Women's Persistence in Computer Science:

A Longitudinal Qualitative Study

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A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2014

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Education

University of Washington

Abstract

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This study examined the factors underlying women's persistence in computer science. Fifteen women who received a computer science bachelor's degree from a major research university in the Pacific Northwest were longitudinally studied using a qualitative study format. The study design consisted of a series of interviews and observations during the women's senior year of college and a career interview four to five years later. The effects of sponsorship and stereotype threat on the participants' initial decision to study computer science and their experiences as computer science majors were explored, as well as the ways in which these women's undergraduate experiences influenced their post-college career pathways. The results indicate that sponsorship had a significant positive impact on the women's initial matriculation in the computer science major and that stereotype threat was prevalent but not a deterrent to the women's study of computer science, at times even acting as a motivating force. The women

often encountered issues with self-confidence in college and in the workplace; personal motivation, conversely, helped them to persist, both in college and in the workplace. When they embarked on computer science-related careers, the women frequently contended with gendered expectations of behavior in the workplace, in both academic and corporate settings. Understanding women's experiences with computer science, both in college and in their subsequent careers, can help us appreciate why and how women succeed in the field of computer science, which in turn can help to inform both women interested in computer science majors and/or careers and those interested in helping them achieve these goals.

Dedication

For my family, my doctoral committee, and all the women in computer science without whom this research would not have been possible.

Acknowledgements

Many thanks to my dissertation chair, Dr. Stephen T. Kerr. Without his encouragement and support over the last few months and years, not to mention his extremely helpful reviews of chapter drafts, this dissertation would not have been possible.

Thanks to my doctoral reading committee, Dr. Angela B. Ginorio and Dr. Elham Kazemi. Their feedback was valuable in ways that I didn't even know was relevant when I began this project. Thanks also to my final doctoral committee member, Dr. Ed Lazowska, whose interest in the topic of women in computer science was invaluable to this work.

Thanks to our babysitter, Nadia Aldossary, for her time and her flexibility.

Thanks to my family, near and far, without whose support and love I could never have completed this dissertation.

Finally, thanks to the women who took time out of their busy lives to share their stories of perseverance. This study would not exist without them.

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Chapter 1: Introduction

A search conducted on Amazon (www.amazon.com) in November 2013 for the terms "women computer science" yielded as its first result a book titled *Computer Science Made Simple: Learn how hardware and software work – and how to make them work for you!* (Spraul, 2010). This unfortunate result has since been fixed; a search in May 2014 using the same terms yielded a first hit of a book about ingenious inventions by women. The underlying problem is undeniable, though. The search results on Amazon are not created in a vacuum; they likely stem from a confluence of factors including previous searches, the keywords with which publishers tag their books, and correlations between searches and purchases.

Computer science (CS) is an intellectually stimulating and challenging field. It affects many different aspects of life, and creates much of the technology that we have grown accustomed to using on a daily basis. At the National Center for Women and Information Technology (NCWIT) Summit in May 2014, Farnam Jahanian of the National Science Foundation's (NSF) spoke of how advances in computing technology have "transformed the way we live, the way we work, play, learn, communicate." Yet in the United States, this field is still male-dominated, which means that only slightly more than half of the perspectives in the U.S. are being adequately represented in this "pervasive intellectual fabric that connects all other disciplines" (ibid). We as a society are lacking the "diverse perspectives and solutions" (ibid) that an inclusive culture of computing could offer.

The underrepresentation of women in computer science is a systemic problem in the United States, both in college and in the workforce. Every article about women in CS will happily tell you the statistics, and they are indeed somewhat alarming. In the year 2010, women comprised 50.8% of the population of the United States (United States Census, 2011), yet in the

year 2010, women only received 18% of the bachelor's degrees that were conferred in computer science (National Science Foundation [NSF], 2012). This number is not continually growing, either. Women's attainment of undergraduate degrees in computer science peaked in 1985, when they received 36.9% of the degrees awarded that year (NSF, 2006). 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 jobs – 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 systems administration – were held by women.

So what is going on? What is causing this gender gap? Academics, corporations, non-profits, and even newspaper reporters have been continually investigating this issue since the early 1990s, and several different problems precluding women's interest in computer science have been identified. These factors include such things as negative stereotypes about women's abilities, a culture of exclusion, a link (specifically for women) between self-esteem and low grades, and even a desire for a more gender-balanced workplace.

Yet despite the plethora of problems, some women do persist in computer science. I propose that we learn from them. This is not to say that the aforementioned concerns are irrelevant. Indeed, they are extremely relevant, because they are issues that even those women who persist in CS will and do encounter. However, I am interested in understanding the factors that cause women to persist despite – and in some cases, as my research shows, even because of – these problems.

My research focuses on women's experiences as computer science majors and their subsequent experiences after college. My goal is to understand both the factors that initially triggered women's interest in CS and the factors that kept them interested in CS. Because I feel

that my participants' own experiences are integral to both their persistence in their degree programs and their subsequent career choices, I used qualitative methods "to gain an in-depth understanding of the situation and meaning for those involved" (Merriam, 1998, p.19).

The study I conducted focuses specifically on a small sample of women (n=15) who graduated with computer science degrees from a prestigious four-year undergraduate program between the years of 2007 and 2009. It is a qualitative study, with data collection methods consisting of interviews and observations, so as to understand these women's experiences at a personal level. The women were interviewed during their junior or senior years of college, when they had achieved senior status by matriculating in 400-level CS courses, and then were interviewed again four to five years later, in 2011 and 2012. This study analyzed the personal qualities and past experiences of these women; their experiences as CS majors, including any challenges that they felt they overcame as women in the field; and their career pathways post-college, including the factors that directed them toward their current careers. Additionally, for the undergraduate portion of the study, observations of CS classes were conducted and the faculty members teaching those classes were interviewed.

Based on the study design outlined above, the specific questions I sought to answer in the course of my inquiry are:

1) What are the factors and experiences that encourage women to persist and graduate with an undergraduate Computer Science and Engineering degree from a major research university?
2) In what ways – if at all – do these "successful" women use their Computer Science and Engineering degrees post-college?

3) In what ways do these women's experiences as "successful" Computer Science and Engineering majors contribute to their post-college career pathways? Do different types of undergraduate success stories lead to different career pathways?

In Chapter 2 I outline the conceptual framework that theoretically grounds my study, including identifying the factors and theories that have relevance to my chosen topic. I also make explicit my expectations and thoughts on my own research, for "any researcher … comes to fieldwork with some orienting ideas" (Miles & Huberman, 1994, p.17). I then review the literature on the field, which – given the very current and relevant nature of the topic – is an interesting amalgam of academic and popular articles. In Chapter 3 I explain my data collection strategies, including my choice of participants and methods of data analysis, and how and why these were chosen. In Chapter 4 I report on the data that I gathered, and in Chapter 5 I discuss what we can learn from this data. Finally, Chapter 6 offers conclusions and suggestions for future research, as well as some recommendations for college and university computer science departments that might help to encourage women in the field. In exploring the above research questions, I hope to contribute in a positive way to the growing body of literature surrounding women's experiences – and their stories of perseverance – in undergraduate CS programs, as well as the literature surrounding female CS majors' career choices.

Our appreciation of how to recruit and sustain women in computer science can benefit from a developed understanding of the experiences of women who *do* succeed in this field in one or more ways. Studying the experiences of women who have successfully navigated a CS major at a nationally renowned university and their subsequent career progressions, as well as how they relate to the CS field and to their undergraduate CS experiences, contributes to our understanding of successful women in the CS field overall. This in turn enables us to draw conclusions about

what helps women succeed in this field, and allows us to better understand the connections between graduating with a CS degree and the subsequent possible career pathways. In so doing, we may inform both future women who are interested in pursuing a major and potentially a career in CS and the people who are interested in helping them achieve this goal.

Chapter 2: Literature

In this chapter I briefly discuss the general purpose of my study. I go on to outline the conceptual framework I used to identify and interpret the factors underlying women's persistence in computer science (CS), both at the college level and beyond. I then elaborate on a couple of relevant academic theories that tie in to both this conceptual framework and women's persistence in CS. Following this, I review the literature on women and computer science, focusing on academic works, but also incorporating articles and publications from other realms, to fully paint a picture of the historical landscape surrounding women in CS.

Conceptual Framework

This study specifically focuses on the undergraduate and career pathways of female computer science majors who persisted and graduated with a bachelor's degree in CS. It explores the factors that initially triggered each woman's interest in computer science; each woman's academic and interpersonal experiences as an undergraduate CS major, including any perceived effect(s) of gender; and the career pathways that each woman pursued after completion of a CS degree. Given the proportion of women completing undergraduate CS degrees in the United States in recent years – approximately 20% in 2006, when I began my research, down to 18% in 2010 (National Science Foundation [NSF], 2012, the most recent year's data available from the NSF) – the participants in this study comprise a minority in their chosen major field. Additionally, since the number of women working in academic and industry computer science-related fields went down slightly, from 26.7% in 2006 (Bureau of Labor Statistics, 2006) to 26.1% in 2013 (Bureau of Labor Statistics, 2013), the participants in this study who chose to pursue a career in a computer science-related field or area after graduation also became part of a minority in their workplaces.

I come to this line of research through a personal channel. Thought I was not a CS major in college, I worked in computer support as an undergraduate, then spent over seven years after graduation working as a software tester in the technology industry. My own pathway into that line of work was influenced by my computer-related experiences in college and the people that I interacted with, both in college and beyond. When I became interested in what led women into, and prompted women to stay in, computer science as an undergraduate major and a career, I opted to conceptualize my study around the experiences these women had had that influenced these important life decisions.

Merriam-Webster (1991) defines "experience" as "the fact or state of having been affected by or gained knowledge through direct observation or participation" (p.437). Thus in a very broad sense of the word, experiences can be understood as a person's interactions with her[1] environment. The use of the word "interactions" here is key – a person is not merely a *product* of her environment; rather, she has a reciprocal relationship with her environment, which is itself constantly changing. Per Bronfenbrenner (1979),

> …the developing person is viewed not merely as a tabula rasa on which the environment makes its impact, but as a growing, dynamic entity that progressively moves into and restructures the milieu in which is resides … since the environment also exerts its influence, requiring a process of mutual accommodation, the interaction between person and environment is viewed as two-directional, that is, characterized by *reciprocity*. (p. 21)

Additionally, no two people are entirely alike. Both personality and all of our past experiences impact the way in which we interpret experiences; therefore, any given person will react slightly differently than any other person to comparable or even identical events. Thus, for example, one person who learns HTML in high school might find it interesting enough that she

[1] I purposely use the feminine pronoun in this case because my study focuses specifically on women; in general the concepts I describe would apply to all people, irrespective of gender.

is inspired to learn further programming languages, whereas another might find it boring and thus extrapolate that programming in general is not interesting to her.

Despite this disparity of interpretation and internalization, there is no doubt that certain experiences are relevant and/or important enough that they affect people's trajectories as computer science undergraduates and beyond. In some cases, these experiences might be common among many people and thus elicit similar responses. In other cases, however, the experiences themselves may be different, yet still yield a similar end result based on how they are interpreted by the individual. Take, for example, two hypothetical women who are CS majors. One of these women was encouraged (e.g., by a parent or teacher) *to* pursue computer science because it was challenging, which piqued her interest and caused her to study CS. The other woman was discouraged (e.g., by a parent or teacher) *from* pursuing computer science because it was challenging, which piqued her interest and caused her to study CS. The two women in question both chose to pursue the path that would yield intellectual stimulation and challenge; however, in one case, this chosen path was in agreement with the external influence, whereas in the other, it was in direct opposition to the external influence.[2] Based on this example, one might infer that the presence of some sort of influential individual, while by no means either a requirement or a guarantee of any given woman's interest in CS, can often have an impact on a woman's pursuit of and/or persistence in an undergraduate computer science major. (See paragraph on sponsorship below.)

Therefore, in learning about the experiences of participants, I hoped to detect common – but likely not universal – themes, both in their experiences and potentially in their reactions to those experiences. I wished to identify and understand commonalities that led each woman to

[2] Please note that this example and the one in the previous paragraph, while similar to experiences that a couple of the participants had, are not direct examples from my data.

initially become a computer science major and to pursue their chosen career pathway after graduating from college. With this in mind, I designed a study whose primary focus is to understand participant experiences in their own words, through the filter of their own personalities and life situations.

Grounding Theories

Given this focus on experiences and the interactions between an individual and her environment, several academic theories seem applicable and relevant to understanding the participants' pathways before, during, and after their tenure as undergraduate computer science majors. Two theories in particular that directly relate to this conceptual framework each focus on how people interpret experiences relating to the surrounding world and its inhabitants.

Stereotype threat (Steele, 1997) deals with the interaction between an individual and her perception of her environment. Defined as "the social-psychological threat that arises when one is in a situation or doing something for which a negative stereotype about one's group applies" (p.614), it can negatively impact people's performance in a given setting. This is particularly a problem for undergraduate female computer science majors. Such women encounter negative stereotyping both about their application to a highly competitive major (several of the study participants received comments indicating that their gender, as opposed to their ability, was what got them into the CS major) and about their innate ability to succeed in a male-dominated field: "Men who face difficulties with course work do not struggle under the additional burden of the presumption that they are somehow inferior by virtue of their gender" (Margolis, Fisher, & Miller, 2000, p.115). Since these women are likely "fearful of confirming the [negative] stereotype" (Margolis et al., p.118), understanding the participants' experiences with, and responses to, potential negative stereotypes in their environs helps inform their experiences as

computer science majors and beyond. While stereotype threat has been studied primarily in a school-based context,[3] there is no reason to believe it does not also exist in the workplace.

Sponsorship professes that someone external, with an agenda of some sort (e.g., wanting women to study computer science), attempts to influence the path or outcome of another person by their actions, and thus that a person's attainment of a particular skill is directly related to the actions or efforts of others who may have helped or hindered her learning. Brandt (1998) defines sponsors as "any agents, local or distant, concrete or abstract, who enable, support, teach, model, as well as recruit, regulate, suppress, or withhold" (p.166). While Brandt's discussion of sponsors focuses on literacy, the concept of sponsorship, and the fact that "sponsors are a tangible reminder that … learning throughout history has always required permission, sanction, assistance, coercion, or, at minimum, contact with existing trade routes" (Brandt, p.167) can be applied to practically any field or endeavor. In the context of computer science, parents, teachers, friends, classmates, coworkers and/or supervisors could have acted as sponsors; additionally, given that sponsorship is not always a positive force, these people might have swayed women *away* from CS rather than toward it. Indeed, sponsors could even have an influence on a person's response to stereotype threat. Thus understanding the effects of sponsors in the participants' lives can help to inform and clarify the experiences that led them to study and potentially work in the field of computer science.

The above framework and theories guided my data collection and initial data analysis. Since qualitative research is an iterative process, further relevant theories that are helpful in explaining the participants' undergraduate and career pathways came to light as I analyzed my data, and these are discussed in more depth in the Analysis chapter.

