regards to the more advanced courses in computer science, including software programming, that she was aware of biases and stereotyping. Mary sums up her feelings with this observation, “The school would usually have the girls read and do problem solving while the boys did more programming activities.” She did feel that this phenomenon was more of a self-selection that was influenced by gender stereotypes rather than something that was mandated by her school.

Mary does not recall ever being exposed to technical career options by teachers or school counselors. If fact, she feels that she, and other girls in her school were discouraged from pursuing technical fields of study. In one such example, Mary recalls participating in career day type events that were held both in her grade school and high school:

> I got to meet individuals in different careers. Mainly fathers and mothers of your classmates, and they teach you about their field, and when you visualize this, the only women I would see were nurses.

Men, the fathers of classmates, represented most of the technical fields. When asked what she took away from this experience, she stated that as a young person she thought, “Oh, I don’t see a woman doing this so it must not be good for a woman.”

Other participants had different levels of exposure to STEM technologies and experiences with regards to using computers in school. LaTosha spoke of her experience with computers at her high school in Texas:

> There were computers, and I had access to one in high school. When they first came out they had a floppy disc. Then I didn’t get another computer to the early 2000’s. I really didn’t get on a computer much. I knew how to type and all that type of stuff. I actually found out about Google from my husband. I asked him a

question and he said Google it. And I said what is Google? That is how often I got on a computer.

Melissa, the student from Utah, states that her experience with computers in school was limited to a junior high school typing (keyboarding) class. As far has her other course options in her school, Melissa noted that "they really didn't have any computer classes at all." Melissa does not recall ever receiving any information about technical careers or areas of study from her teachers or school counselors.

While none of the women in this study reported being denied access to computing resources because of gender, most report their pre-college school experiences as indifferent or even being discouraged from selecting technology as a focus for their studies. None of the participants identified primary or secondary teachers or high school career counselors as supportive or a positive influence in their decision to select a technical career or field of study.

While computers and computer literacy courses were available to many of the participants in school, their use was limited to either learning keyboarding or in support of course work. None of the participants reported having any advanced courses in computing, computer programming, or information technology.

Perhaps most telling of the findings of this study is that nowhere in the experiences of the participants was there indication of any of them having received encouragement, guidance or direction in technical career options from their teachers or school counselors.

Peers and Community

In addition to parents, school counselors and teachers who could serve as mentors, a person's peer group has been identified as an influencer of career selection (Lent, Brown & Hackett, 2000; Kram & Isabella, 1985). One study found that academic selection and achievement can be shaped by a student's peers (Azmitia & Cooper, 2001). Relevant to this study, support of peers has also been identified as an important predictor of selection and persistence in computer science (Barker et al., 2009). It should also be noted that the review of literature suggests peers can also play a role in discouraging women from selecting STEM areas of study, including computer science and information technology.

Most of the participants in this study indicated that they did receive encouragement or support from their peer groups for their decision to pursue a degree in computer science. However, this support was nominal, and came after the decision was made to pursue computer science as a field of study. None of the seven participants indicated that they sought out or received advice from their peers during their decision process. Nor was it reported by any of the study participants that anyone from their peer groups was viewed as a role model. This is in contrast to the findings of the reviewed literature which suggested the influence of peers can play a decisive role in the selection of academic goals and areas of study (Azmitia & Cooper, 2001).

Perhaps this minimal community and peer support can be explained partially by later age that most of the participants made their decision to pursue a computer science education, and for that matter their decision to enter college. As adults who were several years removed from high school, most of the participants' peer groups consisted of working adults who were not planning on attending college themselves. Several participants stated that their friends had only a general idea of what computer science entailed, and therefore could not offer specific support or advice on technical career decisions. However, most participants reported that their peer groups were supportive in general terms of their decision to pursue a college education. For several of the students, peer and community support did become more of an influence as they moved into the workforce or began their military service. As we will see, the pre-college influence of peers on the selection process of the seven study participants is varied.

Even with her early exposure to computers, Nancy never really considered computing as a field of study or as a career option. When asked about this possibility, Nancy stated that she had never really thought about being a computer professional:

> I never really thought of [computer science]. I always thought that it was going to be something that I couldn't do. That it was too hard to do. And my mother would always get so upset with me, telling me that she always saw that I was always with my computer, that I loved computers and that why didn't I pursue it. And it got to the point that I thought, you know, she is right. Why shouldn't I? Why can't I? So I decided to go for it.

The encouragement that Nancy received was from home. Her mother saw her potential and encouraged her. This did not come from her school or her school counselors. Nancy, did state that most of her friends were supportive of her decision to continue her education, but did note that they were surprised with her choice of majors:

> [My friends] are surprised most of the time and the first thing they tell me is that, wow, you must be really smart. I think it is really funny, because I really don't feel really smart sometimes. So I tell them that maybe you should look into it too. I have friends that don't know what to go for. They are still deciding what to do. I tell them, you know what, maybe you should try this out. And their answer is always no, I can't do that.

It was not until after LaTosha was out of high school and married that she started to become interested in computers. She confided that she found out about Internet searching and Google from her husband. "I asked him a question and he said Google it. And I said what is Google? That is how often I got on a computer."

Later she opened a Facebook account and then bought a computer for herself. When LaTosha made the decision to attend college, she did consider computer science, but the decision was hers, and she feels she did not receive any direction from family members. LaTosha recalls her decision to select computer science as her field of study:

> I was going to study business, and my husband didn't think that was a good thing for me to do. So I started to pray on it and started to do some research. Then one day I came across this binary game. Where you had to look at ones and zeros and I got addicted to that game. And then I started to wonder what this was all about so I started to research binary numbers. I found that binary numbers were used in programming. So as I was doing some research it just hit me like, I think I want to be a programmer. So I started to research schools that had computer classes and programming programs. And (college name redacted) was my first choice. I called and talked to them, and then my husband came home and I said, guess what, I am going to school for computer science.

Once she had selected computer science, she did receive encouragement from extended family:

> I think my biggest support has come from my Uncle, and he is not even a programmer. He is a master electrician. But he did take a programming course using punch cards. That is how they did it back in the day. He helped me out a lot.

Before enrolling in college, Pam had very little exposure to computers. In fact, the first time she sat down in front of a computer was during her first year at the Community College. She recalls the experience as unsettling, “I was very nervous. You know, in the labs they would sit you down and say, okay press this button and do this, and this here and do this. It was scary.” Because Pam had no exposure computers or computing in High School, or received any counseling toward a technical field of study, the possibilities of having a career working with computing technology was not part of her conscious until she was exposed to computing in the workforce. Pam feels that her work experience acted as the catalyst for her decision to pursue an education and career in computer science:

> One of the jobs I was doing was sitting there and inputting information into a data machine for billing. They would make the computer cards for every person that we billed, and I thought that was very interesting technology.

When asked to articulate the details of her decision to study computer science, she recalls that she made the decision on her own, based on the observations she had made from her work experiences, and that she did not consult family, friends or colleagues, “I really enjoy watching people work on computers, so I thought that is the program I want to get into.”

As mentioned, Pam was a transfer student from a community college to a university computer science program. Her prior major was Business. She found that friends from her peer group generally were surprised at her change in academic direction:

> [My friends] really cannot believe that I can actually write a program, I mean they have seen me do it and some of them have seen my results, but they are surprised that I can actually program something and that I am doing it. They say, oh, I

could never do that. Talking about themselves, they say that they could never be able to do that.

When asked to comment on their response, Pam felt the surprise of her peers had a lot to do with commonly perceived stereotypes:

Both gender and my personality because as a kid growing up I was one of those kids spaced out with things going around me. I really didn't pay much attention to things. My family was really surprised.

Pam does not feel that friends, or her peer group, negatively impacted her decision process in the selection of computer science. In fact, while no specifics were given, she did report feeling supported by her friends and family in her decision.

Kimberly also started her college career in the field of business. During her second year, she became pregnant and dropped out of school. She later returned to school, but this time as a single mother with two kids:

I went back and decided that I would just finish my business degree. I have enough credits, so I will do that. But that still didn't work. And it was just that I wasn't interested in it. I didn't like it.

Kimberly dropped out of school again and started working for the government of the city where she resided. It was in this professional work atmosphere that Kimberly made the decision to return to school. It was also the experiences in this job that influenced her decision to select computer science as her field of study.

So I finally got a job working for the city. In that position, they kept everything on paper and it just was not a good system that you could find anything on. We had a lot of information come through the shop so I tried to build my own my database.

> It kind of grew from there. And I finally said, I am done with this, I want to go back to school.

Melissa also entered the workforce directly after high school and actually worked in the high tech industry as a technical support agent. While this was an hourly (non-exempt), and largely a non-technical position, it did put her into close proximity with professional programmers and information technology personnel. By this time in her life, her peer group consisted mainly of the people she worked with, many of whom were college graduates with technical degrees. This was a new experience for her; it differed from some of the other participants, in that she received encouragement and support from a peer group that was knowledgeable in technology and computing.

Military experience

An interesting finding of this study was the positive and direct influence that the military had on the selection processes of two of the participants, Mary and Deena.