[3] Much of the research having to do with gender differences in computer science or other related fields has been done in school settings. Those studies that do deal with women in CS-related careers have generally not explicitly explored stereotype threat as a framing concept.

Literature Review

Surveying the literature on women in computer science presents an interesting challenge. The field of computer science is relatively new – according to Wikipedia, the earliest documented CS department was founded at Purdue University in 1962 – and many smaller universities and colleges did not begin to offer a bachelor's degree in computer science until the mid to late 1990s. Academic literature discussing women in computer science and women in computer-related fields is extremely interdisciplinary and hails from the disciplines of education, psychology, and women's studies, to name just a few. (Even some computer science departments are now starting to publish papers on the topic of women in CS, as I discuss further later.) Additionally, because the field of computer science is currently so relevant and yet so gender disparate, the topic of women in CS has been well documented in newspaper articles and popular publications for almost 20 years. In this same vein, foundations and non-profits devoted to increasing women's participation in computer-related fields have been founded, and literature which falls somewhere between academic and popular also stems from those organizations.

An added complicating factor is that much of the literature that is pertinent to understanding women's persistence in CS is not even specific to computer science. Many articles discussing women in science, technology, mathematics, and engineering (STEM) fields in general have relevance to the topic of women in CS in terms of gender balance, gender stereotypes, and grades – even though they may not even mention computer science in their text. Additionally, literature on gender socialization, self-confidence, and mentoring, as well as theories like sponsorship and stereotype threat (outlined above), can also provide information germane to understanding women's persistence in the field of computer science.

Yet a further consideration is that much of the literature that does specifically discuss women in computer science focuses on women's attrition. Many articles have been written about why women leave, how CS is an unfriendly field for women, and other such topics. Very few studies focus on persistence, as this study does. Finally, this longitudinal study of women's persistence in computer science spans both educational and career settings, another unusual occurrence in that most existing literature focuses on education *or* the workplace, and not both. (Usually the focus is on education.)

Thus, for this review of literature, I present a chronological survey of the common themes and major turning points of the literature on women in computer science. I primarily focus on academic literature on women in CS to articulate this chronology, with other relevant academic literature and popular articles being used to support or clarify points along the way. It is worth noting that because the culture of computer science departments and the technology industry is often different in the United States than in other countries, and the participants were all matriculating in a degree program in the United States (and mostly pursuing post-graduate work or school in the United States), while I do include some works from outside the U.S., my literature review is primarily focused on U.S.-based works referencing women and computer science.[4]

[4] For some interesting international articles on women and computer science please see Stepulevage and Plumeridge's (1998) U.K. study on *Women Taking Positions Within Computer Science*; Stepulevage's (2001) *Gender/Technology Relations: complicating the gender binary*, which looks at girls' identity in primary and secondary schools in the U.K. as relates to computing; Miliszewska, Barker, Henderson, and Sztendur's (2006) *The Issue of Gender Equity in Computer Science – What Students Say*, an investigation done at Victoria University in Australia to understand both male and female student perspectives on women's under-representation in CS; Rommes, Overbeek, Scholte, Engels, and DeKamp's (2007) *'I'M NOT INTERESTED IN COMPUTERS': Gender-based occupational choices of adolescents*, an analysis of Dutch students' adolescent occupational choices; Lagesen's (2007) *The Strength of Numbers*, which investigates strategies to recruit women to CS in Norway; Ruiz Ben's (2007) *Defining Expertise in Software Development While Doing Gender*, which addresses the gender gap in the German IT workforce; Vekiri and Chronaki's (2008) *Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school* and Papastergiou's (2008) *Are Computer Science and Information Technology still masculine fields? High school students' perceptions and career choices*, both of which study Greek high school students' thoughts on CS/IT; Gal-Ezer, Vilner, and Zur's (2008) *Once she*

Early Literature

Some of the earliest studies on women in computer science came out of the Massachusetts Institute of Technology (MIT). In 1983, female graduate students and research staff documented the hostile environment encountered by women in CS graduate studies and research in a paper titled *Barriers to Equality in Academia: Women in Computer Science at MIT*. Shortly thereafter, Spertus (1991) conducted a comprehensive survey of the negative influences encountered by women in this male-dominated field. She gave examples and research documenting everything from undesirable stereotypes about women's ability in STEM, to inherent biases in magazine images of computers, to sexist behavior on the part of professors and lecturers, ultimately ending with recommendations for increasing gender diversity in CS. Arguably, with this article, Spertus set the stage for all of the later research into women's underrepresentation in computer science. At the same time, Rasmussen and Håpnes (1991) were doing similar research in Norway into the ways in which the very visible "hacker culture" in CS caused women to feel excluded from the field.

This male-dominated nature of STEM fields is discussed from a philosophical standpoint by Sandra Harding (1991). In her book *Whose Science? Whose Knowledge? Thinking from Women's Lives*, she questions what place women really have in the allegedly objective realm of Western science. As she puts it, "How can women manage their lives in the context of sciences and technologies designed and directed by powerful institutions that appear to have few interests in creating social relations beneficial to anyone but those in the dominant groups?" (p.5-6).

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makes it, she's there!: a case study, an examination of women's matriculation and graduation in CS in Israel; and Othman and Latih's (2006) *Women in Computer Science: NO SHORTAGE HERE!*, Lagesen's (2008) *A Cyberfeminist Utopia?*, and Mellström's (2009) *The Intersection of Gender, Race, and Cultural Boundaries, or Why is Computer Science in Malaysia Dominated by Women?*, all three of which explore the greater gender equity in CS in Malaysia as compared to other countries.

The 1990s also saw the beginning of newspaper coverage of women and computers. A 1996 article spread in *The Sacramento Bee* titled "Women in Computing: Logged On or Left Out" (DeBare) was one of the first discussions of women's place (or lack thereof, based on numbers) in information technology fields, and identified problems that women frequently encountered in IT workplaces, such as being the only female on an otherwise all-male team. Also in 1996, Cherny and Weise's collection of essays, *Wired Women*, showcased a series of personal thoughts and perspectives of women in the field, both in undergraduate settings and in the workplace.

In 1997, Camp contributed the pipeline metaphor, still widely accepted by many people today, to the growing body of research on women in computer science. This line of reasoning suggests that with each stage of schooling and/or career, the number of women participating in computer science shrinks (Camp, 1997). Thus the number of women who study CS in high school will be higher than the number of women who receive bachelor's degrees in CS, which in turn will be higher than the number of women who pursue a career in CS, and so on.[5] Essentially the pipe may leak at any point where there are joists, or transitions from one level to the next. Logically, if these leaks can be fixed, then gender numbers will begin to equalize in the field of computer science.

The New Millennium

Given the rise of the technology industry in the late 1990s, computer science – and particularly women's participation in computer science – became a much more prevalent topic in

[5] One side effect of the pipeline metaphor is that it allows people to "pass the buck" by placing the blame for the low numbers of women in a particular discipline on attrition at previous levels. There thus becomes a smaller incentive for institutions or corporations to encourage women at their own level, because the work needed to have happened earlier in the pipeline; this perpetuates the problem, thereby creating a vicious cycle. Further problems with the pipeline metaphor are discussed in more detail later on in this section.

academic literature in the early part of the new millennium. McGrath Cohoon (2002), for example, wrote a paper whose purpose was to recommend "methods for increasing female participation in undergraduate computer science" (p.48). Within this paper, she discussed techniques for both recruiting and retaining women in CS, including outreach strategies for high school students and suggestions for university computer science departments.

At the same time as this push, though, we began to see further documented connections between masculinity and technology from different areas of academia. Dilger (2000) wrote of the cultural assumption that "Women can't handle difficulty." Postner's (2002) dissertation, which focused on the challenges faced by novice programmers in introductory computer science classes, claimed that "introductory programming courses are notoriously difficult" (p.2), later stating that we need to understand these challenges in order to "increase the number, diversity, and quality of students who enter computer science" (p.3). Adding in Wilson's (2003) discussion of the prevalent "cultural association between masculinity and technology" (p.128) prompted a further gender divide: One of the reasons that computers are the domain of men is because they are *hard*.

Concurrently, there was also a rise of opinion pieces and more scholarly work that focused on the negatives that women encounter in the field of computer science and made some abstruse recommendations for countermanding them. DePalma (2001) wrote a "Viewpoint" in the *Communications of the ACM* discussing problems with computer science as a field and hypothesizing that making it more like math – including the advice to "teach computing without microcomputers" (p.29) – would encourage more girls to matriculate in CS. Beyer, Rynes, and Haller (2004), likewise, outlined the factors that deter women from initially studying CS, and concluded that "The negative stereotype of computer scientists as asocial loners working with

machines needs to change" (p.27), suggesting that things like acknowledging women's "greater interpersonal orientation" and putting a "pleasant computer lab-cum-lounge" in CS departments would help to fix the gender problems in the field.[6] What can really be gleaned from these pieces is that while gender disparity – including specific challenges encountered by women – is easily identifiable, the solution to this problem is not.

Thus around this time began the influx of studies conducted at actual universities (often universities with very high-ranking CS departments). Irani (2003) tracked women at Stanford in the introductory CS courses to understand what made them persist or leave; she found that gender socialization, and the idea that men were somehow more "suited" to CS, was the primary reason for women's lack of persistence. Similarly, Powell's (2005) doctoral dissertation studying first-year female computer science students at the University of Pennsylvania attributed women's attrition to a lack of confidence resulting from a perception of being underprepared, a problem articulated by Wilson (2003), among others.

Margolis and Fisher's (2002) *Unlocking the Clubhouse*, a report of a medium-sized (n=100) longitudinal qualitative study at Carnegie Mellon, expanded this type of work to include both men and women. The authors, having interviewed male and female CS students over the course of four years, discussed the reasons for women's waning interest in Computer Science throughout their undergraduate years. These reasons included not feeling geeky enough and feeling like others were "doing much better with much less effort" (p.77). Tillberg and McGrath Cohoon (2005) expanded this scope in a different way. They talked to exclusively male or exclusively female focus groups of CS students (n=182) at sixteen universities with four-year

[6] The first page of this article had a photograph of a woman dressed in business attire – a blouse and skirt – with a small child of indeterminate gender perched on her lap. The woman was sitting in front of a computer but facing away from it while perusing a printed document. I found myself wondering what the corresponding photograph of a man might look like.

degree programs and asked the question, "What attracted you to the computer science major?" (p.127). They found that "positive introductions" to the field, a "perceived match" between CS requirements and their own abilities and interests, and the expectation of "rewarding careers" (p.136) were some of the primary draws. (It is worth pointing out that, just as I do in this study, Tillberg and McGrath Cohoon chose to focus on the positives of what makes people interested in CS, as opposed to the negatives of why people leave. They even addressed this in their introduction, stating that "Much of the research on this issue focuses on what deters women from entering the field of computer science. In this paper, we focus instead on what attracts students to the computer science (CS) major" (p.126).)[7]

The problems encountered by women in computer science are corroborated by analogous research done in various disciplines about women in general and – more specifically – women in STEM. Rosser (2000) observed that engineering "overall has maintained rock bottom percentages of women for decades" (p.14), and Crocker, Karpinski, Quinn, and Chase (2003) determined that poor grades have a negative effect on self-worth, particularly for women in engineering. Zeldin and Pajares (2000) examined the relationship between women's self-efficacy and their success in mathematics-related fields by interviewing women whose careers relied on extensive use of mathematics or had mathematics prerequisites. These authors concluded that women's self-efficacy was largely dependent on the opinions of important "others" in their lives. Similarly, Ginorio, Marshall, and Breckenridge (2000) analyzed transcribed interview data from 28 women scientists in a range of fields to look at the relationship between female scientists and feminism. They identified – among other things – that "changes promoted by feminists are often

[7] An interesting commonality among these studies is they all use primarily qualitative methods. This type of work lends itself to qualitative research, for "quantitative methods do not provide the opportunity for rich description through narrative" (Zeldin & Pajares, 2000, p.219). This point is discussed further in the Methods chapter of this study.

seen as foregrounding a belief about 'essential differences' against which women scientists have been fighting all of their lives" (Ginorio et al., p.290). For people trying to fit in to a traditionally hostile culture, seeming different can be undesirable.

Working toward a Solution

Despite these problems, by 2005 some concrete actions that could be taken to encourage girls and women to persist in computer science were coming to light. Mentoring, an idea that had been discussed in literature about women in the workplace for at least fifteen years (Noe, 1988; Dreher & Ash, 1990; Blake-Beard, 2001), started to gain traction as an action that could positively influence women's pursuit of STEM fields as undergraduates. Downing, Crosby, and Blake-Beard (2005), in their analysis of female science majors at three New England colleges, determined that "developmental relationships are important for women's pursuit of science" (p.424). (While mentoring does have some previously identified potential problems for women in the workplace, such as the belief that "women participate in formal mentoring programs as a remedial solution for lack of necessary competencies and skills" (Blake-Beard, p.336), arguably at this point the benefits started to outweigh the disadvantages in terms of women in STEM and more specifically women in computer science.)

People had also begun looking more closely at girls in STEM, as opposed to just women. Organizations like Techbridge were founded in the early part of the century "to expand the academic and career options for girls in science, technology, and engineering" (Techbridge, 2014). It was found that, among other things, lack of career guidance from parents could negatively impact girls' pursuit of science and technology careers: "By not providing early support for specific career interests, parents may unintentionally exclude some professions that

require considerable advanced planning and training" (Kekelis, Wepsic Ancheta, & Heber, 2005, p.104).

Around this same time, we saw works which once again focused on problems in STEM fields as regards the participation of women and minorities, such as Barker and Garvin-Doxas' (2004) identification of a "defensive climate" in computer science classrooms at a large research university. Instead of simply identifying problems, though, the commentary was becoming more prescriptive: as Singh, Allen, Scheckler, and Darlington (2007) stated, "Often, the articles made important practical recommendations for changing the field of computer science for women" (p.514). Bystydzienski and Bird (2006) advocated this change in community culture: In their published series of keynote addresses titled *Removing Barriers*, they state that it is not women that need to change, rather, "the (remaining) barriers to women's progress in academia are systemic. Thus, rather than trying to change women to fit the sciences and engineering, these fields need to be changed in order to fully embrace women" (p.4-5).

The theory of the pipeline also came under attack. Bartol and Aspray (2006) contested the metaphor that portrays a person's career as a linear progression, in which schooling is followed by advanced schooling, which is followed by entry level work, which is followed by more senior level work. They argued that in our current knowledge economy, people often pursue schooling post-college or, indeed, go back to school to change careers or further their existing career. Additionally, they pointed out that information technology (IT) workers do not always come from a computer science or other computer-related degree background – recent statistics state that there is a much larger IT workforce than there are people who have acquired related degrees (Bartol & Aspray, p.379).[8] A similar viewpoint was espoused by Jesse (2006),

[8] Many years later, Sandberg (2013), citing Pattie Sellers, corroborated these conclusions with her conception of a modern day career as a "jungle gym" (p.53).

who identifies the fundamental issue with the pipeline metaphor as one of supply and demand. The implication is that "the problem lies with a lack of supply rather than a problem of creating demand" (p.239), which allows workplaces to foist the blame onto academia and academia to blame pre-college schooling: "We simply aren't getting good enough students coming out of our high schools, middle schools, and elementary schools" (p.239-40). (Another problem with the pipeline, which comes up in my own research, has to do with people who are double majors; unless those people pursue a career directly at the intersection of their two majors, they must, by definition, "leak" from one of those fields.)

A lesser discussed topic in the literature, but still a relevant one, is that of websites and other recruitment materials. Hanks (2008) investigated "whether or not there are subtle gender cues on departmental websites." The author examined departmental websites herself, discussing representation of genders, availability of links to women's organizations, gendered terminology, and other such things. She concluded that improvements will only occur as a result of changes to the underlying departmental climate, stating that "Re-evaluating the navigation and communication styles on the website, giving females an equal voice and listing their accomplishments, and representing them appropriately … must follow genuinely valuing the work and contributions of the women in the department." Similarly, around this time the University of Washington Computer Science and Engineering (CSE) department began working to produce a web page for prospective students "with an explicit goal of breaking stereotypes about computer science and demonstrating that computer scientists 'work in a broad range of interesting fields' – everything from designing prosthetics to devising new ways to fight forest fires" (Dean, 2007). (It is worth noting that the depiction of women in recruitment materials is an area that could benefit from further analysis.)

In 2007, Singh et al. reviewed the existing literature on women in computer science, stating that the problem of women's underrepresentation in computing fields was of "critical importance" and had "serious economic, social, and ethical implications" (p.501). *The New York Times* ran an article about the steps that CS departments around the country were taking to recruit and retain women (Dean, 2007), and organizations such as the Committee on the Status of Women in Computing Research (CRA-W) continued their ongoing mission to "take positive action to increase the number of women participating in Computer Science and Engineering (CSE) research and education at all levels" (CRA-W, 2014). New organizations, such as Girls in Tech, whose focus is on the "engagement, education and empowerment of influential women in technology" (Girls in Tech, 2014) were founded the same year.

Consequently, due to the extremely current nature of the topic, researchers began to pursue smaller studies looking at girls and women in STEM and/or CS at their home institutions or schools (e.g., Weisgram & Bigler, 2007; Dentith, 2008; Mikesell & Rinard, 2010). Some of these studies had new foci and uncovered some new results, such as Weisgram & Bigler, who determined that teaching adolescent girls about gender discrimination in STEM resulted in "increases in science self-efficacy and belief in the value of science" (p.262). However, other studies, despite indicating some differences in outcome based on ethnicity (which is discussed in the *Research on Inclusion* section below), showed similar results to studies from five, ten, or even twenty years earlier in terms of topics like self-confidence, being deterred by the hacker image of the field, and grades (e.g., Spertus, 1991; Margolis & Fisher, 2002; Crocker et al., 2003).

At this point, scholars also began investigating the reasons that women might or might not choose to pursue a career in an information technology field. Rosenbloom, Ash, Dupont, and

Coder (2007) examined the role of personality and personal interests – as opposed to discrimination or differences in ability – as a means of understanding women's pursuit or non-pursuit of IT careers. They concluded that "men and women value different aspects of work, and therefore, make different career choices" (p.554). (They go on to acknowledge that because they only sampled people who were already in IT careers, they could not rule out potential discrimination earlier in the career choice process, nor could they control for potential changes in career preference based on work experiences.) Similarly, Ceci, Williams, and Barnett (2009) determined that women's preferences – "both free and constrained choices" (p.218) – and not their abilities, are what are keeping them out of science. Cheryan and Plaut (2010), in a study of undergraduate students, found that women were less likely to be interested in computer science if they perceived that the people in that field were dissimilar to themselves: "having a sense of similarity to the people in a field is an important predictor of interest in that field" (p.484). Rosson, Carroll, and Sinha (2011) focused on the roles that self-efficacy and peer social support played in undergraduate students' orientation toward computer-related careers. Their conclusion was that these two variables have an influence on each other, and that "students' beliefs about their own capacities for technical work, in combination with the support provided by their peer networks, can be predicted by student characteristics that include gender, programming background, computer playfulness, and both positive and negative CIS [computer and information sciences] stereotypes" (p.20).

Research on Inclusion

In the second half of the 2000s we start to see more studies looking at the relationship between gender and ethnicity in computer science. A few earlier studies had specifically focused on minority women in STEM, and more specifically, minority women in CS. *Access Denied*

(Campbell, Denes, & Morrison, 2000), a publication of the National Action Council for Minorities in Engineering, documented the under-representation of minorities as a whole in these fields, and illustrated with certainty that "all minority women, including Asian women, are underrepresented in SME [science, mathematics, and engineering] programs (except in the biological and life sciences)" (p.203). Similarly Lopez and Schulte (2002) determined that there was "virtually no gap between African American females and males" in terms of receipt of bachelor's degrees in CS. However, most of the studies in the early 2000s suffered from the well-documented tendency to equate white women's experiences with the experiences of all women (Roth, 2004).

Moving forward, in 2007 Varma studied the effects of the so-called "geek culture" on the presence of women from different ethnic groups in CS degree programs. Interestingly, she found that overall this culture – which in previous studies had been shown to be a problem for many women – was *not* a deterrent for minority women, largely because "certain benefits accruing from a CS/CE career – such as a social prestige and a good paying job – outweigh the stigma" (p.373). Additionally, minority women were confronted with categorization on many levels, thus "even if the ascribed master status of the geek identity threatens a minority or lower socioeconomic status woman's femininity, it is still preferable to the default master status of 'working class' or 'minority' woman" (p.373). Dentith (2008), correspondingly, determined that students who come from privileged backgrounds "are far more likely to succumb to the standards that men lay before them than they are of forging new paths of liberation for themselves and those who may follow them" (p.162). Johnson, Stone, and Phillips (2008) identified similar results to Lopez and Schulte (2002), namely that Anglo-Americans were more negatively impacted by CS stereotypes than were African Americans.

Buzzetto-More, Ukoha, and Rustagi (2010), however, concluded that underexposure to computing and programming prior to college actually did hinder the success of under-represented students in computing fields. In 2011, Ong, who had previously focused on women of color in STEM with her research on the Double Bind (Ong, Wright, Espinosa, & Orfield, 2011), specifically discussed the status of women of color in computer science in a "Viewpoint" piece for the *Communications of the ACM*. In this article she highlighted some of the unique challenges faced by women of color in CS, including a heightened sense of isolation due to double minority status (i.e., being both female and an ethnic minority)[9] and the fact that women of color more often pursue nontraditional pathways into computer science than their Caucasian counterparts.

In 2009, Klawe, Whitney, and Simard published an article assessing the changes that had occurred in female representation in CS-related careers in the preceding 15 years, as well as documenting strategies that were seen to be working to recruit and retain women. These strategies included things like mentoring, being aware of and combating unconscious biases that discouraged girls from working with computers, redesigning introductory computer science courses "to emphasize applications in areas of interest to females" (p.71), and encouraging women to attend (and helping to finance their attendance at) computing conferences. Interestingly, this article triggered a response letter arguing that all of these strategies miss the point, and that the primary motivation for doing science should be "the learning itself and the inner satisfaction and understanding knowledge delivers" (do Carmo Nicoletti, 2009, p.7). This responder felt that "Many of the 'strategies' described as successful for the recruitment and retention of women in computing are, in my view, ways of reinforcing the existing bias against

[9] Interestingly, this "double minority status" was not always the experience of women who were Asian, a phenomenon that is discussed further in subsequent chapters.

women in science" (ibid).[10] This ties back to the point made earlier, by Ginorio et al (2000), that many female scientists do not want to appear different from their male counterparts.

Shortly thereafter, Frieze, Quesenberry, Kemp, and Velázquez (2012) conducted an analysis of the CS department at Carnegie Mellon that focused on culture. They found that "women, alongside their male peers, can fit successfully into a CS environment and help shape that environment and computing culture, for the benefit of everyone, without accommodating presumed gender differences or any compromises to academic integrity" (p.423).[11]

Not Better Yet

While steps have been taken to fix gender bias and problems in STEM fields, the process is by no means complete. Farrington (2012) focused on "myth-busting" (p.107) as it relates to things like equal pay and equal opportunities for men and women, pointing out that factors like stereotype threat and gender differences in communication and positioning still negatively affect women's equality in the workplace. Similarly, Heilbronner (2013) also refuted the notion that the "gender gaps no longer exist" in STEM fields. This view is supported by a recent study conducted by Moss-Racusin, Dovidio, Brescoll, Graham, and Handelsman (2012), in which 127 biology, chemistry, and physics faculty members (both males and females) were given the resume of a person applying for a laboratory manager position. Half of them received the resume with a female name, and the other half with a male name. The male candidate received higher marks on competence and hireability, as well as more prospects of mentorship (i.e., the faculty

[10] It is worth noting that the author of this letter was from Brazil, not the United States, and as previously mentioned, countries outside the United States often have different experiences and perspectives on gender equity in computing fields.

[11] This idea of fitting into an environment while also shaping it is exemplary of the idea of transformational resistance, espoused by both Solorzano and Delgado Bernal (2001) and Brayboy (2005), which purports that students can "persevere in school as a form of resistance" while practicing "accommodation without assimilation" (Brayboy, p.196). This is discussed in further detail in the Analysis chapter.

members were more willing to mentor him) and a higher salary than the identical female candidate.

It was found that stereotypes continued to have a pervasive influence on women's pursuit or non-pursuit of a computer science major. Cheryan, Plaut, Davies, and Steele (2009) determined that women's interest in CS was boosted to the same level as men's by the absence of stereotypical visual cues, such as a *Star Trek* poster or video games. Similarly, having a short exposure (two minutes) to a male or female stereotypical role model of a computer scientist – the stereotype in this case being embodied by appearance and stated hobbies – negatively impacted women's interest in CS, promoting a "reduced sense of belonging in computer science" (Cheryan, Drury, Vichayapai, 2012, p.72). Further research in 2013 indicated that the presentation of non-stereotypical computer scientists in fabricated newspaper articles caused women to be more interested in pursuing CS than the presentation of stereotypical computer scientists, indicating once again that "recruiting efforts to draw more women into computer science would benefit from media efforts that alter how computer scientists are depicted" (Cheryan, Plaut, Handron, & Hudson, p.58). (This relates back to departmental websites, and the ways in which they can promote or not promote pervasive cultural stereotypes of computer science.)

Relevant newspaper articles also became more plentiful around this time, many of which drew on academic resources to understand the relevance of computer science, what the problems were with women in CS, and, indeed, why these problems still exist. A 2011 *New York Times* editorial by Ed Lazowska, professor of computer science at the University of Washington, discussed the need for "computational thinking" in all walks of life, stating that "there is no field with greater impact or leverage than computer science." Joanne McGrath Cohoon, a science,

technology, and society professor at the University of Virginia whose academic research is referenced previously in this literature review, talked about stereotypes and confidence and why we need to ensure that women are not continually discouraged from pursing computer science (*U.S. News & World Report*, 2012). Similarly, Margo Seltzer, a CS professor at Harvard, was interviewed for *Txchnologist* about the ways in which girls and women are unintentionally marginalized in computer-related fields and professionals (Peck, 2012). Even more recently, *The Washington Post* ran an article discussing the same phenomenon as Crocker et al.'s (2003) findings about grades, specifically citing current research being done by Peter Arcidiacono, an economics professor at Duke University, which indicates that girls and women might self-select into fields that yield higher grades (Rampell, 2014).

Current Trends

In more recent years, examples of the ways in which women's participation in CS has increased have begun to surface. In 2013, Maria Klawe, president of Harvey Mudd College (HMC), published an article discussing the steps that had been taken to increase the number of female computer science majors at HMC from 10% in 2005 to close to 50% in 2013. The strategies implemented to effect this change included making the introductory CS course more engaging, bringing female students to the Grace Hopper Celebration of Women in Computing, and providing summer research opportunities for first-year women in CS. The benefit of undergraduate research for women in general is recognized by Kim, Fann, and Misa-Escalante (2011), who determined that research experiences for undergraduates " have the potential to begin to positively influence both women and men in a way that lessens these disadvantages and promotes women's participation in CSE" (p.15).

In a similar vein, representatives from the University of Washington (Eney, Lazowska, Martin & Reges, 2013) and the National Center for Women in Information Technology (NCWIT) (DuBow, Farmer, Wu, Fredrickson, 2013) both discussed successes they had had in encouraging girls and women into the field of computer science. Similarly, the nonprofit sector began responding to this need to encourage women's participation in CS – Girls Who Code, an organization whose mission is to "inspire, educate, and equip girls with the computing skills to pursue 21st century opportunities" (Girls Who Code, 2014) and that runs summer "coding camps" for high school girls, was founded in 2012, and continues to add major cities to its outreach every year.

Furthermore, recent works have talked about women in technology from the perspectives of women in technology. Sheryl Sandberg's (2013) book, *Lean In*, written from her perspective as COO of Facebook, encourages women to "please ask yourself: What would I do if I weren't afraid? And then go do it" (p.26). Similarly, a *Techopedia* article from late 2013 interviewed women working for high-tech companies about why there are so few women working in high-tech companies (Struyk, 2013). However, these popular pieces can be problematic in both their content and their presentation. A *Washington Post* article on how women are building networks within high tech is housed in the "Style" section of the paper (Friedman, 2014), and a recent Microsoft ad campaign shows women using technology either to plan weddings or to keep their children happy (Hay Newman, 2014). Feminist scholar bell hooks (2013) commented that Sandberg's self-labeled "sort of … feminist manifesto" (p.9) "begins and ends with the notion that it's all about gender equality within the existing social system" which means that "the structures of imperialist white supremacist capitalist patriarchy need not be challenged" and went

on to critique the absence of commentary on issues of poverty, patriarchy, and race in Sandberg's work.

High-tech companies themselves are becoming more cognizant of issues surrounding women in computer science. Google recently published data making public the gender and ethnic breakdown of their workforce, stating that "being totally clear about the extent of the problem is a really important part of the solution" (Google Official Blog, 2014). Google also began to understand that an application-based promotion system actually disadvantaged women and started taking steps to correct this problem (Kang, 2014). In a similar vein, in 2014 Google published a white paper documenting a study they conducted "to identify and understand the factors that influence young women's decisions to pursue degrees in computer science" (p.2), determining that encouragement and exposure were the "leading factors influencing this critical choice" (ibid).

As can be seen throughout this review, the amount of literature surrounding women in computer science – both academic and popular – has grown immensely over the last 15 years. While in some cases this can be attributed to particular authors focusing on the topic and writing multiple works (e.g., Margolis, McGrath Cohoon, Varma, Cheryan, etc.), there are also several authors who have written single papers on the subject, or who focus on this topic from disciplines that have not traditionally studied women in CS, such as economics. I believe it is accurate to say that the main reasons for the increase in the study of women in computer science are the growing understanding of the increasing relevance and pervasiveness of computing technology in our society and the potential negative consequences if the gender gap in CS remains unclosed.