Mary had joined the U.S. Army after high school, in part to raise money for college. She was assigned a position in a call center, which was part of a technical support department for a series of military computing systems. This was an assignment, and not something she chose or even knew that this type of job existed prior to her assignment. When asked if she had known of this option would it have been something that she would have been attracted to or would have chosen:

> No. I would not have chosen it. Because I didn't feel comfortable with the technology, or with computers. Just because I was never around such an advanced portion of computers. I told them that I would have chosen

> warehousing because I am such an organized type person. I am good at figuring out where to put things.

When asked when and how she became interesting in computers and computer, Mary states, “I would say that the military actually brought me into the world of computing and computers. And just because they pushed me into it.”

While in the Army, Mary worked in a technical environment that consisted of both men and women. Officially, the position she held, which is termed a military occupational specialty or MOS, was gender neutral, but she does feel that as a woman, she was treated differently by her peers:

> [The women] were treated differently. We were mainly kept on the call center because women have more of a knack for customer service and the men went out to fix things. Or to call a customer to resolve the issue.

Upon the end of her enlistment, Mary remembers the initial repose of her friends to her decision to enroll in a university computer science program, “I think they are shocked. As soon as they know I am in computer engineering, their reaction is surprise, ‘oh really? That’s cool.’” When asked if she thought their reaction was due to her gender, Mary replied:

> Yes. I don’t even have to think about that. If my husband were to say, I am going into computer engineering, they would be like, oh, that is really cool. That is interesting, versus for me, oh, isn’t that is kind of hard? (laugh)…. I don’t know if it is the view

that women are not that intelligent in that aspect of computers or it's because they don't know anybody (women) in that field.

Deena's first exposure to computing technology was also in the military. She joined the U.S. Army right after high school, and traveled overseas. She remembers taking a series of aptitude tests and doing well in the technical portions of the tests, "Because of my interest scores, they either wanted to put me in the Morse code discipline or computers. Between the two, I chose computers."

Deena's initial expose to computers and computing was positive. She received positive feedback on her job performance, and this further motivated her to put forth the effort to excel at her position. When asked to comment on the support she received, Deena identified the relationship she had with a senior technician who she later came to see as a type of mentorship:

> Yes, my team lead helped me. He was more than willing to help me, because I asked questions. Anything I didn't know how to do, and that is a discipline they teach in the military, if you don't know how to do it, then ask somebody. Don't ask somebody who doesn't know anything more than you know, ask somebody who knows more. So because he was team lead, I asked him all the questions that I had. And I also spent more time after work trying to master what it is that I was tasked to do.

Deena was assigned to a position using computers that involved data entry and reporting. As she continued to excel in this position and received additional training, her desire to pursue a technical education was fueled:

> And because I had received awards and accolades for my accuracy, it sparked a something in me to pursue it further…. I like venturing into the unknown. And technology, once I ventured into technology, because it changes so much, I wanted to continue learning.

Even after serving in the military and receiving technical training in computing, she still did not receive family support for her desires to study computer science. She recalls the reactions from her family when she announced her decision to pursue computer science as a field of study, "I ran into so much with my family. It was like what are you doing? Do you need some help? Because it was unheard of in my family for a female to do what I did." Deena's experience is unique as she is the only study participant that reported negative family support with regards to her decision to pursue a computer science education.

Self-efficacy

As defined by current studies, the belief in one's ability to perform well in a specific field or at a certain task is referred to as self-efficacy. (Bandura, 1997; Pajares, 2005; Zimmerman, 2000). These and other studies support the construct that academic fields of study and career choices made by individuals are significantly influenced by their Self-efficacy. As such, self-efficacy is considered a significant predictor of the level of motivation toward a particular task and ultimately of performance of the task itself (Bandura & Locke, 2003; Zeldin, Britner & Pajares, 2008). Additionally, there is a central theme that has emerged from recent research that supports the conclusion that a person's computer behaviors are largely influenced by how they perceive their computer self-efficacy (Compeau & Higgins, 1995; Ware & Lee, 1988; Bates & Khasawneh,2007).

Self-efficacy has also emerged as a central theme in this study. Pajares (1996) argued that students with high self-efficacy will experience feelings of serenity in approaching difficult tasks and activities. The participants in this study exhibited these positive attributes of self-efficacy during their selection process, and later, in the persistence of a computer science major. Self-efficacy, as it applies to the selection process of the participants, will be discussed in this section. The relationship between self-efficacy and the persistence of the students in their academic studies will be will be discussed in the next chapter.

The source of self-efficacy varies with the individual, but it is generally agreed upon that individuals form their self-efficacy beliefs by interpreting information primarily from four sources: mastery experience, vicarious experience, social persuasions, and physiological reactions (Usher & Pajares,2008; Pajares;1996; Bandura, 1994). These studies find that for most individuals, the greatest influencer of self-efficacy is the interpreted result of individual performance of a task. This is often referred to as a mastery experience. In other words, individuals tend to gauge the effects of their actions toward task completion and goal achievement, and their interpretations of these effects help create their efficacy beliefs. Success in task completion helps build a robust belief in one's personal efficacy.

A resilient sense of efficacy requires experience in overcoming obstacles through perseverant effort. Some setbacks and difficulties in an individual’s pursuits often serve a useful purpose in teaching that success is often not a linear path, and usually requires a sustained effort (Schunk, 1995). After people become convinced that they have the capabilities to succeed, they persevere in the face of adversity and quickly rebound from setbacks. By persisting at a task and sticking it out through tough times, a person will usually emerge stronger, with an increased self-efficacy (Bandura, 1994).

The second way of creating and strengthening self-beliefs of efficacy is through the vicarious experiences of seeing people similar to themselves succeed in a task or achieve a goal. This has the effect of reinforcing the belief that they too possess the capabilities to master comparable activities (Schunk, 1995). In other words, people form their efficacy beliefs through the vicarious experience of observing others perform tasks. Observing the successes and failures of peers who are perceived as similar in capability contributes to the belief in one's own capabilities. Frank Pajares (1996) observed that these vicarious experiences also involve social comparisons that individuals make with their peers. These observations are often seen as powerful self-efficacy influences. Additionally, Bandura (1994) found that in situations in which a person’s peers have little experience with which to form a judgment of their competence in a particular area, these types of peer models still have a positive effect of individual self-efficacy, and have been found to be useful in increasing self-efficacy (Compeau & Higgins, 1995). The findings of this study support this conclusion.

Social persuasion is a third way of strengthening self-perception. People who are verbally persuaded that they possess the capabilities to master given activities are likely to martial greater effort toward the activity and sustain it than if they harbor self-doubts.

The forth source of self-efficacy is physiological reactions, or feedback. Physiological and emotional states such as anxiety and stress, along with one's mood, provide information about efficacy beliefs. Typically, optimism or a positive mood enhances self-efficacy, whereas depression, despair, or a sense of despondency diminish it. As with the other sources, it is not the intensity of the physical indicator or mood state itself that is important, but the individual's interpretation of it (Bandura, 1977). Although this source is the least influential of the four (Redmond, 2010), it is important to note that if a person is more at ease with the task at hand they will feel more capable of successfully completing it, and have higher beliefs of self-efficacy.

Of the four sources, the mastery experience was identified as part of the pre-college experience of several participants in this study. Nancy relates that even though she was the youngest in her family, she was the go to person whenever a technical issue arose:

> Whenever there were issues at home with the computer, with viruses and what not, I would always research what to do to fix it. I was able to fix the computer most of the time. I really never needed much help getting it fixed or cleaned up.

Kimberly, reports a similar experience of being identified as the person with expert problem solving skills with regards to computers and computing. Her mastery experiences took place while she was working in a technical position before deciding to pursue an education in computer science:

> I went back to school a little later in life so a lot of my jobs, I ended up being the techy person that people came to but yet I wasn't really qualified so I wanted to be that qualified person that people could actually come to. And that kind of pushed me to start programming to make things easier and it just came to the point that I needed to go back to school and learn programming… anyone that has been around me for anytime knows that I am the person that when they have a problem I get the call.

As previously noted, Mary was one of the study participants who received her initial exposure to computers while in the military. It was while serving the Army that Mary experienced many positive performance outcomes. Working as a customer support specialist she notes that she was singled out because of her high performance and remembers that many of the customers she serviced would ask for her by name. When asked if she received advancement because of her performance, she replied:

> Yes, it wasn't just for my customer service. It was because I was willing to resolve the issue in a timely manner and I would take time out of my schedule to resolve their issues. So they felt important regardless. Even if I didn't have time, I would stay after work and would work twelve hours to resolve an issue if I had to.

Mary also recalls that she received positive performance outcomes for the level of her commitment:

> Yes, they were quite shocked because most of the people they would go to were male, but not because of that, but that I had much less experience. And because of that and because I was actually involving myself in trying to resolve computer issues physically and program wise, I learned my whole job aspects within a year instead of two or three.