Chapter 3: Methods

In this chapter I briefly discuss the general format of my study and articulate the research questions I sought to answer. I then document the research methods used therein, including information about setting, participants, data collection methods, and strategies for data analysis.

Study Outline and Research Questions

This research study focuses specifically on 15 women who completed an undergraduate Computer Science and Engineering (CSE) degree at a major research university between 2007 and 2009. These women were included in the study based on their planned completion of a bachelor's degree in computer science (CS) or computer engineering (CE). Because CS and CE were very similar degrees, involving somewhat different class requirements for general education and science courses and only slightly different requirements for CSE courses, throughout the rest of this study I will use the term CS to refer to both CS and CE majors.[12] The study is both qualitative, consisting of interviews and observations, and longitudinal, due to the implementation of a follow-up interview four to five years after the women's original interviews.

The first part of the study is the undergraduate portion. This consists of three interviews with each woman conducted during her time as an undergraduate senior ("senior" in this case is defined as taking 400-level computer science classes; thus, the participants ran the gamut from third-year students to fifth-year students at the time of our interviews), observation of a computer science class in which each participant was enrolled at the time (in some cases, multiple participants were in the same class, so one observation counted as data for more than one participant), and an interview with the faculty member teaching that class. This series of

[12] Some examples of the differences include that CE required technical writing and a greater number of math and science courses than CS, and that CS had a foreign language requirement whereas CE did not.

interviews brought to light the personal qualities of these women. The questions focused on their backgrounds with computers, their experiences as CSE majors, including any challenges that they felt they overcame (as women and in general) and their perspectives on their computer science courses.

The second part of the study is the career portion. I followed up with the women from the undergraduate study four to five years after our original conversations, which was three to five years after their college graduations, depending on the student. (Because not everyone was in the same graduating class, and because some people took longer or shorter amounts of time in college than the typical four years, not everyone's follow-up interviews took place at the same time in their life chronology.) For the career portion of the study I was able to include data for 14 of the original 15 participants, as is discussed in further detail in the *Participants* section below. When speaking with the women at this later date, it was with the intention of understanding what they had been doing since we last spoke, what they were currently doing, and why.[13]

The specific questions I sought to answer in the course of both parts of the study are:

1) What are the factors and experiences that encourage women to persist and graduate with an undergraduate Computer Science and Engineering degree from a major research university?
2) In what ways – if at all – do these "successful" women use their Computer Science and Engineering degrees post-college?
3) In what ways do these women's experiences as "successful" Computer Science and Engineering majors contribute to their post-college career pathways? Do different types of undergraduate success stories lead to different career pathways?

[13] For the purposes of citations, the three undergraduate interviews are noted as U1, U2, and U3, and the career interview is noted as C1.

Research Design

Why Qualitative Methods?

Consider the difference between the following questions, both of which could be used to ascertain whether or not a person chose to pursue a computer science-related career after college:

(1) Please list the positions you've held since college, with job title, company name, dates worked, and a brief description of the position. (Please account for any gaps in employment.)

(2) The last time we spoke was four and a half years ago, during the spring quarter of your senior year at [university name]. You had just received a job offer from [company name]. Tell me what you've been up to since then.

While the first question could be expanded to get greater input from the person being surveyed, one of the key points of survey writing is to make sure that people don't get bored while taking a survey. To that end, questions need to be short and to the point, as well as limited in number. Additionally, the somewhat terse wording necessary to convey a need for a complete chronology might put some people on the defensive if, for example, they had been laid off or had gaps in their employment experiences. Conversely, a conversation could go on for hours, involving detailed recall of past events. The personal element of remembering when you last spoke to your participant, how long ago that was, and what was going in their life at that time can help to put a person at ease and make her more willing to speak in depth about her life and experiences. Another example:

(1) As a woman, do you feel like a minority? Y/N

(2) Women are a numerical minority in computer science, but do you *feel* like a minority?

While an answer to the former question might yield some interesting statistical information, it will not enable the researcher to understand any of the myriad things that might

come up with an answer to the second question, such as the participant's internal understanding of the word minority, or her possible belief that she feels marginalized or different for an entirely separate reason, such as ethnicity or other distinguishing physical characteristics.

This type of in-depth questioning obviously does not work for all kinds of research. For questions that are truly binary or naturally result in short answers, such as "What was your college major?" or "Do you own a house?", a quantitative survey would be more appropriate. But for a study whose purpose is to understand the factors that keep women engaged in the field of computer science, both at the undergraduate level and beyond, "quantitative methods do not provide the opportunity for rich description available through narrative" (Zeldin & Pajares, 2000, p.219).

The focus of this study is on specific people and specific aspects of the overall culture of being female and a computer scientist, as well as these same qualities in the post-college careers of the participants. The study draws comparisons between and among the women's experiences. This in turns enables identification of common themes and/or differences between and among both the women themselves and their specific experiences, based on the grounding theories identified in the previous chapter. Because of the use of qualitative methods, the study focuses on "discovery rather than confirmation" (Merriam, 1998, p.19).

Setting

The initial setting of the study was a large research university in a major metropolitan area in the Pacific Northwest. The university was classified by Carnegie (2008) as an RU/VH – Research University with very high research activity – with a majority undergraduate population. At the time the study began, the university enrolled approximately 31,000 undergraduate students and approximately 12,000 graduate and professional students. The focus within the

university was on the Computer Science and Engineering department, which is housed within the College of Engineering and offers two majors: computer science, a Bachelor of Arts degree program in the College of Arts and Sciences, and computer engineering, a Bachelor of Science degree program in the College of Engineering. At the time of the undergraduate portion of the study, this department had around 500 undergraduate majors and 300 graduate students, and graduated approximately 160 undergraduates each year, evenly distributed between the two majors.

The choice to begin research at the university level was intentional. Given this study's focus on experience, and how experience impacts outcome, initially meeting participants when they were on the verge of graduating with a CS degree enabled understanding of their experiences up to that point, as well as how those experiences might have impacted their "successful" outcome as CS majors. The CS department at this particular institution was mostly male, which also enabled the study of elective minority status; women who pursued a major in computer science or computer engineering did so knowing that they would be a numerical minority in their major field. In addition to being male-dominated, the CS department was (and still is) highly competitive, ranking in the top ten programs in the United States, and required an application process to be accepted. Thus the women in this study are exemplars of the choice to pursue a competitive field, as opposed to one that was less competitive or had no application process.

Studying undergraduate seniors specifically, as opposed to people earlier in their major track, was also a conscious choice. This facilitated a better understanding of *all* of the experiences leading up to each of these women's graduation with a CS or CE major, as well as enabling the study of persistence in a potentially challenging major. Senior-level students

evidence persistence yet still have undergraduate experiences fresh in their minds, as opposed to freshmen, whose persistence is as yet unproven, or recent graduates, whose memories could be clouded by their subsequent experiences and/or career choices.

Participants

The participants in my study are women who were senior CS majors in the first half of 2007 and the first half of 2008, respectively. Their qualification for senior status was based on having matriculated in one or more 400-level majors-only CS classes before or during the quarter in which they were recruited for the study. They were recruited to participate in the first three months of the year via the CS department; the academic advisors sent an e-mail (the preferred method of communication within the department) to all junior and senior female CS majors alerting them of the study and encouraging them to participate. If interested in learning more, each person was asked to fill out a short survey comprising name, e-mail address, and status with regards to 400-level classes (taking them/not yet taking them). The results of this survey were then communicated to me in spreadsheet form, and all of the students who fit the criteria were contacted.

The first year I conducted the study 15 women (over 50% of the senior female CS majors) replied to the survey indicating that they were interested in participating. Given the large number of responses, I was forced to limit my study to people who were already matriculating in 400-level classes, which dropped the 2007 responses from 15 to 12. Of those 12 people, 9 responded to my invitation e-mail and scheduled interviews to participate in the study. The second year I conducted the study 8 women (around 30% of the senior female CS majors) replied to the survey indicating that they were interested in participating, including one woman who had responded favorably the previous year but had not been included due to the aforementioned

restriction regarding 400-level classes. Six women, including the woman who filled out the survey both years, responded to my invitation e-mail and scheduled interviews to participate in the study.

The 15 women participating in my study are a diverse group of people. They hail from five different countries (including the U.S.) and three different U.S. states, and evidence quite significant age diversity. While most of the women were of average college senior age during the undergraduate portion of the study, some were only third-year students and some were fifth-year students. Moreover, four of the women were up to ten years older than typical college seniors for reasons such as having had families or having previously attended college (including medical school) in their home countries before moving to the United States. Seven of the participants had attended community college under a variety of circumstances, including improving their English skills or doing Running Start to get a head start on college while still in high school. Eleven of the participants were computer science majors while the other four were computer engineering majors, and nine of them were double majors with a field outside of CS/CE. (Please see Appendix A for a chart containing comparable personal details about the participants.)

These same women were contacted again approximately four and a half years after their participation in the undergraduate portion of the study. When possible, I used the contact information supplied by the participant herself. If that resulted in no answer, the CSE department's help was enlisted to obtain current contact information for the remaining participants. Contact was made with all 15 original participants via e-mail, and all 15 responded favorably to the solicitation e-mail, indicating memory of the original study and willingness to participate in the follow-up interview. The women seemed very comfortable in my presence; many of them shared personal cell phone numbers, a number of them brought me into their place

of business to conduct the interview, and one person even invited me into her home. Unfortunately, despite repeated attempts on her part to send a consent form in the mail, I never received a Human Subjects consent form from one participant, thus was only able to include career interview data for 14 of the original 15 participants.

Data Collection

Data for this study consists of undergraduate interviews with students, interviews with faculty, classroom observations, and copies of unofficial student transcripts for each student, followed by a career interview with each participant. A complete data set for the undergraduate portion includes three interviews with each student (one discussing her pre-college past, another discussing her college CS major experiences, and one discussing her class session), a copy of the student's unofficial academic transcript, a classroom observation of one of her CSE classes, and an interview with the faculty member teaching the class. In both the student and the faculty cases, the interview discussing the class occurred after the observation, so as to understand not just generalities about CS classes but specifics about the class I had observed. The career portion of the study consists of a single interview with each CS graduate approximately four and a half years after the undergraduate portion of the study.[14]

Not every participant yielded a complete set of data for the undergraduate portion of the study. Every student participated in the first two interviews, discussing background and experiences as a CS major, but only 13 of my 15 participants chose to share their academic transcripts, and the data surrounding classroom observations was variable for a number of reasons (e.g., a student not currently matriculating in any computer science classes, the class

[14] I had originally hoped to model the career study on the undergraduate portion, conducting workplace observations and interviews with the participants' supervisors and/or colleagues in addition to interviews with the participants themselves. Unfortunately, this was determined to be infeasible within the scope of this project due to issues of corporate confidentiality, so I limited the career portion of the study to an interview with each participant.

professor not wishing to have an observer in the classroom, the student being absent from class on the day of my scheduled observation, or the professor consenting to my observation but preferring not to conduct an interview, among others).

Data were collected via audio recordings and written notes. All of the interviews were digitally audio recorded, with permission of the subject, and field notes were taken to highlight significant points. The classroom observations were not audio recorded, for confidentiality reasons; rather, handwritten notes were taken. Data acquired from classroom observations were discussed with the participants (students and the corresponding faculty members) in an interview setting to help enhance understanding of what was observed in the class session. Total data at the end of the study consisted of 9 hours of classroom observations and 61.5 hours of recorded interviews.

After data were collected, pseudonyms were assigned to each person. Interview recordings and any other digital files with the participants' personal information were re-labeled with the appropriate pseudonym. Data analysis (described below) was conducted using these pseudonyms. The CS faculty members with whom I spoke were also assigned pseudonyms in the same fashion. Since all of the participants had agreed to be re-contacted in the future per a check box on the consent form, e-mail addresses were retained, but no written connection between the e-mail addresses and the data was preserved.

Interviews were and are crucial to developing as complete an understanding as possible of a person's experiences. As Merriam (1988, cited in Zeldin & Pajares, 2000) points out, the purpose of interviewing is to "enter into the other person's perspective" (p.223). Relying heavily on interviews as a data collection method allowed a focus on the participants' own perspectives on their experiences, which supports the conceptual framework outlined in the previous chapter.

Undergraduate interviews.

The main purpose of the undergraduate interviews is to understand the women's experiences from their own perspectives. Learning the women's own thoughts enables an appreciation and further understanding of the role that the factors and theories identified in the previous chapter played both in their academic history and on their path to successful completion of a bachelor's degree in CS.

The undergraduate interviews (Appendix B) focused on the participants' experiences, both with computers and as computer science majors. The questions were open-ended in nature, and allowed for more or less conversation on the part of the students (exemplified by the difference in interview times among the participants – total interview times for all three interviews ranged from a total of an hour and a half to a total of almost four hours for the same set of questions). The questions asked about the participants' experiences both in college and before college, so as to fully acknowledge the influential role that their pre-college context and experiences played in their lives. The first interview discussed the students' pre-college experiences with computers and computer science, as well as any relevant or notable events in their past that they felt contributed to becoming a CSE major. The second interview discussed the students' experiences as CS majors. The third interview was a follow-up to the observation of the computer science class, and discussed specifics of that class. One of the benefits of conducting a follow-up interview after the observed class session is that it allowed an understanding and comparison of perspectives, since the students may have had different perceptions of class events than an outside observer would have had.

Classroom observations.

The classroom observations (Appendix C) help enable an understanding of the dynamics that these women encountered in their routine interactions with the academic side of the CS department. The data acquired from the classroom observation focused on the structure of the class, faculty/student roles in the class, the participation levels and actions of the specific students participating in the study, and these students' interactions with the professor and/or the other students. Information about curriculum materials and the presentation of materials (discussed as part of the interviews) allowed questions about the accessibility of the books and/or handouts, as well as the professor/student perspectives on the relevance and usefulness of class materials. With one exception (a capstone class in animation), all of the observed class sessions were lecture classes.

Faculty member interviews.

Interviews with faculty members enable an understanding of the level of interaction that students often have with computer science faculty, and give further general information about the program in which the participants were matriculating. An interesting benefit of this data collection method is that it allows a comparison between faculty and student perspectives on the same events and situations (in this case, the observed class session). The faculty member interview (Appendix D) focused on the class session I observed. It also touched on faculty members' experiences with, and perspectives on, computer science students, including anything notable about female computer science students and any general differences they might have noted between men and women in their classes and in the major. Based on their years of experience, the faculty members with whom I spoke were often able to share some interesting and relevant perspectives on women's experiences in CS.

Career interviews.

The main purpose of the career interviews is once again to understand the women's experiences from their own perspectives. Learning what had happened to each participant since her graduation from college helped me understand the factors and theories that affect the persistence of qualified women in the computer science workforce. Connections can also be drawn between the women's experiences in college and their post-college career pathways and choices.

The career interviews (Appendix E) once again focused on the participants' experiences. The questions were open-ended in nature, allowing for more of a conversation than a structured interview, and the interviews ranged in length from one hour to over two and a half hours. Each participant's interview concentrated on what had happened in the time since her undergraduate interviews (which, in most cases, was shortly before her college graduation), and discussed what led that person to her existing circumstances, including any notable events, and her current employment situation, whether it was a job or graduate school or something else entirely. In preparation for each participant's career interview, I listened to that person's second undergraduate interview, jotting down notes and questions about things that might have changed or been impacted since that interview, such as the participant's prospective career plans or her reactions to extra supports for women.

Data Analysis

Comprehensive data analysis of all data occurred after both the undergraduate and career components of the study had been completed, and all analyses were conducted by the researcher

herself.[15] The three research questions were scrutinized and loosely mapped to the different participant interviews. Question 1 ("What are the factors and experiences that encourage women to persist and graduate with an undergraduate Computer Science and Engineering degree from a major research university?") maps to the first two undergraduate interviews that discussed pre-college experiences and experiences in the CS major, Question 2 ("In what ways – if at all – do these "successful" women use their Computer Science and Engineering degrees post-college?) maps to the career interview, and Question 3 ("In what ways do these women's experiences as "successful" Computer Science and Engineering majors contribute to their post-college career pathways? Do different types of undergraduate success stories lead to different career pathways?") maps to a combination of the second undergraduate interview and the career interview. Additional data sources – the classroom observations, faculty interviews, student interviews discussing the observed class session, and unofficial academic transcripts – aided in a better understanding of the women's experiences as computer science majors, which in turn helped to answer both the first and third research questions regarding women's persistence in the major and the relationship between student experiences in college and their post-college career pathways. All components of analysis were done by the researcher.[16]

Interviews were first transcribed using transcription software in conjunction with word processing software. Following that, I created two spreadsheets – one labeled "Student

[15] Complete data analysis for two participants, including analysis of faculty member interviews and classroom observation notes, was conducted shortly after the first year of the undergraduate portion of the study. This was done to fulfill the requirements for a qualitative methods class and further doctoral research obligations at that time. Since there was a gap of several years between the undergraduate and career portions of the study, all undergraduate data – including data from these two participants – underwent extensive analysis shortly before all the career interview data was analyzed.

[16] Since the undergraduate portion of the study was conducted for a class on qualitative methods, data analysis methods and coding, as well as examples, were discussed and shared with my study group for that class. They were also discussed and shared (to a lesser extent) with the class professors. Since the study group was no longer meeting after career data was collected for this study, subsequent data analysis did not undergo discussion, although similar methods of analysis were used.

Interviews" and the other labeled "Professor Interviews and Class Notes." In the student interview spreadsheet, I created tabs for the first two undergraduate interviews and the career interview. In the professor interview spreadsheet, I created tabs for the professor interviews and the third undergraduate interview. I then placed each question from my interview protocol as the column header and put each person's pseudonym in a different row. After setting up these spreadsheets I went back to my audio recordings and listened to each interview again, sometimes multiple times, jotting down summary notes and relevant full or partial quotes for each question in the appropriate cell of the spreadsheet. (Please see Appendix F for an excerpt from the typed transcript and the student interview spreadsheet.)

Spreadsheets were printed and reviewed person by person, with themes of particular interest (e.g., "liked CS because it was challenging" or "came to college to study STEM" or "HTML programming in HS?") being noted at intervals on multiple separate pieces of paper, allowing comments to be written for each person under any given theme.[17] Common themes were then identified and written up in the Results chapter of the study. (The data collection was extensive, so not every theme is included in the Results.) Unofficial academic transcripts were consulted during the review of the participants' second interviews and interesting points of note from the transcript were identified, such as the students' own academic standards (e.g., what they referenced as a "bad grade" in their interview sessions) or how the students' grade point averages (GPAs) changed throughout the course of their tenure in the CSE department and – for those students who had attended community college – how they compared to community college

[17] Since the purpose of the comparative analysis was to compare student experiences, faculty interviews did not undergo the same level of analysis as did the interviews with my female participants. Instead, key points were identified directly from the spreadsheets, and ,where relevant, faculty perspectives were noted under the same themes as those of the participants. This process was manageable because there were only a small number of faculty interviews (eight) and they were relatively short (19 to 55 minutes, depending on the interview, with an average interview time of 40 minutes).

GPAs. Notes from classroom observations were compared to notes from the student interviews discussing the class session and to notes from the faculty interviews, thus identifying interpretations of similar events and faculty perspectives which might help inform our understanding of women's experiences and persistence as computer science majors. Written transcripts from the interviews were consulted to fill in partially noted quotes in the spreadsheets, to understand the context before and after quotes, or to find quotes for notes written in shorthand or remembered data that later became relevant.

Similarities among the women provoked interesting questions about the link between certain personal characteristics or experiences and success as a computer science major; such similarities also provoked questions about the types of people who are willing to participate in research studies. Differences among the women, on the other hand, countered the possibility that success in CS is contingent on certain personal characteristics or experiences. This is discussed further in the Analysis chapter of the study.

Chapter 4: Results

In this chapter, I document the results from all of my interviews and observations. I start by giving information about the participants, including elaborating on their varying backgrounds and initial orientations towards computer science. Then I move on to discussing the participants' experiences as undergraduates in the computer science major, many of which were common and/or shared. Finally, I review the participants' post-college career pathways, and discuss their experiences in the first three to four years of their chosen careers.

Life before Computer Science

Participants

The study participants are a diverse group of people. My sample size is only 15, yet those 15 women represent five different countries (including the U.S.) and three different U.S. states. Some of the women from other countries moved to America specifically to attend college right after high school. Others moved here under other circumstances, either with their families or on their own, then attended university here, sometimes after attending one or more years of college in their home countries.

In addition to geographic diversity, there is quite significant age diversity among the participants. While most of the women were of average college senior age at the time of their undergraduate interviews, a couple of people were third-year students and thus a year younger than the average college senior, one person was a fifth-year student, and four women were up to ten years older than average for a variety of reasons (e.g., one of them was married with three children, while another had completed medical school in her home country prior to moving to the U.S.).

Community college also played a big part in the college pathways of these women – 7 of the 15 participants attended one of the local community colleges before attending the university. Some of the community college attendees were older than the average college student, returning to college after a number of years away from school; others were non-native English speakers who attended community college to improve their English before matriculating in a four-year college; finally, a couple of participants had done Running Start to earn college credit while still in high school.

The women with whom I spoke were pursuing one of two degrees: computer science (CS) or computer engineering (CE). Computer science awarded a Bachelor of Arts degree from the College of Arts & Sciences, and computer engineering awarded a Bachelor of Science degree from the College of Engineering. Eleven of the participants were CS majors while four of them were CE majors, and at the time of our undergraduate conversations nine of the women were double majors with a field outside of CS/CE.[18] More than half of the double majors were pursuing a second STEM degree and a couple were pursuing an artistic second major (art, music, dance, etc.). The two people pursuing minors were either minoring in a fine arts field or a STEM field. While there were two people whose second major fell into neither of the above categories, it is interesting to note that none of the participants were majoring or minoring in a traditional social science or humanities disciplines, such as anthropology or English or philosophy. (Please see Appendix A for a chart containing comparable personal details about the participants.)

[18] The difference in the two majors was minimal for the purposes of this study, thus as mentioned in the Research Strategy and Design section (Chapter 3), I will henceforth be using the term computer science (CS) to refer to both CS and CE majors.

Motivations and Directions

Approximately 13 of the women considered computer science their primary major. If they were double majoring it was in something that they considered supplemental or less interesting or relevant, even if computer science was technically the second major they had declared. In a couple of cases people had switched to CS from another major, sometimes after discovering that they hated that other field "with a fiery passion" (C-U1[19]). The remaining 2 participants, Xenia and Penelope, were interested in a particular study area at the intersection of their two majors, and thought that a computer science degree would be useful in furthering knowledge or ability in this area of overlap: as Penelope told me, "it's sort of that intersection that I'm really interested in" (U1).

While the people I spoke with were indeed self-selected, and thus might not be entirely representative of women in the computer science department in general, I had at least one person tell me informally that I was basically talking to all the girls in the department. (Based on the numbers, my nine participants the first year comprised around 32% of the senior women in the department, and my six participants the second year comprised around 24%.) Additionally, I had several women voice opinions about how they felt they were atypical, which influenced their participation in or their perception of their own usefulness in my study. One of the women specifically told me that "I'm definitely a non-traditional student, so my outlook on things is going to be really different. That's one of the reasons I wanted to do the study" (R-U1), while another indicated that she didn't think she was a "good candidate" for the study because she wasn't heavily into programming (C-U1). While there were a couple of people who declined to share their unofficial academic transcript during the undergraduate portion of the study, I had

[19] For the purposes of citations, my female participants' names are abbreviated to their first initial. Additionally, as previously mentioned in the Methods chapter, the interviews in the undergraduate study are noted as U1, U2, and U3 and the interview for the career study is noted as C1.

one student who was excited to show me her transcript specifically *because* she thought her grades weren't great and she wanted me to see an example of a computer science major with a slightly lower grade point average (GPA) (H-U2). Interestingly, in almost all cases, the people who mentioned specifics about why they were participating or what they wanted me to get out of the information they were giving me did so because they thought they were atypical students in that regard. Since every woman I spoke with was different, it is hard to make a global assessment of typical versus atypical female CS majors.

Initial Exposure to Computers

My study participants came from a variety of backgrounds. Some of them were the children of engineers, from high-tech areas of the country such as the Pacific Northwest or the California Bay Area, with experiences that one might expect from such a background. Penelope's dad, for example, built computers at home, an activity that she would "tag along with" (U1), and she attended at least one friend's birthday celebration as a child where the party games consisted of disassembling a computer and other electronic devices. Likewise, Andromeda was also exposed to computers at an early age and felt she had been "bred into" computer literacy:"My father probably pushed computer literacy since I can remember … having two engineering parents it was just kind of like 'Well, obviously she *has* to be computer literate, it's like she's been bred into it'" (A-U1). Similarly, Niobe's dad "had always played computer games as well" and she found that "the computers at school were always kind of behind the computers that we had at home" (U1).

However, other women had greatly different experiences: Rhea attended a high school where "the interest was in getting married and having babies" and didn't touch a computer until returning to college for a second time, at which point in her first programming class she "wasn't

sure how even to turn the computer on, honestly" (U1). Rhea's lack of computer exposure was mirrored by Electra, who started using a computer during her third or fourth year of university and "didn't understand anything about it and … comfortably could press one button: Enter" (U1).

It is worth noting, however, that just because a person had engineers for parents and computers in her house didn't necessarily mean she was going to embrace early computer use. One woman's father had a degree in Engineering Physics and worked as a software engineer and her mother had a degree in computer science, and there were always computers in their house, yet she "didn't really use computers when I was a kid at all … um … I hated the Internet" (I-U1). Likewise, Daphne's dad was a scientist, and her family had a computer at home when she was little, but she didn't use their home computer much at all, preferring to be outside chasing bugs or reading (U1).

Similarly, the participants' pre-college experiences with computer programming were mixed. Several people, such as Rhea, Iris, and Thalia, didn't take any programming classes at all prior to the introductory course at the university or in community college: as Thalia put it, "I didn't do any programming or anything, I never even thought about that, until I got to college, it was not something that I ever was interested in or I thought about doing" (U1). Other people, such as Andromeda, were exposed to programming and programming concepts their entire lives, even to the point of being too young to fully understand what they were being taught: "It's just it's kind of difficult to explain the concept of a variable to a fifth grader who hasn't had algebra or anything like that" (U1). Still others were somewhere in between, either teaching themselves HTML and making their own web pages before matriculating in college, such as Niobe or Cassiopeia, or taking more formal programming classes in high school.

People's experiences with programming classes were also mixed. Helen took an HTML class in high school and enjoyed it. Subsequently, at a teacher's request, she used her web design skills to create a web page for an AP Psychology class, thereby encouraging her to do something with technology and reinforcing the notion that technology could be used to create things meaningful to her (U1). As a counterexample, Daphne's high school Visual Basic class basically put her off programming because it was not challenging enough: "It made me think that programming was really really boring and not something that I would enjoy" (U1). Leda's computer class in high school made her think "Oh yeah, I want to be a programmer" (U1), whereas Gaia's experience was similar to Daphne's – she took some computer programming classes in high school, but had a very boring teacher who put her off computers (U1). Xenia took a Visual Basic class her first year of college in China and did extremely poorly, again due partly to a boring instructor, yet got a 4.0 in the introductory CS course at community college and thought "Wow, this is nice, you know I'm totally getting the concepts, I love the class, and I was doing well" (U1).[20]

Based on the wide variety of stories presented here by women who graduated with a computer science major, early computer use, let alone early programming experience, clearly is *not* a requirement for success in CS. Leda did not come from a particularly technical family, but realized about a year after getting her first computer at age 12 that she wanted to be a programmer when she grew up (U1). Likewise Rhea, who had no prior background with computers or programming, said of her first programming class in college: "I absolutely loved it. I absolutely loved it," and then later, "I would dream in C" (U1). Interestingly, one of the professors with whom I spoke, Felix, had a similar experience to several of the participants. He

[20] Please note that I am transcribing my participants' words from our interviews, so any grammatical errors result from the informal nature of the conversation or, in some cases, from the fact that English was not their first language.

didn't write a computer program until he took an introductory programming course his freshman year of college, but then ended up majoring in CS and continuing on to become a CS professor. This was a career trajectory that he sometimes shared with his students if they felt that they were behind because they hadn't done any programming prior to college. Gaia, who was from Asia and didn't use a computer until around age 11, summed it up nicely:

> People in America, they got exposed to computer[s] at a very young age … they have advantages because they have been programming for so long, but it turns out that – not really, they don't really have that much advantage – I mean, they may have some, but that's not really that big of a deal. (U1)

College Experiences

Scientific Leanings

An interesting commonality among the participants, which was self-identified by all but two people, is that they came to the university specifically planning to study a STEM field. While some of them came to the university specifically for the CS department, such as Andromeda and Rhea, many of them came planning to study other science or engineering fields, usually math or some variant of biology. (The introduction to CS happened in different ways for different people, which I discuss in more detail shortly.) Thus even though they might not have been specifically interested in computer science when they first matriculated in college, they did start their university careers with an interest in or intention to study a science and/or engineering discipline.

Sometimes this interest was based on a cultural norm – for example, Gaia indicated that people who do well are sort of expected to go into the sciences: "So I chose science because it was somewhat a social expectation – that's part of it, I think" (U1). In other cases it was mandatory – Sibyl's government scholarship to study in a first-world country required her to

study a STEM field (U1). However, for others this interest was triggered in a variety of ways, such as for Penelope, who told me that when she was little she wanted to be a scientist when she grew up (U1), or Xenia, who had always liked and done well in science (U1), or Medea, who enjoyed a challenge but generally found school easy, and felt that STEM fields were more challenging for her than other fields (U1). A pertinent question to ask, given this finding, is how likely it is that someone who did not start out with scientific leanings would end up as a computer science major. Thus it is interesting to look at the stories of the two people who did not originally intend to study science when they matriculated in college in the U.S.