Not surprisingly, Mary credits the military for helping in her personal growth and giving her the confidence needed to select and persist in goals. In summing up her experience and the areas of growth, Mary states:

> Definitely the confidence. The military in general give me the confidence of I can do anything as long as I put my mind to it. My parents did that too, but it was more like I see myself in music or the art industry. Just because that came naturally to me (laugh). But the military did influence me the most.

Deena, also received her first exposure to computing in the military, and like Mary, she excelled in her technical position and this positive experience influenced her computer self-efficacy:

> I was exposed to computers in the personnel department. And I was trained to use the key punch, and to enter military data into the system. It was a military system. Computers weren't really available to the public at that time. But the military was just starting to get into it really good. And because I had received awards and accolades for my accuracy, it sparked something in me to pursue it further.

It is clear that the experience of being the technical expert among friends, family and coworkers increased the computer self-efficacy for the above named participants. They exhibited a visible pride when they spoke about their expert status.

In the participant interviews, there were self-efficacy sources of vicarious experience from observations and social persuasion that were also identified. Pam recalls observing coworkers:

> One of the jobs I was doing was sitting there and inputting information into a data machine for billing. They would make the computer cards for every person that we billed, and I thought that was very interesting technology…I really enjoy watching people work on computers, I can do what they do, so I thought that is the program I want to get into.

Nancy reports receiving positive social persuasion from her peer group who were aware of her computer expertise. When the subject of her selection of computer science came up, one of the first responses she received from her peer group was surprise followed by comments along the lines of "you must be really smart." According to Bandura, (1994) and Pajares (1996) This positive feedback, even though it is just verbal, builds self-efficacy.

Melissa worked at a call center before entering college. And while working as a phone support technician, she recalls what could be framed as a vicarious experience as she observed the more senior engineers:

> I love being challenged. I love to have new things to learn. To always having something to learn, and computers are always changing so that you are always going to have to learn something. I felt I could do what they were doing.

Physiological reactions, or feedback, is the forth noted cause of self-efficacy. Although this source is the least influential of the four (Redmond, 2010), it is important to note that if a person is more at ease with the task at hand they will feel more capable and have higher beliefs of self-efficacy. As with the other sources, it is not the intensity of the physical indicator or mood state itself that is important, but the individual's interpretation of it. Physiological reactions, such as anxiety and stress along with one's mood provide information about efficacy beliefs. Typically, positive feelings and optimism when performing a task enhances self-efficacy. After all, if a person is confident and feels no anxiety or nervousness in task performance, then they may experience a sense of excitement that fosters a greater sense of self-efficacy (Pajares, 1996).

Deena expressed these positive feelings when discussing experiences that influenced her to choose to study computer science:

> I like venturing into the unknown. And technology, once I ventured into technology, because it changes so much, I wanted to continue learning….and that

is interesting to me because I like change. You know, especially if it is positive change and progression.

Melissa expressed a similar positive physiological reaction toward her chosen field of study.

I love being challenged. I love to have new things to learn. Computers are always changing so there is always going to be something new learn.

It is clear that Kimberly also experiences positive emotional feedback when she is working with computers.

I love the challenge of programming. I love having to figure things out and to make them work. The puzzle part of it. That is the main reason that I got into programming. I like solving puzzles. When you build a program and it works, it is like "oh my gosh, it works!" It is simple, but it is awesome. It works!

Nancy, the participant who thinks that computers "are the most amazing things ever," was almost emotional when she spoke of her decision to pursue computer science as a major, "I really didn't have anything that I was really passionate about until I stumbled upon Information Technology and computing."

Bandura (1977) has stated that if one is more at ease with the task at hand, then they will feel more capable and have higher beliefs of self-efficacy. Examples from LaTosha's experiences support this construct. During her decision process, she came upon an educational computer game. The more she played the game, the better she became. Her self-efficacy grew, and from there she expanded her research into computing and technology;

College Experiences

The review of literature identifies many factors that influences the entry of students in a computer science field of study. From the previous section, it was found that the pre-college experiences of the participants of this study are juxtaposed with the findings of current research; they are somewhat outside the normal in several key areas, and generally they became aware of computer science as a field of study later than what would be considered the average age range of traditional first year college students. Most have work experiences, and even military experiences, that were a significant influence on their selection. What was common among the participants was that with their decision and selection processes, they all displayed a high confidence level, self-efficacy and enthusiasm.

Selecting a Major

In light of their diverse backgrounds, an interesting commonality among the participants was that the selection of computer science was made rather quickly once the decision was made to enter college. Four of the students self-identified that they came to the university specifically planning to study computer science. The three additional participants who had originally declared other majors, changed to computer science within their first year of college. Of the four that enrolled in computer science from the outset, the selection process was very straightforward.

Nancy, who was introduced to computers and computing in the workplace, selected computer science as her major upon her initial enrollment in college.

> As a child, I like to draw a lot. So I always thought I would be some type or artist or illustrator or designer. As I began growing up, I started to shift toward graphics design. But then I noticed that it was becoming more of a hobby. It was

> not much of a career that I wanted to pursue. So I really didn't have anything that I was really passionate about until I stumbled upon Information Technology.

Pam was also influenced by the work experience that she had, and she selected computer science as her field of study when she enrolled in college. "I had it [computer science major] picked out. I really enjoy watching people work on computers, so I thought that is the program I want to get into."

Like Pam, Melissa, the first generation college student from Utah, credited her work experience as a positive influence toward her selection of computer science as an area of study.

> I have always loved computers, but I guess my love for computers really after I started working after high school…. I was actually tech support for Accer, Gateway and E-machine computers, and that is when I actually started to want to go to school for computers.

Deena, who received computer training in the military, had worked in the high tech industry for a few years before enrolling in college. Her goal was to continue her technical education and she selected computer science as her major upon entering the university:

> So I decided to go to school. I had mastered the main frame so well, I wanted to, you know, to learn the other end. A lot of what I was doing before I left work was merging data with the main frame and the web.

Mary also received work experience and training in computing in the military. She credits a particular experience for building her self-efficacy:

> The military in general gave me the confidence of I can do anything as long as I put my mind to it. My parents did that too, but it was more like I see myself in

> music or the art industry. Just because that came naturally to me (laugh). But the military did influence me the most.

Upon discharge from the military Mary entered college with a declared major of Archeology, but she soon changed her major:

> But then I was too board [archeology]. I was not problem solving. I got use to that and so I started actually researching different majors that the school offered. I tried computer science, but I don't like that programming aspect. So I switched to computer engineering because that is what I mainly, what I love doing anyway.

Kimberly originally enrolled in a business major, but as stated previously, she soon dropped out to start a family, and then took a local job. It was during this employment that she made the decision to return to school.

LaTosha's experience was similar. She was also a business major, but did not feel it was a good fit. She had experienced positive self-efficacy while working with technology in a job after high school, and this motivated her to research computer science as a career option.

Culture of the Computer Science Department

In this study the use of the term culture refers to the complex and broad set of relationships, attitudes, behaviors and values that bind a specific community together either consciously or unconsciously. Computer science, both in an academic setting and in the professional workplace, is no different than any club or tribe: it that it has its own unique culture. Much of this culture has been carried over from its parent disciplines, electrical engineering and math. There is also an ongoing tension between computer science and the engineering disciplines, and these factors tend to obscure what is unique in the study and practice of computer science. Added to this is the fact that the culture of computer science is not static, and it continues to evolve. The one thing that computer science does share with the cultures of math and engineering is that it is primarily male based, and this does present some unique challenges for women who pursue the study of computer science.

From the review of literature, the findings concerning these challenges are mixed. Some studies report women who feel disrespected in their computer science departments because of their gender, while others report gender to be much less of an issue (Vitores & Gil-Juarez, 2015; Whitecraft & Williams, 2010). The participants in this study felt gender to be less of an issue. A possible reason for this is that most of the participants felt they had gained experience in navigating and working in a largely male environment. These were from pre-college work and military experiences. Most participants reported feeling at ease interfacing and working within in a male dominated professional environment. These experiences did serve to build self-efficacy, and as noted, did play a significant role during the selection process of most of the participants. The students in this study did experience unique challenges in the classroom that their prior work experience did not fully prepare them for. However, in this section, the discussion will be focused on the overall perceptions the participants have of their respective computer science departments.

Describing the atmosphere of the computer science department she is a part of, Melissa was very complementary:

> It is open. Everyone is more than willing to ask questions and most everyone gets their questions answered. It doesn't matter what the question is. My Dean is just great. He is actually the one who is teaching my class right now.

When asked if she felt any intimidation about entering a major that was so male dominated, Mary was confident in her past experiences working in a male dominated occupation while in the military:

> I didn't have any concerns. Mainly because of the military. I know there were not a lot of women in the military, so I knew it was going to be a struggle. Not just to enter, but to be in there with the men. Men are not around women all that often in the military in the first place. And this experience brought me to realize that there is not going to be an issue.

Mary also feels that she is being treated equally by her department and describes the computer science department that she is part of as lively and open:

> They have bought in more women from the industry, not just because it makes them look good. It is because women bring more of an outside look into things than men. Men are more, or seem more focused on what is going on versus women, who say, lets resolve this and this is how we should do it.