One of the women in question, Electra, had attended medical school and done her residency in her country of origin before deciding that she was not interested in being a doctor there, due to low pay and poor work conditions. After realizing this, she managed a charitable center for six months before moving to another country to be a travel agent, which, counter to social norms in the United States, paid better than her job as a doctor in her home country had done. From the travel agent job, she moved to the U.S. to be an au pair, and ended up in Seattle because that was the location of the family for whom she chose to work. She knew that she wanted to go to university for a different career path than medicine, but didn't have specific plans of where she wanted to study until she moved to Seattle.

One might argue that Electra's choice of CS might have been influenced by her previous experience in the sciences as a physician, but her love of her job as a travel agent indicates that she was not set on science as a career. (She was interested in continuing to work as a travel agent in the U.S., but was unable to find any such available positions when she moved here.) Electra ended up studying CS because she wanted something that she could be passionate about, and was inspired by a former boyfriend who worked for a major software development firm and "just so

loves his job and stuff like this that after listening to him I said 'Yeah, that's probably what I want to really do'" (U1).

Daphne, the other person who did not come to the university to study any kind of science field, has what might be a more common story for people initially heading to college without specific scientific leanings. In her schooling, math had been presented as work, as something she *had* to learn, as opposed to subjects – like art and history – that were fun. Consequently, she had not liked math in high school, thinking it was busy work, and her one pre-college experience with programming was the aforementioned HTML class in which she was bored silly. She grew up in the nearby area, and started college via Running Start at a community college, intending to major in English. When that didn't work out she considered history and philosophy. Her interest in computer science was initially sparked by a logic class that she took expressly so she could avoid taking a math class; she liked it so much that she tutored students in logic afterwards, and in that context encountered many people who were tutoring math. Her logic professor asked her why she didn't like math; since she had no good answer, she took a math class and found that she loved it. A subsequent coworker at an after school teaching job told her that he thought she'd like programming, and she found this to be true when she found time in her schedule to take the introductory CS course at the university, where she was already majoring in math. (Based on her background with math, Daphne indicated that "to this day I'm better at calculus than I am at arithmetic" (U1).) When asked why she chose to major in CS, as opposed to just take classes, her response was twofold: firstly, it was hard to take many of the available CS classes without being a major, but secondly, "I tend to be a very all or nothing type person … pretty much I just ended up falling in love with programming" (U1).

Choosing Computer Science as a Major

Some people came to the university specifically intending to study computer science, such as Helen and Niobe, who selected CS on their application to the university and were directly admitted from high school, and Andromeda and Sibyl, who were so committed to the field that if they had not been accepted into the major they would have considered switching universities rather than switching majors. However, these people do not represent the majority of the participants. Many people, such as Daphne, were pulled towards CS by a good experience in the introductory course, often accompanied by e-mail encouragement from the professor to consider it as a major. Even people's reasons for matriculating in this course were varied, though. Iris took the introductory CS course sequence because it was a specific requirement for a different engineering discipline she was considering, but found when she matriculated in the courses that she was really good at it and thus decided to major in CS (U1). Cassiopeia, on the other hand, took the second class in the CS intro sequence because she was unhappy in her existing STEM major and her boyfriend (himself a CS major) suggested that she give CS another try (U1). (Cassiopeia had taken the first introductory class previously and not liked it, but was inspired to pursue CS by the "awesome" professor she had for the second introductory course.) A little later Cassiopeia paid it forward, recruiting her close friend Thalia (a fellow student in her former major) to the introductory computer science class (U1). Thalia later told me that she had been starting to burn out on her other major and when CS came along as an option she felt "here's a purpose now again" (U1).

Several women commented on how the male-dominated nature of the field was an early deterrent from studying computer science. Penelope's father worked in the computer industry, and she had come to the conclusion that he was a "big geek" and that she didn't want to do what

he did because she "didn't want to be a big geek" (U1). She was interested in science, however, and took the introductory CS course both because it was a prerequisite for many other engineering majors but also because "I might as well, might be fun" (U1). Likewise, Gaia said of herself in high school "Yeah, I think I might have some stereotype back then about you know women in computer science; I didn't want to do computer science and get stuck with all those geeky guys" (U1). Both of these women were swayed towards the major by the women's seminar they took concurrently with the intro course. This course was offered by the CS department, and discussed what computer scientists actually did in the "real world" and showcased women in the technology industry. The class made Gaia realize that one could do more with a CS degree than she had originally thought (U1), and for Penelope "It definitely lured me into the major a little more" (U1).

Medea's interest in computer science was triggered in an entirely different way. She had spent most of her life feeling that school in general was easy and gravitated towards STEM fields because she found them more challenging. While in community college she attended a presentation by a visiting speaker from a satellite campus of the flagship state university, who advocated for the computer science program at the satellite campus because the CS program at the main campus was very competitive and hard to get in to. Her response to this was not what the speaker had intended. Instead of considering the satellite campus's program, she immediately disregarded it as too easy: "That sort of made me think that if this was something hard to do, and it was challenging, well, I was gonna do it" (U1). Amusingly, when she submitted her transfer application from community college, she was admitted to the highly competitive CS department before she was admitted to the university itself.

Job prospects also had an influence on the participants' choice of computer science as a major. Even though none of my questions specifically addressed this, all but a couple of the women brought up career opportunities as an appealing aspect of a CS major. Rhea definitely wanted a practical major that would ensure her a job upon graduation so she could support her kids, but when referring to future job prospects she also commented that "I'm gonna get paid to play – I mean, how cool is that?" (U2). Likewise Daphne saw computer science as a field that enabled the application of interesting concepts: "I really liked logic but there really wasn't a whole lot you could do with it, for the most part, whereas once you got into programming it was logic but it did something cool when you were done with it and there was actually functionality to it" (U1). Similarly, Medea stated that "The reason that I picked *this* challenge and field of knowledge to study above another one is because there is something that I can do with it that is useful and leads to a career and a job pretty much after graduation" (U2).

In some cases this desire for a practical major was initially prompted by parents. Niobe, for example, felt that she was expected to choose a practical major; her parents "definitely wanted me to get a career, like you go to college to get a career, it's an expectation" (U1). Cassiopeia had a similar situation: when her other STEM major didn't work out, she considered finishing school with just her fine arts major, but stated that her "parents weren't going to keep paying for college or helping pay for anything if I did that" (U1). Her parents' influence wasn't the only relevant factor, though, for in our next interview Cassiopeia herself stated that "there was no way I was going to only graduate with an art major," both because of job prospects but also because it was "not quite the same mental exertion" (U2) as CS. (It is worth noting in both of these cases that the parents were not specifically pushing computer science; rather, they were

advocating for a major that could lead to a job. The choice of CS specifically was a result of each person's own interest in the subject.)

This personal desire to major in something practical was mirrored by Helen, who, when I asked why she applied directly to the computer science department with her university application, gave the following response:

> I don't remember why I picked engineering, I think it was more of like I heard that there were good jobs and there were good job security and … after I'd come back from this whole "I wanna be an artist" I was like "Oh I need to do something practical with my life, I need to grow up and have a real job." (U1)

Later Helen indicated that she was really happy that she was getting "trained in something, instead of studying for four years and getting a fluffy degree" (U1) that would either require further schooling or on-the-job training to use. Leda also considered herself a *very* practical person (her emphasis), to the point where "if I don't see how I'm going to apply it somewhere, it's not interesting" (U1), and she liked CS because with it she was able to see a future career path.

There was one person who specifically did not see employment prospects as a perk of computer science – Gaia told me that "when I think about undergraduate degree I don't think about how you can use it as a tool to get a future job," and then later, "I see undergrad degree as some sort of experience, this is the last chance you get to do whatever you want" (U2). However, most of the participants seemed to regard the employment opportunities afforded by CS as an additional benefit to something they enjoyed doing anyway.

Though one of the class professors I interviewed expressed some concerns about people majoring in CS purely because of the job opportunities – "You want people in computer science who are really motivated by the way they can change the world, rather than by feeling that this offers them employment" (Wolfgang) – it seemed from talking to the participants that these two

outlooks were not mutually exclusive. Niobe wanted to do something meaningful with her CS knowledge: "Ideally I'd like to find some kind of job where I could really feel like I was making a contribution to something very useful with my programming" (U2). Sibyl, an international student from a south Asian country, was encouraged to stay in the field because of job prospects after graduation, but in the long term she was interested in the practical applications of computer science and software development in her country of origin, and hoped to use her CS knowledge to enhance the opportunities and services available to people in her home country. Like Niobe and Cassiopeia, Sibyl was encouraged in this goal by her parents (her father was a computer programmer, who had won an award for his entrepreneurship); However, instead of specifically being focused on job prospects after college, Sibyl's parents were primarily interested in her studying something that they thought would be big in the future in her country, and science fit this criteria.

Engagement with Computer Science

One of the primary reasons that the participants continued to engage with the CS department even after they had been admitted was the ongoing challenge presented by the coursework and the department as a whole. Rhea had spent her whole life feeling that academics were really easy for her, but she met her match when she got to the CS department. She was no longer the smartest person around – "I'm surrounded by geniuses, and I'm like 'okay, so I'm not so smart any more'" (U1) – and this provided intellectual stimulation that kept her continually engaged with the subject matter and the department. Sibyl had a similar story – she found CS interesting specifically because it was challenging; the department is "hard, but it keeps me going – oh, there's something I didn't know yet" (U1). Electra, likewise, commented that the CS

department "stretch[es] your mind" (U2), and Niobe felt while she "didn't really study that hard in high school," in the CS department "you have to put the effort in" (U2).

Some people mentioned how this challenge related specifically to classes and grades. Daphne stated "I get bored easily if I'm not challenged – it's probably why I fit in with the CS people" (U1) and then later reiterated in our second undergraduate interview, "I don't do well in classes that I find easy." Gaia felt similarly – the classes that she liked the most were not necessarily the ones that she found the easiest: "I like theory. Not that good at it, but I just like it" (U2). Andromeda also liked to challenge herself – she told me in our first undergraduate interview that "I'd rather keep myself busy and get decent grades than be bored and get 4.0's." Penelope mentioned the effect that this challenge had on the rest of her schooling at the university: "It's definitely raised my expectation of classes, so when I take other classes and they're not as challenging or difficult as CS classes, I remember 'oh this isn't CS'" (U2).

Thalia found the department challenging as well – she stayed with the CS major because "it's challenging and fun" (U2) – but she framed her challenge in a different fashion than some of the other CS majors with whom I spoke. As she put it, "It's hard because it's new, but it's not hard because it's somehow more advanced than any other area" (U1). Xenia had a similar take on things: in her second undergraduate interview she told me that "It's challenging in a good way. It's challenging because I'm learning new stuff all the time." This viewpoint raises an interesting question: is computer science inherently more challenging than other disciplines, or is it simply more challenging because the material is (often) unfamiliar? One of the professors with whom I spoke, Gustav, commented on this very phenomenon. He believed that one of the reasons women often majored in biological sciences instead of engineering was that biology was a familiar field that they had already been exposed to in high school, which made them more

open to studying it in college. The frequent absence of a CS course or courses in high schools meant that people – both men and women – were missing the opportunity to "learn about computing under the circumstances of no expectations." He felt that the addition of a standard CS course to the high school curriculum could help to make people more open minded about computer science and more informed about the field in general, which would in turn prompt more people to consider CS as a major in college.

On the apparent flipside from the people who were challenged, Cassiopeia stuck around in the department because "I've found this really easy" (U1) – classes were easy, it was easy to get jobs, etc. – and she found it puzzling that some people found getting jobs or internships competitive or difficult. Cassiopeia's experience of ease ties in to another commonality that I discovered among some of the women: that of "fit" in the CS department. Daphne's quote above about why she "fit in with the CS people" exemplifies this, and was echoed in Leda's sentiment that the CS department was the place she was meant to be: "When I got to the department I realized 'oh my goodness, this is exactly what I was looking for and more' so it was just like a little dream that didn't get broken up" (U1).

In certain cases this sense of connection can be correlated with upbringing – Gaia told me that "Yeah, I've been surrounded by geeks my whole life, so it is not really something new to me … I guess I fit in [in the CS department]" (U2). In Thalia's case, even her mom noticed how well she fit in as a CS major: "My mom's like 'You had to become a Computer Scientist to be cool' and I was like 'thanks mom' ... yes, I am cool among the Computer Scientists; I have found my people" (U2). While on the surface this immediate fit and ease might appear to be the opposite of the people who enjoyed the challenge presented by CS, it could be argued that the element of fit and ease for the individuals described above is a direct result of their engagement with computer

science and the computer science department. This in turn prompts the question, which I will discuss in further detail in the next chapter: does it matter *why* people are engaged, or just that they *are* engaged?

Interestingly, very few of the participants expressed excitement about technology for its own sake. Rather, the prevailing attitude seemed to be one of interest in what one could accomplish or do with computers. Cassiopeia stated that she "like[d] computers because of their influence" and that "they're touching everything, the companies working on them are cool" (U1). Thalia noted "how useful they [computers] were," and stated that "To really make huge breakthroughs I think we really have to be able to use computers" (U1). Niobe was interested in how computers and technology are "really changing culture, changing society, changing the way we act" (U1). Daphne noted the societal influence of computers: she really liked her other STEM major, but also acknowledged that "it's not where I'm going to end up, just because I want to have more of an effect on my environment than I would there, and I think that CS would let me do that" (U1).

Helen had a slightly different reason for engaging with computer science: "it was fun." As she told me in our first undergraduate interview, "I'm still totally about the fun side of computers." Social networking applications like Facebook and MySpace, as well as computer games, were her areas of interest; she felt that there were enough smart people working on the more technical side of things to make computers faster or smaller, and she wanted to focus her efforts "on different problems, especially the problems that affect people" (U1). It is interesting to compare Helen to Rhea, the most technical participant, who was more concerned with understanding the inner workings of a computer and wanted to do circuit design: "Embedded systems is my real interest, and programming at that low of a level. I'm not interested in

programming at a Java level in industry" (U1). This wide range of interests among the participants illustrates that computer science is actually a far-reaching and varied field that can accommodate a wide spectrum of interests. This fact often goes unrecognized in societal perceptions of the field that equate computer science with programming. This misapprehension was noted by one of the faculty with whom I spoke: "I think the notion that you're going to be a programmer chained to a desk is just so wrong, and it turns people off" (Johann).

Another very common theme among the participants was a shared love of puzzles and problem solving. Medea stated that she "enjoyed the puzzle aspect of programming" (U1), and many people spoke of how rewarding it was to "solve" a program: "What really keeps me going is when everything compiles - it's beautiful" (I-U1); "When you see the results of your effort it's like a lot of fun for me" (E-U1); "…when it starts working you just get so excited and you just want to jump and you're like 'oh yeah, it works, look at this!'" (L-U2); "When I do coding and programming, if I can solve something that I never thought I can solve, it's really satisfying, oh I love the feeling of being able to solve problems with my knowledge at that time" (S-U1). Xenia tied this feeling back to academics – she told me that she does better at her programming homework than at her problem sets because there is some sort of prize waiting for her when she finishes a program successfully, which is not the case with problem sets.

Culture of the Computer Science Department

Most people with whom I spoke felt that there was a sense of friendly community in the computer science department. Penelope stated that "It's fun, you know it's friendly, everyone's really friendly" (U2), and Iris's assessment was "I like it, there's a lot of really great people here (U2). Andromeda spoke of the "close knit community" and the fact that it was like a "nice little family within the computer science department" (U2). Cassiopeia was even more positive about

the culture, telling me "I think it's awesome. I think like the 200 coolest students at the university are all CS majors … I really really really like the culture here … just a lot of low key hanging out" (U2). Many people, especially those who were double majors and had spent a lot of time in another department on campus, such as Thalia and Daphne, commented that this sense of community was fostered by the presence of the undergraduate labs in the basement of the CS building, where people convened to work on projects and other programming homework and – at times – just to hang out.

This sense of community contributed to a sort of home away from home feeling in the computer science building. Iris told me, "There's definitely some people who are in the labs all the time, you see them every day whether or not they're working on a project they just live there. One guy actually just sleeps in the hardware lab sometimes" (U2). This sentiment was echoed by Gaia, who told me that the department was "like home" (U2), and Electra, who joked that "I feel here more is home than at home, because I barely is there" (U2). Niobe had a similar (and highly amusing) take on this feeling of home in the CS department:

> You just feel like you have a home here. It's a home, and sometimes I felt like this is a big house, and the professors are the parents and they live on the top floor and all the young people live in the basement. We're the kids, we live in the basement, the grad students live somewhere in between. (U1)

Some people felt that the department was very cooperative in nature, which probably contributed to the sense of community described above. Sibyl appreciated that "All the students are very helpful, like that's the best of it" (U2) and Iris stated that "I think it's more cooperative, because I mean the curve's so high everybody's gonna do well" (U2). This isn't particularly surprising given the departmental focus on group work, especially in the higher level classes: In our second undergraduate interview, Rhea commented that "Engineering is collaborating." Penelope believed that "Everyone's excited to be here, everyone's excited to learn, and I don't

think – we're never encouraged to do better than our neighbor, that's not the emphasis, ever" (U2). Johann, one of the professors I interviewed, thought that the admission to major process itself facilitated collaboration: as he put it, "You're in now, it's time to stop being competitive."

At times people did find the culture competitive, but that was often specific to particular people or events. Cassiopeia "never felt competed against in general," but noticed that on specific occasions, "some of the women are competitive" (U2). This sentiment was echoed by Thalia. Leda noted that people were sometimes competitive about grades, and Iris saw increased competition around interview time. Andromeda felt that some people saw giving help as a *way* of competing – "It's viewed as a 'oh you won' if you have to give help to somebody else" (U2) – and Thalia made an interesting observation that the competitiveness in the department was more about "who *appears* to be the smartest person or who is judged by their peers to be the person with the most knowledge about computers … like it's that kind of status" (U2). This desire to appear to be the smartest or most knowledgeable is a point that I will touch on more in a later section.

Counter to the prevalent stereotype identified earlier, that Computer Scientists spend their entire day "chained to a desk" programming (Johann), the general consensus was that people in the department were well adjusted, and had interests – such as sports – outside of CS: "There are some people who love to do computer science and they do it in their free time, but most of the people it's very much like they have other stuff going on, too" (T-U2). As Penelope put it in our second undergraduate interview,

> We'll spend a lot of time programming, but sort of the stereotypical nerdy smelly dude sitting in the basement at a computer, the only light in the room *is* the computer, the monitor, I feel like there's a lot more than that, a lot of different people, a lot of different styles … I feel like you can be a pretty social person, you know, be a happy, well rounded person, and still do okay.

While the participants certainly noticed the stereotypical computer science "geeks" – Gaia aptly pointed out that everyone will notice them, because they are the people that are always in the lab (U2) – the overarching opinion was that these people were just one subset of many different groups and types of people within the department. Andromeda actually regarded the hardcore nerds as "adorable" (U2). While Helen did identify a somewhat "Lord of the Flies"-ish subgroup within the CS major, which involved a lot of posturing and one-upsmanship, even the presence of that group wasn't deemed all bad because "you have to learn to be around obnoxious people because you're going to be around them in industry" (H-U2). (While obviously this expectation of obnoxiousness in the workplace is problematic in and of itself, my participant's attitude towards it was positive and healthy. Workplace issues will be discussed in further detail when the participants' post-college experiences are explored.)

A few people felt a little distanced from the overall computer science community. Medea, for example, felt that CS students on the whole were "not an overly friendly, gregarious bunch" (U2), and Xenia thought that she was "not quite in the community" (U2). However, that slight sense of displacement also seemed to correlate with being a non-traditional student. Medea had a child at home and a job outside the university, and Xenia was married and a double major, with CS interests very specific to her other major, and had added a CS major quite late in her schooling. Medea stated of the department: "I think it's best for somebody who has no family obligations and no job" (U2). This feeling that one needed to have no distractions and/or obligations outside of computer science to feel fully comfortable in the department is supported by Penelope's experience that "the more time I spend at home the less I feel connected in the CSE community, actually." Rhea, who was married with three children, actually got an apartment close to campus for her final year so that she could fully focus on CS instead of having

to spend hours commuting via ferry and bus. The upside? "I actually get to sleep on a regular basis" (R-U2).

Diversity within Computer Science

When asked about diversity within the computer science department, people's responses varied widely. Some people said it was very diverse, whereas others said it was not. The wide range of responses seemed to result from differences in definitions of diversity, which itself resulted from people's upbringing and past experiences. Rhea, who was from a rather homogenous state, told me that there were people from all over the world and that the department felt like a melting pot (U2), but Xenia, who was from East Asia, said "And then you can see Caucasian, Asian, Indian – they say the three groups. So I don't think it's very diverse" (U2). Electra, who was from Eastern Europe, thought that there were people from a lot of places (U2), but Gaia, who was from Asia, said she had lots of friends of her own ethnicity but knew hardly anyone from Japan or Korea (U2). Thus, similar to Xenia, Gaia felt that even though there were people from many different countries the CS department still wasn't necessarily that diverse (U2). Unsurprisingly, the participants tended to identify people from countries with which they had familiarity, often due to geographic proximity: Someone who was from Asia would differentiate between people from China, Japan, and Korea, whereas someone from Eastern Europe would differentiate between people from Russia, Hungary, and Bulgaria.

Leda, who was from Eastern Europe and spoke three languages herself, described the CS department as "very very diverse" and spoke specifically of language diversity: "Most of the people know some other language as well besides English because they will be coming from somewhere else or they're just learning some other language because of their ethnicity, even though they were born here" (U2).

Certain types of ethnic diversity were somewhat lacking, as Penelope called out when she mentioned that she could think of only one African American student in the whole department – as she put it, "the university in general's pretty bad" (U2). However, several people mentioned that the CS department had more women than their other major. Xenia, who was a double major with a biological science, commented that in CS "with the girl population it's more diverse I guess … If I say diverse that means we have more white girls" (U2).

Age diversity was also prevalent. As previously mentioned, almost a third of the participants were older than average college age, and half had attended community college prior to matriculating at the university. Thalia and Xenia both commented on this age diversity, and Xenia followed up her above remark about lack of diversity with the following comment: "On the other hand, I think the age range is diverse, because there's always maybe one or two or even more people that look like they went to the industry and they're coming back to school" (U2). She thought that this age diversity in CS was very different from both her other major department and the university in general.

Another type of diversity that was brought up to me is diversity of interests. Based on her experience talking to people in the department, Daphne observed that CS had more double majors than any other department she'd encountered, and she hazarded a guess that around 80% of the CS students had a second major outside of computer science. (The actual number was closer to 35%.) Even Daphne's co-TA for one of the introductory classes was also a Drama major. She saw this type of diversity as a big perk: "One of the things that I love about the CS department is how varied the environment is, like just the different people that are in it and stuff like that, mostly because of their interests" (U2). Penelope and Thalia also commented on this type of diversity, and the general consensus was that you could be into anything – music, role

playing, TV, movies, webcomics, gaming, extreme sports, etc. – and still fit in in the CS department. On a related note, Medea thought that "most CS people are pretty open-minded – there's a lot more variety of people and dress and hair and it's a little bit more unconventional I think than other departments" (U2). Thalia attributed this openness to a shared interest in computer science: "since we're all computer scientists … you don't really notice as much that we have different backgrounds or whatever, because what we talk about is computer science" (U2).

Surrounded by Smart People

All 15 of the participants agreed that the computer science department consisted of "a lot of really smart people" (I-U2). Cassiopeia, who was a double major with a fine arts field, told me that "CS students are much more convinced of their intellectual superiority than art students are. I wouldn't say that's unfounded, but it certainly exists in the general psyche" (U2).

This perceived abundance of intelligence in the computer science department was intimidating to many people, at least upon first matriculation in the department. Rhea stated that she feels comfortable now, but did not when she first became a major: "I was just intimidated by the intelligence of the department … like holy cow, there's a lot of smart people" (U2). Iris also "wasn't really completely sure of my abilities when I first got here" but subsequently realized that "the more time I spent in the labs most of the time people are just goofing off" (U2). Xenia had a similar story:

> In my first quarter I felt nervous to go into the lab, to turn on computer especially – everybody's doing fancy programming and I still don't know how to use Emacs. Now it's much better, I feel like "okay I know more" and … yeah, I feel more comfortable now. (U2)

In addition to this sense of intimidation, a large number of the participants felt that they knew less than others, or that they were playing catch up when they matriculated in the computer

science department. Sibyl felt that it sometimes took her longer to understand concepts than it did other people, often because others seemed to have had previous exposure to these concepts (U2). Helen, likewise, thought that "I don't necessarily have the degree of understanding that everybody else does" (U2). Xenia commented that for a long time she did not picture herself as a Computer Scientist because "I never feel like I'm the fastest one in the class. I know I have no problem with following it, but I know I'm not the one that's just getting it right away either" (U2). Thalia also experienced "this sort of feeling of unpreparedness and feeling that that I'm not as good as my peers, that I'm a little bit behind them constantly," and sometimes found herself wondering "Am I good enough? Is my 'good" good enough?" (U2).

Interestingly, even people who felt they had a natural aptitude for technical fields, such as Leda, thought they did not "get" things as quickly as other people. Leda stated that "For me, Math and computer science, I understand it well, but maybe somebody else doesn't understand it, like it will take them more work" but subsequently commented that "Some people get things fast, some people actually have to study for it. I think I have to study for it a little more" (L-U2). Similarly, Iris had always been good at math and science and had known since junior high school that she was going to be some kind of engineer, yet still felt that she was not one of the "super geniuses" that could get things done really quickly. Iris' perception was that "it might take me a little longer than most people to do stuff, but I mean I usually get it" (U2). Rhea self-identified as having a more analytical mind (U1), yet also believed that "I'm not the quickest person in the department" (U2). Gaia grew up "surrounded by geeks" and thus felt that she "fit in" in the CS department (U1), but *still* was concerned that she was not geeky enough to be there (U2).

One potential reason for this feeling of unpreparedness in the CS department is that "There is a pretty big expectation of knowledge that isn't taught or that you're expected to

research on your own" (M-U2). This ties back to Sibyl's observation that people often seemed to have previous exposure to concepts that were discussed in class. Rhea felt that "Sometimes it seems that it's expected that we should have grown up in front of a computer" (U2); Daphne believed that "Definitely part of the reason why it's challenging is because in addition to learning the material they're presenting I'm also learning the material that I should have learned previously, just through experience" (U2). Andromeda concurred that CS majors were expected to know how and where to find things and expected to obtain or acquire knowledge without hand holding (U2). Medea did not see this as all bad, though: even though she found this expectation of knowledge "frustrating at first" (U2), she subsequently came to the conclusion that

> I think it's great, and I think that is a really nice thing to have that confidence that somebody can throw a set of really unfamiliar tools and subjects at you and you know that you have the resources how to use them. (U2)

One unfortunate side effect of this expectation of knowledge is that it triggered a concern with "looking stupid": as Medea put it, "nobody says 'I have no idea what you're talking about' because nobody wants to look stupid" (U2). Along the same lines, several of the participants were "hesitant to ask questions in class" (R-U3) because they did not want to appear less knowledgeable than other students. Leda stated outright that "I try not to ask stupid questions in class" (U2), and Rhea preferred to "go to office hours or ask somebody else than ask in class" (U3). Xenia observed that "People will get embarrassed if they don't know" (U2), and Thalia admitted that "if it seems like everybody else understands it, and I'm just struggling, maybe I won't [ask a question]" (U2). Amusingly, immediately after making this comment Thalia acknowledged that "it could be that everybody else is thinking the same thing" (U2), which was supported by Felix's professorial observation that "If no one ever admits that they're lost … then you actually think you're the one person who's lost."

Felix attributed this phenomenon to self-confidence: "There's 50 of them and they're really smart and they're not gonna raise their hand and say 'I'm totally lost, what do you mean?' They're just not. They're gonna – you know, they just don't have the sort of self-confidence to do that." Both Felix and Johann saw a gender correlation here as well: "I think there are a lot of women who are confident in their intellectual abilities but are uncertain particularly about the material, and are kind of waiting, sitting back, to see what's going on around them" (Johann). This observation ties in to some other interesting themes that arose surrounding gender and perception that I will touch on later in this chapter.

As the participants progressed through the department, they came to the realization that people had varied abilities within the different subfields of computer science. Thus in any given class, the people in the class might be particularly strong or particularly weak in that specific area of study. Leda mentioned that some people are so "with it" in class that they can answer questions even when called on directly from a nap (U2), which can seem intimidating, but Electra observed that "it depends from class to class, one person can be very easy with some class … but struggling in another class" (U2). Penelope spoke of how the required classes "are sort of all over the board" and that a CS major necessitates that you work outside of your comfort zone: "It's a broad range of topics, maybe you might be stronger in one, you might have a greater interest in one of those areas, but they require you to sort of get exposed to another area" (U2).

The end result for the women I spoke with was that while the abundance of smart people could at times be irksome, especially in terms of grades – "Sometimes when I felt like I put so much effort for that class, but I know a lot of people in that class are really really good, and then the result that I'm getting is like 'oh I'm not really satisfied with the result compared to the effort that I put in'" (S-U2); "Sometimes it's frustrating because everybody's so smart and sometimes I

feel like I'm not always being rewarded for the amount that I personally learn because there's still a lot of variation in skill level here" (N-U2) – these frustrations neither deterred nor made people regret studying computer science. Rhea expressed it nicely with her comment that "Sometimes I feel really intimidated. Sometimes I don't talk technical too well, and so sometimes I'm like 'wow, I picked completely the wrong thing to do with my life,' but I love it, so I figure I can't be wrong if I love doing this" (U2).