Nancy, the computer science student from Colorado, did not feel that she had been treated differently in her academic program because of her gender:

> No, not at all. I haven't noticed anything. All of my teachers are very respectful and encouraging when it comes to my assignments, and whenever I turn them in.

LaTosha felt the same as Nancy, and didn't think she'd received any sort of treatment based on her gender:

> I don't think that I have been treated special because I am a woman. I think you go in there and you put in the effort and you try and everybody will be willing to work with you and they will give you the help you need. I don't see a difference.

Pam also made it a point to emphasize that in her current program she has been treated equally and fairly, and that she is pleased with her program selection. Kimberly was also quick to note that she had not been treated differently by any of her instructors.

Being accepted by the faculty, staff and administration of a department is a critical first step to fostering a feeling of ambient belonging. Most computer science departments in the United States have made significant efforts to attract and keep female students. These efforts include building institutional support and in making a greater effort to promote a gender-neutral learning environment (Cohoon, 2002; Blickenstaff, 2005). It is clear that the three universities that represent the students in this study have largely succeeded in this regard. All of the participants report feelings of being accepted on an equal footing with their instructors, professors, and academic staff. Having this level of acceptance and support was seen as a positive factor towards the persistence within the respective programs by all of the students in this study.

Being part of an academic program that espouses a gender neutral environment of acceptance does not necessarily offset the fact that women are vastly underrepresented in most computer science departments. Current figures released by the National Science Foundation (2015) show that women obtaining Bachelor's degrees in computer science are less than one third that of men. The women in this study were very aware that they were in the minority. When asked to speculate on the percentage of women to men in her classes, Mary stated, "Oh, if I had to judge by all my classes, I would say a max of three women to fifteen men. There is just three of us, and I see them in all of my classes." Nancy notes that oftentimes she is the only woman in many of her classes. Kimberly's experiences are very similar:

> It started out with mostly doing the IT side of it, and there were more women there. But once I started to move into the programming classes, I was generally the only woman.

Pam, the student originally from Iowa, also commented on the lack of female students in her discipline, "In the graphics design classes, it has been a mix of men and women but for the computer technology classes, the programming, it has been all men." LaTosha's experience has also been similar. As far as gender is concerned, she considers herself very much in the minority.

> I say probably 5 percent of my class is female. Maybe less than that. At the beginning of the module you will see maybe ten guys and three or four girls, and then by time at the end of the course, you see mostly men.

The findings from this study are consistent with the review of literature that women are a minority in STEM programs, and in particular are significantly underrepresented in the study of computer science (Snyder & Dillow, 2012).

Motivation

One of the conclusions that can be drawn from this study is that the participants possessed a high level of personal motivation to progress through their computer science programs. Ryan and Deci (2000) define motivation as being "energized or activated toward an end" (p.54). In the case of this study, all participants agree that the "end" in question is to persist in the field of computer science and graduate in order to fulfill their personal goals, which for all of the students in this study, is to secure a career in the field of computer science.

Self-efficacy plays an important role in motivation (Bandura, 1977, Schunk, 1989; Maddux 1993), and as demonstrated in the previous section, all of the participants exhibited a positive self-efficacy during their pre-college selection process, which has been carried over into their college experience. Self-efficacy and motivation are enhanced when students perceive they are becoming more competent (Schunk, 1989). All of the study participants experienced a reinforcement of their self-efficacy during their study of computer science at their respective universities.

Nancy recalls how her confidents grew along with her motivation as she progressed in her course work:

> When I first started, like when I was doing Java applications, I was thinking, what did I get myself into? I don't understand any of this. But throughout the course I started to feel more confident. And the second Java class that I had, I started to understand what the teaching was talking about. And that made me feel a lot better because I had actually considered dropping out. But I am really glad I didn't because I feel that I have learned a lot.

LaTosha sums up her personal experiences with regards to personal growth:

> Personal growth. I am more confident. I feel that since I have been in college that honestly I can take on the world and I can make it happen. After everything that I have been through and still maintain my 4.0 and do everything that I need to do. I think that before I started college that I was not that strong.

When asked what motivates her to continue in her studies, she states:

> Because I have determined to make a difference. Not only for my children and for my life, but I want to leave a legacy behind. And I really, really want to do

> something to create devices and do things for people with disabilities and to make learning easer and to make our world a better place. That is my biggest motivator is to make a difference.

In spite of feelings of isolation, Deena feels that she has maintained a positive attitude and high motivation. In other words, her self-efficacy has continued to grow throughout her academic progress:

> Oh, I have a very positive outlook on my education. I feel like I have grown and accomplished things, and I have reached a greater maturity. I have learned a lot and have new goals. I know that there is so many opportunities out there. So now I feel prepared. That is what school has done for me.

Kimberly, who is on the Dean's list with a solid 4.0 grade point average has accomplished a great deal by anyone's standards. While still very motivated, she does express some lack of self-confidence:

> You never feel, even when you are doing a hundred percent, even with my 4.0, you never know it. I never feel that I know the material. I have to google it. It is like I need to figure out all of this works because I don't understand all of it, but somehow it all works. I always expected that somehow you would sit down and code and you would know exactly what you are doing. I have found that you don't always know a hundred percent of what you are doing. There is a lot of asking questions and figuring things out.

Interestingly, Kimberly was the only participant to express lack of confidence in her studies. This is perhaps because she is the one who has expressed the stronger feelings of isolation. However, despite her feelings and lack of self-confidence, this has not noticeably deterred her motivation to persist in her major. Motivation is interesting, as it can be defined not only by its level but also by its orientation. In other words, it is not just about how motivated a person might be, but it is also about the reason a person is motivated (Ryan & Deci, 2000).

Given that this study tracked only women who are successful in the persistence in computer science, the question of the level of motivation has been answered: all participants exhibited enough motivation to persist and continue. What might be more interesting, and perhaps more relevant in the context of this study, is the “why” of motivation. To put it another way, why are these female students motivated? As it turns out, the female participants of this study are motivated for a variety of different reasons. These reasons range from wanting a more fulfilling career, or as Melissa put it, “I got tired of working in call centers,” to Mary’s desire to find a direction in her life, something that she can do, be good at, and enjoy. Mary says, “I decided that I need to go to college, I need to do something more with my life than sit at home and dream about a job I enjoy.” LaTosha is driven by a desire to make a positive difference in other people’s lives. She feels that this can be accomplished by using her computer science skill set:

> Because I have determined to make a difference. Not only for my children and for my life, but I want to leave a legacy behind. And I really, really want to do something to create devices and do things for people with disabilities and to make learning easer and to make our world a better place. My biggest motivator is to make a difference.

A significant motivation for Kimberly’s is the challenge of computing, though she also expects to move into a professional development position upon graduation:

> I love the challenge of programming. I love having to figure things out and to make them work. The puzzle part of it. That is the main reason that I got into programming. I like solving puzzles. When you build a program and it works, it is like "oh my gosh, it works!". It is simple, but it is awesome. It works!

Multiple studies have found that motivation increases the amount of effort and energy that people will expend in activities directly related to their needs and goals (Csikszentmihalyi & Nakamura, 1989; Maehr, 1984; Pintrich & Garcia, 1993). It is clear that the participants in this study have and continue to expend large amounts of time, energy and effort towards their academic end goals. It is for this reason that motivation, along with self-efficacy is a significant theme in this study that directly affects these student's persistence.

Mentors, Role Models and Female Instructors

An interesting gap in the findings of this study has to do with mentoring and female role models. As discussed in the literature review, many studies have identified links between women's persistence or success in workplaces and the presence of a mentor (Dreher & Ash, 1990; Blake-Beard, 2001; Downing, Crosby, & Blake-Beard, 2005). For the participants in this study, mentoring did not seem to be particularly relevant. A few students did identify having a mentor, but most did not.

When asked if she had a mentor, Kimberly she stated, "No, I don't have anyone like that. I am my own mentor." When the question was asked of LaTosha if there was anyone that had worked with and helped her to the level that she could consider them a mentor, or if there was anyone in the computer science department or industry that she looked up to, LaTosha answered in the negative, and stated, she did not have a mentor, and that, “I have only had one female instructor, the rest have all been male.”

Pam had no mentors, no role models, or any female instructors. When asked in hindsight, if during her selection process would the predominance of male faculty in the computer science department would have given her pause, she replied, “I don’t think that would have affected my decision. I really like programming and it is something that I really wanted to get into.” Mary did have a female college advisor who she considers a role model. She describes the relationship:

> She broadened my horizons. Because she could do it. Especially since she is 60 plus and worked when women were not even considered for that industry. She was the old female, she informed me, for a long time. She was in Alaska.

The students, like Mary, who did identify a mentor mentioned it in passing, and only because the question of a mentor was asked. Unlike the findings in many of the studies in the literature reviewed, mentorship does not appear to be a strong influence in any of the participant’s decision-making processes, or as a factor in their persistence in their study of computer science. One possible reason for this is that the study participants were not typical computer science students. Most were older and had work experience, which, as we have seen had the effect of building their confidence and self-efficacy.

Challenges

The result of the inequity between male and female computer science students is that women frequently find themselves alone in a room of men, including the instructor. Computer Science professors are almost always men (Fox, 2010; Wilson, 2002). Research identified in the literature review suggests that women in computer science majors experience certain challenges based on the male hegemonic climate of their environment.

Participants noted numerous encounters with peers, faculty, and tutors that left them feeling isolated and an outsider to the classroom peer experience (Margolis, Fisher & Miller, 2000). The following sections identify several themes that have emerged in this study that current research has identified as challenging to persistence in STEM fields of study.

Feelings of Isolation

General anxiety in the classroom can be mitigated to some extent by feelings of interpersonal familiarity and acceptance by peers. Students, both male and female, feel more comfortable if they interact more with peers who are similar to them (Varma, 2006). The more students feel they can communicate openly with their peers, the better they are likely to do in learning outcomes. They will develop their social identity based on how they fit into relationships with other students (Myers & Bryant, 2002). One of the challenges that women in a male dominated academic setting often face is the feeling of isolation (Seymour & Hewitt, 1997). The students in this study are no exception. All of the participants interviewed had experienced some feelings of isolation, and they viewed themselves as outsiders to their male peers. Pam summarized the feeling she has of her minority status by stating, “I think it is kind of that overall feeing of not fitting in. You just have to make your own way, and sometimes that is really hard.” Melissa stated that she has often found herself as the only female in a classroom. This has led her to experience feelings of isolation and inferiority:

> I think it is if you are the only girl in the room, then you probably feel singled out. But what girls don’t understand is that even if you are the only girl in that room,

> chances are the men know more than you do on the programming because they have spent a lot more time at programming.

Kimberly describes herself as an outsider. She feels her male peers do not exclude her consciously, but rather it is more about different communication and social skills:

> A lot of them (men) don't know how to interact with people. I was coming from the business end of it, so I could see they wouldn't interview very well, but they are very intelligent in other ways. So they don't really build relationships, and they don't communicate well.

Lack of Peer Support and Collaboration

In addition to feeling isolated, all of the study participants noted the lack of peer support and difficulties communicating within their classrooms. Research conducted by Barker and Garvin-Doxas (2004) identified the link between defensive communication and attrition in computer science among college students. Defensive communication is defined as the type of communication that occurs when an individual perceives threat or anticipates threat in the group. The person who behaves and communicates in a defensive manner, even though he or she also gives some attention to the common task, devotes an appreciable portion of energy to defending himself or herself. According to Stamp, Vangelisti, and Daly (1992), defensive communication reduces opportunities for students to talk openly with classmates about classwork. A study by Rosson, Carroll, & Sinha, (2011) concluded that peer support, by way of social learning networks, strongly influenced self-efficacy, which is significant to this study as self-efficacy has been identified as the single most important predictor of persistence in computer science (Barker, McDowell, & Kalahar, 2009).

None of the seven participants established permanent peer group support among their computer science peers. Peer group support and collaboration is a significant factor in computer science. The ability to create supportive peer relationships and to work effectively with peers in small groups within the computer science classroom has become important focuses of many university computer science programs. This mirrors most professional computing work environments. Over the past three decades, the profession of computer science has had to adjust to the increasing complexity of software development and systems design. In doing so, it has adopted a more team-based discipline. Agile project management, which emphasizes small, cross-functional developmental teams, has become the standard in the software development industry. The increased emphasis on team based development and problem solving is in part driven by the order of magnitude in complexity that modern software and hardware solutions have become (Battin, Croker, Kreidler & Subramanin, 2001; Faraj & Sproull, 2000). Being able to assimilate, work and communicate in a team environment have become essential skillsets for the successful computer science professional today.

In order to prepare students for this collaborative, team based work environment, many computer science departments have adopted curriculum and teaching methodologies that emphasize team-based assignments and projects, with the goal of promoting communication and providing insights and experience with group-based activities and interactions.

When speaking of her experiences while working with her classroom peers and with the several group projects she has been involved in, Kimberly feels that she is most often on the outside looking in:

> I think with classmates there have been very few classes that I have had where there has been another female in the class. A lot of the classes you work together

> on projects and I am kind of on the outside. It's not done on purpose, but working in a group when you are the only women is stressful. You are treated different because of it. It seems that I am the one who is always asked to take the notes. But at the same time I was also a tutor for a while, so they kind of look at you like, yup, you know it anyway. But I couldn't build those relationships to study with as easily as the other guys in the class could.

Nancy, who's focus is in programming languages also feels that there is a "clique" that seems to develop with men that has the effect of excluding women:

> I haven't had many group assignments yet, but when it comes to group discussions, all my classmates are very complementary, but they [men] all seem to have a common background. They hang out in the labs together. I have never felt that included.

One of the participants notes that from her observations it might be the camaraderie that men have that makes it easier for them to commutate with each other. As she thought more about this, she related this example, "In some of the classes we had a male tutor and a female tutor. Most of the guys would go to the male tutor even though he wasn't the computer science tutor."

From the review of literature, there are studies that affirmed that human learning primarily occurred in social environments (Schunk & Mullen, 2012). One study by Tillberg and Cahoon (2005) suggests that the influence of peers is significant in both creating interest in a task and persistence in task completion. In other words, it's always harder to go it alone.

As mentioned previously, all seven of the participants entered college with high self-efficacy and a confidence in their ability to use a computer and learn new computing skills. However, once enrolled, participants experienced feelings of isolation. Most identified a lack of social interaction with peers both in and out of the classroom. These experiences are consistent with the findings in the review of literature. Without social learning opportunities, the participants of this study missed out on the essential human connections needed to validate learning milestones and share information to speed up group learning.

Stereotypes

Computer science and other engineering disciplines are stereotyped in modern American culture as male-oriented fields that involve social isolation, an intense focus on machinery, and inborn brilliance (Cheryan & Meltzoff, 2015). These, and other gender stereotypes, are often reinforced by lack of female computer science faculty, and the general lack of women role models in the high tech industry.

The review of literature identifies Stereotype threat as a fear of confirming a negative stereotype, such as women's lesser abilities in technical fields of study (Steele 1997, Steele & Aronson 1995). Fears that are generated by stereotype threats can cause a person to underperform, which in turn supports the stereotype. Negative stereotypes often result in discrimination, and denial of opportunities (Steele 1997). Stereotype threat is very real for underrepresented students, and according to a study conducted by Jane Margolis, Allen Fisher, and Faye Miller (2008), stereotypes are especially threatening among students who studied technical, computer related topics. There is also evidence that suggests that common computer science stereotypes are a negative factor in the persistence of women in the study of computer science (Beyer, Rynes, Perrault, Hay & Haller, 2003).

All of the students in this study were aware of stereotypes. Some participants expressed negative emotions in relation to computer science stereotypes prior to their enrollment in a computer science program. The level of awareness of stereotypes and perceived stereotype threat differs for each of the participants. For some, stereotype threat is always there:

> It is not so much something that they say straight out, just like that. But it is something that surrounds that media and it is pretty much something that you see all the time. In movies and shows. It is always the man that is into gaming and into computers and they are the smartest person ever. Usually, I only know of one show that shows a woman as a professional with computers.

Mary, who grew up in Washington D.C., feels the effects of stereotypes in her program with the socialization that takes place within the classroom. LaTosha also reports that stereotypes are a part of her college experience:

> Yes, I have seen a lot of stereotypes. Whenever I think of computers and technology, I think of some geek. But when I went into computer science I was totally having to have my make up right. I am totally a diva (laughter). When I tell people that I am in computer science, they say, get out of here, you don't even look like the type.

When discussing her academic environment, Kimberly says she is well aware of stereotype threat. She attributes her feelings of isolation to the effects of stereotypes:

> I have never fit in. I wasn't that one going out and playing video games and you know they had their little groups at school where they would come in and play video games. I think it is kind of that overall feeing of not fitting in. You just have to make your own way, and sometimes that is really hard.

Like the other students, Deena has also experienced the negative effects of stereotypes. Even though she has been successful in her program and is close to graduation, she confides that it still bothers her:

> Oh, yes. I ran into this stereotyping once I got out of the military. And as I started, I went to school when I got out….I was able to function but it still bothers you when people are dropping innuendos. But they did respect my input a lot. They would come to me when they couldn't find an answer. And I didn't mind sitting and mentoring and assisting because I am a team player.

While the emotional power of participant computer science experiences is difficult to quantify, it was important to highlight. Though all participants expressed negative emotions in relation to collaboration in computer science classrooms, particularly in group projects, four students directly defined their experience as not fitting in and being on the outside of the peer experience. They exhibited signs of stereotype threat, and even articulated as much. Though the study methods limit what could be known from the faculty and peer perspective, all of the participants recognized that their experiences were not the same as that of peers because of their gender.

Chapter 5: Summary of Findings, Results and Interpretations

Introduction

Much has been written about the dearth of women who take up the study of computer science. A review of literature confirms a significant effort has been expended in attempting to explain the phenomenon of why women are not attracted to a discipline that, despite efforts to integration, is still dominated by men. Additionally, there have been studies conducted that attempt to answer the question of why the few women who do select a STEM area of study, such as computer science, fail to persist in it.

This study has attempted to explore the problem of women's selection and participation from a different angle. Despite the statistics, there are women who select and persist in computer science. These women have met and overcome the roadblocks and hurdles that are inherent in being an unrepresented class, a minority if you will, in a challenging, technical, and male-dominated discipline. This study has attempted to give voice to a few of these women.

Conclusions

As mentioned above, this study focused on the experiences and perceptions of women concerning their selection and persistence in a university level computer science major. The first research question embodied an important focus of the study: what are the experiences that lead women to choose a computer science major? Understanding the experiences of why the participants of this study first chose computer science helped to frame the phenomenon of their persistence in the program. Even though the participants came from diverse backgrounds, there were some shared experiences as they made the improbable choice to study computer science. Understanding the similarities, and more importantly, what set these participants apart from the women in other studies is important as these same factors may affect future experiences of women who select and attempt to persist in computer science and in other STEM areas of study.

Research questions two, three and four represented the core of the study. These questions attempt to ascertain the intrinsic motivations of the participants to remain in school and to persist in the study of computer science, and to identify the shared activities, programs and practices within their academic experiences that are biased toward the male gender.

Research Question 1:

"What are the experiences that lead female students to choose a computer science major?"

As noted in the preceding sections, several significant pre-college themes have emerged from this study that do not fully conform with many of the observations identified in the review of literature. The first finding concerns the influence of parents. Of the seven participants, only Mary and Kimberley had parents who attended college. This is significant, as there are several studies in the review of literature that suggest that having highly educated parents is the main predictor in the decision for women to select a technical field of study, such as computer science or engineering (Hill, Corbett & Rose, 2010; Margolis & Fisher, 2003; Ware, Steckler & Leseman,1985; Anderson & Minke, 2007). From these and other studies, a common assumption has been made that highly educated parents are more likely to be early adopters of technology, and are able to afford computers and other computing devices for their children (Baruch and Nagy, 1977). While this is a common theme that is supported in the review of literature, the findings of this study suggest that it is not indicative of all students, especially students who come from lower income households.

This segues into another theme that was identified by the literature review as another predictor of women's selection of computer science as a major. This is the development of an early love of computing technology fostered by access to a computer in the home (Margolis, Fisher & Miller, 2000). In this area, the findings of this study are mixed. Four of the study participants, Mary, Nancy, Kimberly and Melissa did have access to a home computer. But three participants, LaTosha, Pam, and Deena, did not have home computer access.

Another pre-college character that emerged from the participant interviews is that none of the participants reported any programming experience until they enrolled in college computer science courses. Again, this theme is a departure from the findings of several studies in which participation in entry-level technology courses in high schools was found to foster and encourage the participants' interest in technology (Sanders & Nelson, 2004; Schofield, 1995). While not considered course level instruction, four of the participants, Pam, Melissa, Mary and Deena did have pre-college work and military on the job training, and did have experience in the use computers.

The response to the participant's decision to study computer science was generally positive within their family and community; though support was limited, and did not extend beyond verbal affirmations. The reasoning for this appears to be because participant families and peer groups exhibited a general lack of knowledge of what computer science consists of. This nominal level of support did little to amplify the study participants' self-efficacy. Of the seven participants, only Deena reported receiving push back from family and friends.

An interesting finding of this study was the direct influence that the military had on two of the participants, Mary and Deena. Both entered the U.S. Army directly from high school, with no prior work experience. Both participants were given an aptitude test and then assigned to a technical military occupational specialty (MOS).

Both Mary and Deena reported that while their assigned technical jobs were demanding, they enjoyed the challenge of learning new technology. These women showed perseverance, and received recognition by their peers and commanding officers. This was influential in their development of positive self-efficacy and motivation to succeed. These two participants reported that their military experiences were a positive influencer for both their decision to enter college and their choice of college majors.

I feel this finding exposed a gap in current research. The review of literature revealed there has been little attention paid to the impact military training has on women's selection of computer science as a field of study or as a profession. In the case of these two participants, we have a situation where they were tested for aptitude, and from the results of these tests, they were assigned a technical computing position. Importantly, both Mary and Deena report these were gender-neutral jobs. They were given training and support equal to that of the men, and they excelled. The positive outcome of this finding suggests there is a need for further research.

Research Question 2:

"What are the factors and experiences that influence female students to persist in the study of computer science?"

The participants in this study came from different geographic regions of the country, and their age range spanned almost forty years. This is a diverse group. Their path though the selection process and into a university level computer science major is as diverse as their backgrounds. Because of this diversity, not all of their selection experiences were in alignment with the findings of current research. However, once enrolled, the experiences and perceptions of the participants were similar in many ways, and supported by the results of other studies.

The literature review suggests that women who do not fit the typical image of a computer science student often experience exclusion, lack of peer support and stereotype threat in and out of the classroom. This study supports these findings. All of the participants report feelings of isolation and exclusion. All of the participants reported experiencing stereotype threat to some degree.

What sets the participants of this study apart from many female students who do not persist is that none of these experiences were enough to overcome their strong self-efficacy and motivation, and their desire to succeed. To date, all seven of the participants are still enrolled in their major of choice, which is computer science. All participants, despite the challenges highlighted in the previous section, are successfully moving forward toward achieving their educational goals.

This study found that a high level of positive self-efficacy and motivation are the determining factors in the persistence of the seven participates in their computer science programs.

Research Question 3:

"Are there factors that are related to the discipline of computer science that discourages female students from participating in the study of computer science?"

This study supports the findings of current research that while progress has been made, society in general still tends to stereotype females into weak, dependent roles, and there are gender stereotypes associated with computer science. This gender stereotyping was experienced by all of the students in this study, which confirms that it is still an issue, and it starts early. In summing up her feelings on gender stereotypes in computer science one participate stated:

> I think it just has to do with how men see gadgets in their lives. That, you know, women when they get a new gadget, they tell their husbands to take care of it. They get a new DVD or telephone, they have their husbands take care of it and set

> it up. Women were taught to take care of the family, and men to take care of everything else.

When asked if she believes that computer science stereotypes are still around, Mary sums it up with this example:

> Yes. I don't even have to think about that. If my husband were to say, I am going into computer engineering, they would be like, oh, that is really cool. That is interesting, versus for me, oh, isn't that is kind of hard? (laugh).

The results of this study suggest that stereotypes, and the threat they produce are a significant factor for women in both the decision to select, and in the persistence of computer science education. The lack of support and collaboration with male peers is directly traceable to effects of stereotypes, and stereotype threat, and the isolation that these female students experience as a minority class in computer science.

Research Question 4:

"Are there gender related feelings, observations, traits, or experiences which female computer science computer science majors share?"

The majority of participants shared characteristics that were ideal for college students to possess: internal motivation and desire for high academic achievement. Though several of the participants were first-generation college students, they were motivated to enter college and complete a degree. These characteristics of high motivation and self-efficacy are what have enabled these seven students to overcome many of the negative aspects of being part of an underrepresented population in computer science.

As far as shared experiences that could be termed negative, all of the participants held common feelings of isolation and exclusion. This is one of the overriding themes of this study. All of the participants repeatedly expressed feelings of exclusion. All participants were well aware of their gender minority status. Everyone one of the participants shared the desire to meet, collaborate and share experiences with other female students, but because of the low numbers of female students in their classes, this was not often possible. These feelings and desires have been noted in other studies identified in literature (Margolis, Fisher & Miller, 2000; Hill, Corbett, & St. Rose, 2010; Lagesen, 2007). Additionally, all of the participants commented on the dearth of female role models and female instructors, which caused further feelings of isolation. Mary sums this up well:

> Not enough women in the classroom. Women feel more comfortable with women. And if they see an instructor that is a woman. That can boost the ego, even if that is the only female in the room. That is what pushed me on is that I have seen other women teachers, teaching in the field. Not only that, but in the military, when we had to take classes for certification, some of the instructors were women.

The lack of female instructors and women role models has also been noted by women in other studies (Cotner, Ballen, Brooks & Moore, 2011; Young, Rudman, Buettner, & McLean, 2013).

Chapter 6: Summary

Statistical analysis of data can provide powerful insights into behavioral patterns, with varying levels of confidence. However, statistical analysis cannot always explain individual behavior, and there is always the concern of conflating correlation with causation with statistical studies. With this in mind, I selected the Interpretive Phenomenological Analysis as the form of qualitative analysis for this study. This was done with the aim to explore the experiences of the individual participant and what meaning these experiences hold with regards to the selection and persistence in a university level computer science major.

With regards to the scope of this study, seven participants are not likely to report experiences that are completely generalizable to all female students. Nor should the three western universities that the participants were chosen from be considered representative of the academic environment of other regions in the United States. These limitations need to be taken into consideration when reviewing the results and implications of this study. However, it is felt that research on this specific and limited population was counterbalanced by the richness of the data taken from the personal narratives.

The conclusions of this research show definitive patterns of high self-efficacy and motivation among the participants that has been further enhanced by their academic achievement and persistence. Yet a lack of a correlation between several factors identified in the review of literature and the narratives of the students of this study should give pause. Again, the limited pool of participants in this study preclude any far reaching conclusions, but that was not the goal. The goal was to give voice to female students of computer science. All of the participants of this study are successful students. They are students who have encountered and dealt with the hurdles and roadblocks common to any underrepresented demographic. The experiences and observations of these women can be used as a guide to further research, including a focus on the gap in current scholarship pertaining to military experience that this study has exposed.

Perhaps more importantly, the lessons that can be taken from these students could be of value to women who are contemplating a technical career in computer science. In this regard, I will let the women of this study speak for themselves.

Here is advice from LaTosha:

> You have to really, really know this is what you want, first of all. Because that is going to be your drive, that is going to be your motivation. That is going to be your determination and that is going to help you in the times that you think you might want to give up. You have to have a purpose behind it. You have to have a "why" you really want to do it. And you have to take that "why" and make it your success key. So that you know that at the end of the day this is what your goal is. This is what has helped me out.

LaTosha continues with:

> You have to put your emotions aside and sometimes you have to sacrifice more than just a little time. You might have to give up some time with the kids, you have to give up going out with your friends, you have to keep going to get your nails done or getting your hair done or all of that stuff. Because you have to make sure your priority is that making sure you succeed in your studies. Because honestly, if you slack just the slightest bit, you are going to have to work ten times harder to catch up than you would if you just going with the flow and just stay on a time management schedule. Stay persistent and consistent with what you are doing and don't give up.

Words from Nancy:

> Keep it up and work hard. I really can't stress this more. You need to be determined and you have to work hard. It is not something that is not easy and it takes time and a lot of practice to learn it.

From Pam:

> If this is your dream, then go for it. Even if you are a very non-traditional student like me. You need to follow your dream and to keep on working toward it.

Pam's advice for dealing with male peers:

> I think that a woman has to be able to not take things personally. Some men, and this varies, will try to try to make you fail. They will keep picking at you, and you have to overcome that. You have to put your blinders on and not see the gender bias.

And her general advice to women who are looking at computer science as a possible academic major:

> I would tell them to keep going, to do it. That they will love it. I would just tell them to not worry, but to focus on what they love to do. And that the more they get into it, the more interesting and the more rewarding it is.

These are the observations from Melissa that she would like to pass on to women who might be hesitant to enter a computer science program:

> Do not be scared of [men] them. Because I think part of the reason that most women don't what to go into a computer field is because when you go to the school and you go into the computer lab where they are teaching the classes it is all male. Everyone in there is male…..don't be discouraged because everyone stresses out about school or whether they are doing the right thing. If this is what

> you enjoy, and if computer science or computer engineering is what you want to do in your life, then do it. Don't let anybody else tell you otherwise.

Advice that Deena would like to pass on:

> You have to be a self-disciplined person to not only have to keep your skills up to date, but to have the drive to go a step further and to think about how you can improve upon this technology yourself. You have to have a willingness to want to help others and work as a team, and not be just an individual to shine on your own. Because, technology, especially when it comes to programming and projects, you have to be a complete team player. I would tell them to take a good look at what all the different technologies offer and make a decision how their life is going and what direction they would like to go, and to make sure whether they have a good support system, a foundation, to be able to give them a boost when things start to get a little rough for them. Because there is one thing that I have learned working in technology, if it is not your thing, then it is not going to be good for you. It is going to test you.

Further research

This research represented an attempt to have a conversation with a group of female students, a conversation about their success in selection and persistence in computer science. It is my hope that this study will help to ultimately improve the experiences of all women who seek to study computer science and who share commonalities with this group. Specifically, female students from all ethnic backgrounds and ages, who might not fit the normal demographic for college-bound students.

While it might seem odd to recommend any courses of action based on a sample size of only seven participants, there were nonetheless a few things, specific to these women's particular experiences that do seem worth exploring. Many of these women were older when they began their academic journey. Most had worked for several years before they enrolled in college. Because of this, their experiences, both in the selection of and persistence in computer science, differ from many of the studies identified in the review of literature. An example of this is that of mentorship. As discussed in the literature review, many studies have observed links between women's persistence in STEM majors and presence of a female mentor. Several studies identified mentorship as a predictor of persistence. However, for the participants in this study, mentoring did not overall seem particularly relevant. One possible reason for this is that the women who participated in this study were not typical students. They were older and had professional work experience, which served to build positive self-efficacy prior to entering college. This might have somewhat offset the perceived need for a mentor.

In recent years, the percentage increase in the number of students age 25 and over who enrolled in degree-granting institutions has increased to about one third of the total college population (Newbaker, 2012). The participants in this study reflect this fact. Even though many of these women are older, they are no less committed to academic excellence. It is hoped that this study will serve to emphasize the importance for researchers to include, or at least be aware of these demographics in future studies.

Much discussion has been given to the role that the military, more particularly, the United States Army, played in the development of a positive self-efficacy toward technology and computer science education for two of the study participants. As noted in a previous section of this study, both participants received computer training and both reported that this training, and their military experiences, were a positive influencer for both their decision to enter college and their choice of college majors. Because of positive experiences reported by participants of this study, it is a recommendation of the author that the influences of military service on women's career selection and preparation is a topic that should be considered for further research.

Closing Thoughts

The women in this study were very open to talking about their experiences. Even though I was a relative stranger, they were willing to speak with me about their thoughts, perspectives and to share their observations. I feel that I was able to connect with them on a technical and academic level because of my background as a working professional in software development. All of the participants were very interested in seeing the results of this research, which indicated to me their desire to see positive change with regards to women's selection and persistence the area of their study. These women believed that attracting more women into computer science would drive any change, and they felt by participation in this study, they were being part of this process.

One of the central themes that emerged from this study is that all of the participants were highly motivated, even in the face of potentially troublesome situations. All were aware of their minority status and all had experienced the effects of gender stereotypes. They took this in stride and did not allow it to affect their self-efficacy. This, I believe is the key to their success.

The dearth of women in computer science and related STEM fields is an ongoing problem. Qualitative research, such as this study, can help us to understand on an individual basis not only what is going wrong, but also, what is going right. Success stories, such as the ones identified here, can then act as motivators for future generations of women. If women see that others before them were successful, then that task no longer seems quite so daunting.

This study detailed the stories of seven women who made the study of computer science work for them. In so doing, these women illustrated that women from non-technical families, who had little exposure to computers and technology before college, can be successful in a university level computer science program. Thus, it is my hope for this study that it might be considered interesting, informative, and useful to anyone, both male or female, who might be contemplating attending college and entering the study of computer science.

It is my personal opinion, one that has been formed over twenty-five years of working in and teaching computer technology, that the study of computer science can be an equalizer, a shared language that connects people, as opposed to something that segregates them. It is my hope that this effort moves us a little closer to that goal.

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Appendix A

Call for Participants

Are you female college student who is studying Computer Science?

Consider taking part in this study!

A study is being conducted as part of a doctoral thesis at Northeastern University of Lynn Thackeray, to gain insight into what it is like to be women in a largely male dominated field of study.

In order to participate, individuals must be female and be currently enrolled in a 4-year post-secondary college or university in the study of Computer Science or closely related field and have successfully have completed two semesters or four quarters (one academic year) in a Computer Science or Computing Technology field of study. All qualified individuals are encouraged to apply, regardless of race, ethnicity, class, religion, (dis)ability, or national origin.

The study consists of one in-depth interview, which may be conducted either by phone, Skype®, or in person. This interview focuses on the participant's life history and present day experience in relation to the topic (approximately 30-60 minutes). During this interview the participant will be encourages to reflect upon experiences and factors that contributed to the selection of Computer Science as a field of study, and any factors or experiences that have supported or discouraged persistence in the study of Computer Science.

If you or someone you know would like to participate in this study or learn more, please email thackeray.1@husky.neu.edu, or call 801-310-4558. Selection for the study will be determined during a brief 5-10 minute intake call. Participation is entirely voluntary.

Confidentiality is a high priority in this study, and participants' names, or the name of their school will not be shared with others or used in the published results.

This study is conducted by Lynn Thackeray, an EdD doctoral candidate at Northeastern University.

Appendix B

Interview Intake Call Form

Intake Call Protocol

Institution: *Northeastern University; 360 Huntington Avenue; Boston, Massachusetts 02115*

Interviewee:

Interviewer: *Lynn Thackeray* Date:

Location of Interview:

****

Thank you for calling and expressing interest in this study. My name is Lynn Thackeray, and I am a doctoral student at Northeastern University. This research is being conducted as my doctoral thesis project. The purpose of the study is to explore the experiences of a women who is studying in a computer science program at the university level, and to identify and explore the common factors and experiences that contribute to women's selection and persistence in field of study that traditionally a male dominated academic major.

As the Student Researcher, I am also the person who will be conducting the interviews as well as the intake calls, like the one we are doing right now.

Today, I'd like to ask you just a few criteria-based questions, to determine if you qualify as a participant, and if so, I'll give you a more detailed explanation as to the scope of this project. At that point, if you're interested in proceeding, we can talk about setting up the interview time. Sound good?

- *Are you female?*
- *Are you a currently enrolled college student enrolled in a Computer Science or Computing Technology major?*

- *Have successfully completed two semesters or four quarters (one academic year) in a Computer Science or Computing Technology field of study.*
- *Are you committed to completing your technical degree and graduating with a Bachelor's of Science degree?*

Thank you. I'm happy to say that you meet all of the criteria in regards to participation in this study. Now I would like to tell you a bit more about the scope of this project.

This is a phenomenological study. The main question being asked is: "What are the common factors and experiences that contribute to women's selection and persistence in computer science as an academic major?"

This study will consist of one in-depth interview lasting between 30 and 60 minutes. I will be asking follow-up questions concerning your background and the decision making process that you used to make your selection of computer science as a field of study. I will also be asking questions concerning your experience as a computer science major and will be encouraging you to expound on experiences, both positive and negative, that have impacted your decision to persist in the study of computer science.

That is a very brief overview of the study. Do you have any questions in regards to the research itself?

With that said, are you interesting in proceeding as a participant in this study?

Thank you for your interest. What I'd like to do now is set up a time for us to do interview. Considering your location, I think it is best that we do it (by phone, Skype® or Zoom® , in person)—do you agree?

I will email you an electronic copy of Consent Form, which tells you a bit more about the study and answers some common questions people often have in regards to research. I ask that you *please read it over before the interview. If you have any questions or concerns, you are of course free to contact me. We will go over the Consent Form together at the beginning of the interview call, giving you another chance to ask any questions. If you then decide to continue with the interview, you will just have to give verbal consent at that time.*

Thank you. Before we wrap up this call, I'd just like to ask you to consider if you know of any other college students who also might meet the criteria for this study, and be interested in participating? If so, I would definitely appreciate it if you tell them about this study, and give them my contact information should they wish to participate.

I look forward to our first interview on _______. I will call you at this time.

I look forward to our conversation, have a good day!

Appendix C

Consent Form

Northeastern University, Department of Education in the College of Professional Studies.

Name of Investigator(s): Dr. Kristal Clemons (Principal Investigator), Lynn Thackeray (Student Researcher)

Title of Project: Women in Computer Science: An Interpretative Phenomenological Analysis that Explores Common Factors that Contribute to Women's Selection and Persistence in Computer Science as an Academic Major.

Request to Participate in Research

We would like to invite you to take part in a research project. The purpose of this research is to The purpose of this research is to explore the common factors and experiences that contribute to women's selection and persistence in computer science as a post-secondary academic major, which is a traditionally male dominated field of study. The main question being asked is: "What are the common factors and experiences that contribute to women's selection and persistence in computer science as an academic major?"

You must be at least 18 years old to be in this research project.

The study will take place at on-line using either Skype® or Zoom® and will take about 30 to 60 minutes. If you decide to take part in this study, we will ask you questions concerning your background and the decision making process that you used to make your selection of computer science as a field of study. There also be asking questions concerning your experience as a computer science major and we will be encouraging you to expound on experiences, both positive and negative, that have impacted your decision to persist in the study of computer science.

The possible risks or discomforts of the study are minimal. You may feel a little uncomfortable answering personal questions.

There are no direct benefits to you for participating in the study. However, your answers may help us to learn more about the experiences associated with being a female Computer Science college student.

Your part in this study will be handled in a confidential manner. Only the researchers will know that you participated in this study. Any reports or publications based on this research will use only group data and will not identify you or any individual as being of this project.

The decision to participate in this research project is up to you. You do not have to participate and you can refuse to answer any question. Even if you begin the study, you may withdraw at any time.

You will not be paid for your participation in this study.

If you have any questions about this study, please feel free to call Lynn Thackeray at 801-310-4558, or by email thackeray.l@husky.neu.edu, who is the person mainly responsible for the research. You can also contact Kristal Moore Clemons at 617-373-2400 or by email k.clemons@neu.edu, who is the Principal Investigator.

If you have any questions about your rights in this research, you may contact Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: n.regina@neu.edu. You may call anonymously if you wish.

You may keep this form for yourself.

Thank you.

Lynn Roy Thackeray

Appendix D

Interview Protocol Form

Interview Protocol

Institution: *Northeastern University; 360 Huntington Avenue; Boston, Massachusetts 02115*

Interviewee:

Interviewer: *Lynn Thackeray* Date:

Location of Interview:

****

Introductory Protocol

You have been selected to speak with me today because you have been identified as someone who has a great deal to share about the experience of being a college student.

This research project focuses on the experience of female college students who have chosen computer science as a program of study.

Through this study, we hope to gain more insights into the experiences and factors that contributed to your selection of computer science as a program of study, and the experiences, both positive and negative, that you have experienced as a computer science student that has affected your desire to persist in the program.

Because your responses are important and I want to make sure to capture everything you say, I would like to audio record our conversation today. This audio recording will be kept in a secure location and I will be the only person that will have access it. The audio files will be destroyed within two weeks after I have transcribed it. I can assure you that all responses will be *confidential and your name along with your school and any place names will be replaced by pseudonyms. Only your pseudonym will be attached to the transcript.*

As a requirement of this research project, I must have your stated consent to participate in this study. As a reminder, you can withdraw from the study at any time. At this time, I am inviting you to ask any unanswered questions. Do you agree to participate? I would like to begin recording this session now, is that alright with you? OK, the audio recording has begun.

(Turn on the video and audio recorder, read the formal consent statement and verbal consent). Thank you for your participation.

Interview Introduction

As mentioned, the intent of this study seeks to explore the experiences of women who have selected computer science as their college major and have persisted in a computer science program over a year. The approach that I will be taking with this qualitative study will be to first explore each participant's background and experiences prior to college. Then to examine the participants current experiences in college, and finally to ask participants to reflect upon the meanings of their experiences.

I have prepared some introductory questions to start out conversation. Are you ready to begin?

Interview Questions

General Background

- *Did your parents or other close family members attend college?*
- *Do you have anyone in your family who uses a computer as part of their employment?*

- *Did you grow up with a computer in the house?*
- *If so, who used the computer the most?*
- *Did you have your own computer or access to a computer at home, school, or work?*
- *In High School, did you have access to computers at the same level as the boys did?*

Interest in Computer Science

- *When and how did you first get interested in computers and computing?*
- *Did you have the opportunity to learn programming skills before college?*
- *Who was most influential in your decision to major in Computer Science or a computing discipline?*
- *Are you acquainted with anyone who is a computer programmer or works in the high tech industry?*
- *Why did you decide to go to college?*
- *At what point did you decide on a Computing program?*

Experiences and Thoughts on the Computer Science Major

- *How does being a Computer Science major compare to your expectations of what you thought it was going to be like?*

- *What part or parts of your Computer Science program were the most memorable? Why?*
- *Do you know other women who have graduated in Computer Science and are working in industry?*
- *What interests you most about Computer Science?*
- *What interests you least about Computer Science?*
- *Are you a member of any professional technical organizations or computer clubs?*
- *Are you a member of any campus or professional women's organizations?*
- *How would you describe the atmosphere in the Computer Science department now?*
- *Has your interest in Computer Science changed over the course of your studies?*
- *What skills do you think are necessary to be a successful Computer Science student?*
- *What is the best thing about this major?*
- *What is the worst thing?*
- *What were some of the concerns you had when you were deciding on a Computer Science major?*
- *What do you feel is the percentage of the Computer Science faculty that is female?*
- *What would you change about the Computer Science major if you could?*
- *Have you ever thought about switching majors?*
- *Have you ever felt discouraged?*
- *If so who did you talk to or how did you handle it?*
- *Have you felt any problems with mixing Computer Science and school with the rest of your life?*
- *Why do you think that you have been successful in Computer Science?*

- *Are you planning on working in the High Technology industry upon graduation?*

Gender and Computer Science

- *Do you have a mentor or someone you look up to who in in the Computer Science industry?*
- *Have you met or are you aware of successful women who are in Computer Science or a High Technology field of study or profession.*
- *What do you think is the men to women overall ratio in Computer Science at the school you attend?*
- *Are you treated differently by faculty or students because of your gender?*
- *Do you think your school should make any further efforts to attract and retain more women in Computer Science?*
- *Research shows that more women than men drop out of Computer Science. In your opinion, why do you think this is so?*
- *Are you aware that there are very few women in Computer Science generally?*
- *Why do you think this is?*
- *Have you experienced any problems in your program because you are a woman?*
- *Have you experienced any advantages because you are a woman?*
- *Do you feel that you have been treated differently because you are a woman?*
- *What is your advice to new students?*
- *Would this advice be different depending on whether the new student was male or female?*

- *Have you changed since enrolling in college?*
- *Is there anything we haven't discussed that you would like to add? Anything about life in Computer Science that we should know about?*
- *Can you say a few words on computer science stereotypes?*