Success Factors

An almost universal truth, expressed by every single one of the participants, was that the computer science major was very time consuming. When I asked what life was like as a CS major, Electra's response was "There is no life. If you're a computer science major, there is no life" (U2), and Helen told me that CS took up "all my time" (U2). In Helen's case, she was spending so much time working on CS that the women in her sorority, where she was the only person in a STEM major, encouraged her to quit, espousing the belief that she should "Do what makes you happy, and obviously if you're working hard you're not happy" (U1). (Shortly thereafter, Helen and the sorority parted ways.) A couple of people, such as Sibyl and Andromeda, mentioned the hazards of procrastination to one's success as a CS major (U2), and Thalia and Gaia spoke of the absolute necessity of time management skills (U2). Even the professors acknowledged this aspect of computer science courses: Ludwig told me that "I guess in general our courses are notorious for taking a lot of time."

While the courses were definitely time consuming, most of the women in the study believed that the work was more time consuming than it was difficult, and that you could always "get" things with enough time. When asked about her classes, Leda told me "Yeah, I think it's more the time commitment because really it's not extremely difficult" (U2). Similarly, Iris

commented that it was "mostly the time constraints" (U2) that made her CS classes challenging. As Medea put it, "If you have sort of unlimited time to meet with the professors, TAs, work on projects, I think if you got into the department then you'll be successful" (U2). This general sentiment was echoed by Helen, Sibyl, and Xenia, among several others. Johann and Igor, two of the professors with whom I spoke, agreed with Medea's assessment that the admission to major process helped to level the playing field by ensuring that all the students in the major were capable of succeeding.

A couple of students mentioned how time spent on CS classes correlated with grades. Cassiopeia stated that she thought time and not any specific ability was really the distinguishing factor between those with average grades and those with high grades:

> I don't know anyone who thinks it's that hard; I know people with lower or higher grades, but I get the feeling that everybody's really putting in about the same amount of work, unless you're getting 3.9's and 4.0's, in which case you're just putting in more time, but I don't think at that point you're putting in much more thought. (U2)

Helen felt that higher grades resulted from letting CS take over your life – "The people that get 4.0's are the people that sleep CS, that breathe CS, that eat CS" (U2) – and Andromeda told me that "The material itself isn't terribly challenging, like I could succeed with minimal effort on my part, but in order to do really well it's a big challenge. I could be average if I didn't care" (U2).

While everyone I spoke with was willing to put in large amounts of time to finish their CS work, and Thalia even noted that one of the selling points of computer science was that the work was interesting and made you *want* to keep working, several people indicated that they were not willing to put in unlimited time to finish the work for their computer science courses. Thalia, for example, stated "I have to have my own life" (U2). Helen expressed a similar sentiment when she observed that you "have to let it [CS] own you, and I've never been willing

to do that, I've never been willing to totally give up all my time and all my life and all my hobbies and everything to be in computers" (U2). Interestingly, Thalia noticed a gender correlation with this perspective – "In the classes that I've been in where … getting it done wasn't really a matter of understanding the material but just of continuing to work on it until you got it finished, it seemed like the girls tended to do less well" (U2). In terms of these two women specifically, Thalia thought that having a cut-off point for time spent on CS work only rarely impacted her grade, whereas Helen felt that her unwillingness to let CS consume her entire life meant that she was never going to get particularly high grades.

At least one person took the opposite approach. Instead of allowing CS to encroach on her life, Andromeda instead brought her life to CS, camping out in the computer lab in which she was working on her animation capstone class. The lab had a well-stocked pantry, and she kept a change of clothes there, as well as flowers from her boyfriend, because she spent more time there than she did at home (U3). For Andromeda, however, this didn't feel like a sacrifice: "Most people would be like 'oh my god I have to study for so long' or 'I have to stay at school' – yeah, I do that little complaining, but I wouldn't have it any other way" (U2). Andromeda did not feel isolated from her friends, because her capstone classmates *were* her friends.

While time was clearly important to one's success as a CS major, it was not the only factor. Almost everyone I spoke with, including the professors, indicated that in order to do well in computer science you have to *like* computer science: "You need to like it, if you don't like it it would be frustrating to be here" (E-U2); "You have to be interested in it, because you can't force yourself to learn something you don't like, and spend a lot of hours on it" (S-U2); "You do have to like it because there are so many hours you have to innately like what you're doing – you're not going to do well if you don't like what you're doing" (I-U2). While the words that people

used were sometimes different – "passionate" (H-U2); "motivated" (N-U2); "dedicated" (A-U2); "curious" (X-U2) – the sentiment was the same. This sentiment was reiterated by Gustav, who stated of his students that "If they don't have any native curiosity about it [the material], then they do struggle."

When asked if they believed there was such a thing as "innate talent" for computer science the participants were split. Many people thought that was a myth, and even those people who did think it was true seemed to mostly see it as a marker for the type of intellectual stimulation you naturally gravitated toward: as Leda stated, "Some people are good with math, some people are good with art, some people are good at writing essays, and some people are good at solving problems" (U2). Some people, such as Thalia, saw the very idea of a talent for computer science as problematic because it often acted as a deterrent for girls and women:

> I definitely think it hurts women in the field, because I think that we tend to not believe that we have this innate computer science coding or whatever ability, that because it's a male dominated field because girls just aren't encouraged to do it that much, but for whatever reason I think that we're less likely to be "oh my god, I'm totally a rock star computer scientist" and so then when you go over and tell them "well, the good computer scientists have this innate ability" and then you're like "oh well, I'm pretty sure I don't have an innate ability for CS so it's probably not – I'm probably not going to do well in it." You know what would be better to tell girls? CS is really hard but it can also be really rewarding, and if you work hard at it you have a good chance of succeeding. (U2)

Ludwig, one of the professors I interviewed, tied the concept of talent back to the necessity of interest in the field: "I think most of the talents can be learned … I think often the rate at which you assimilate those talents is tempered by your interest in the subject and how interesting the subject is made to you personally." Thus the overwhelming sentiment was that even if there was such a thing as a natural talent for computer science, it was neither necessary nor sufficient for success as a CS major. Thalia summed it up well when she said that "If you

enjoy something you're going to become good at it, 'cause you're gonna do it, and if you don't enjoy it, you're never gonna be good at it, no matter how much of an innate skill you have" (U2).

Gender Differences in Computer Science

The general consensus among the participants was that men were better prepared than women to be computer science majors, for a variety of reasons. These reasons included men having used computers for longer – "Most of the guys interacted with the computer from a very early age, and I started very late" (E-U2); men having always planned to major in computer science – "There's a lot of guys that are in here that have been into computer science for a very very long time, like they always knew that's what they wanted to go into, and they've been coding for like eight years or more" (D-U2); men understanding the culture better – "Boys know how to navigate the system and girls just don't, like they're born knowing to come in that you need to go kiss ass and spend some time bonding with the professor talking about something random you have knowledge about" (H-U2); women getting into CS later than men – "A lot of the girls that I know ended up here [in CS] because of something else, whether … they had one major and they switched to a double like me, or if it's their second degree … this wasn't necessarily the first thing they thought of" (D-U2); and men being perceived as a better fit for the CS workplace – "CS is kind of a guy job" (G-U1). Thus many women definitely felt like guys fit in better in the computer science department, at least at first.

This feeling of being underprepared manifested itself in women's attitudes towards their coursework. Johann noticed "… more women [as opposed to men] who are ready to at the beginning of the quarter say, come in and say 'I'm not sure I'm gonna be successful.'" Felix commented that "Women who are pretty near the top of the class are less likely to know it than men who are pretty near the top of the class."

However, as they matriculated in the department, the participants came to understand that despite the aforementioned markers, men were not necessarily better at CS than women were. Indeed, much of the perception of men's superiority in computer science could be attributed to people "posturing to be visible" (H-U2). As Daphne put it, "it isn't that guys are necessarily smarter; they tend to show off their intelligence more than the girls do, I think would be a good way to put it" (U2). Because of this phenomenon, guys were more likely to go out of their way to "offer you advice on things or let you know that they can help you with things" before they were even asked (D-U2). Similarly, Penelope felt like "some guys would boast" (U2) and Helen observed that a particular group of guys had a "pay attention to me, I'm really smart" (U2) sort of attitude. Rhea attributed this persona to a need for attention. Of the men who repeatedly asked questions in the class session I observed Rhea stated that "they're the ones that need attention all the time" (U3).

This attitude did seem to be largely gender based. Leda thought that men felt a greater need to look smart – "I would feel more if I was a guy I would be like 'okay I gotta look like I'm very smart'" – and that it would be "more inappropriate" to ask stupid questions as a man than as a woman (U2). Likewise, Helen commented that men were unlikely to let people know when they didn't understand something: "I think the men that don't get it you will never see and you will never hear from" (U2). From the other direction, Electra observed that girls "don't pretend to talk smart and try to be smarter than they are" (U2). When discussing her CS classes, Cassiopeia commented that "Women are less likely to ask questions to sound smart" (U3). Thalia referenced societal expectations regarding this phenomenon:

> Guys are constantly trying to prove to each other how smart they are, and I think that's a lot harder for girls, like we're a lot used to being more passive, especially in arguments, we're more likely to be the ones who are like "well, you could be right." (U2)

This idea that women were more likely to defer to people who seemed more knowledgeable was corroborated by Ludwig, who observed that in his teaching experience "women are – at least initially – much less likely to speak up in class, more likely to defer to someone who gives the appearance of knowing what they're talking about."

Conversely, the general opinion surrounding women was that it *was* socially acceptable for a woman to say that she did not understand something. Electra observed that, unlike men, women were not ashamed to admit a lack of knowledge: "guys try to pretend more than girls … we are girls, we can not know that … so what, that's us" (U2). Niobe thought that "women are more vocal about their struggling" (U2), even though she believed that men and women probably struggled equally. Penelope observed that "initially my female friends would be more open, just saying 'I have no idea what's going on' or 'I'm totally lost,' whereas guys would not initially do that" (U2). Interestingly, one of the professors noted that the women in his class "ask the questions that … probably lots of people would like to have those questions answered" (Igor). (It is worth pointing out that just because it was socially acceptable for women to not know things does not mean that women – including the women I talked to – were necessarily comfortable admitting a lack of knowledge. Penelope's comment above seems to imply that women were more likely to admit struggles to a friend than in front of a class full of people.)

One notable side effect of this societal acceptance of female ignorance is that it was easy to get help as a girl. Cassiopeia noted that "because we're female my impression is that I can get help on anything, with like the drop of a hat" (U2). Electra indicated that this help was "mostly from guys" (U2), and Daphne told me that "I think some things may have been easier just because being a girl and not ugly there are definitely people that are willing to help you" (U2). Cassiopeia's story surrounding her recent experience was both amusing and telling:

> Like I mean like my lab partner and I were working on the lab the other day, and there were probably eight other guys in the labs, or in the hardware lab at the time, and we were like – I mean she was just like "you guys, we don't really know – do you know which directory we're supposed to use?" and all eight of them walked around and were like "we can help, we can help." It's like "hey" – like I never lack for help. Ever. <laugh> (U2)

Unsurprisingly, this ease of getting help was itself a double edged sword, because it came hand in hand with the risk of appearing incompetent: "With guys, I don't know, I feel like – well, I can't look completely dumb, 'cause then I don't know, they'll think I'm this girl that's not very smart" (L-U2). Likewise, Andromeda found that "I feel like it's hard getting partners and stuff to work with you, 'cause they're like 'oh, I'll have to help her a lot' or something, but you generally get a lot more help, it's kind of like damsel in distress style" (U2).[21] For this exact reason, Helen had "a very small circle of people that I'm willing to ask for help ... just because they're people that I know are nice and that will have time and that will not think I'm stupid" (U2). There were several women in the program, such as Xenia, Andromeda, and Daphne, the latter two of whom self-identified as more competitive, who preferred to figure things out on their own rather than ask for help. Xenia told me in our second undergraduate interview "I like to solve problems by myself if I can."

While some people in the department clearly held the attitude that "oh, the girls are dumb" because they asked for help on things, Andromeda thought this interpretation was ridiculous: "It's like 'no, they're not dumb, they're smart, because they *said* they didn't get it'" (U2). Unlike the men that Penelope encountered, who "you'd think they were like totally on top of things, and you'd find out that they'd totally got a way lower score than you on homework"

[21] Speaking of damsels in distress, it is interesting to note that Andromeda's animation capstone class was making a movie about tree frogs that featured just such a female. Claude, the professor, mentioned this in our interview, saying that the class talked in advance about whether or not that was the best way to go with the story. As a group the class determined that that particular storyline was the easiest way via which to develop the movie's main character.

(U2), women were often more pragmatic about their approach to help. While Thalia felt a little uncomfortable about taking advantage of the help because of the damsel in distress perception, at the same time she came to the conclusion that "yeah, whatever, it's useful" (U2).

It is worth noting that this ability to ask for and accept help despite the potential damage to one's "image" as a smart person might be related to the participants' status as undergraduate seniors versus entry-level students. Whereas "men come in already confident, at least most men do" (Ludwig), women tend to develop confidence throughout the program. Penelope spoke of her perspective on higher-level classes versus lower-level classes in the following way: "I'm a little bit more easygoing. I don't feel as embarrassed to ask a really – what I think might be a really dumb question because I don't even care anymore" (U1). When asked if he thought women were less concerned than men with "looking stupid" when they asked questions in class, one of the professors replied with "These women are, but again the fact that they persisted into the fourth year of their computer science career suggests that there may be something atypical about them" (Igor).[22]

Another difference between men and women in computer science is that in general men seem to have more computer-related experience than women. Igor identified a subset of guys from the classes he taught who "always used computers, they picked up programming on their own, like it was just kind of a natural thing." This phenomenon was rarer for women than for men, and contributed to the feeling of unpreparedness discussed earlier among the participants. Sibyl believed that in general guys "have more experiences so they have a lot more questions to ask and to compare with whatever we learn in the class" (U2). Ludwig, one of the professors,

[22] My understanding from this conversation is that Igor was not speaking specifically about earlier female attrition in this computer science major specifically; rather, he was referring to the overall low percentages of women in CS in general.

thought that this gendered proclivity towards computers could cause confidence problems for women:

> …for women who have not had a lot of experience in the field already, haven't done a lot of high school computer programming classes and things, you know they come in and they're just – boy, they hear all these people talking about stuff that makes no sense to them, and wow, you know, "geez I must not be at the same level as these other people," and so they naturally start to … they have this natural inferiority complex of "I must not be as good those people" or "I'm not as well prepared." So that puts them in a mentally inferior state, and they need to get confidence builders to help them boost out of that.

In most cases this earlier exposure to computers and computer technology was the result of greater interest on the part of men than of women. Thalia identified this interest as a result of computers being more of a "guy thing" – "in general we've grown up in a place that video games, playing video games, messing around with your computer a lot, writing programs or whatever, that's really more of a guy thing" (U2). Rhea made a similar observation in our first undergraduate interview:

> From the time that we're children, you're raised in such a way that you're pushed in one direction or another, and boys are expected from society differently than women are expected from society, so just because in engineering you don't see a lot of women, well a lot women were never really that interested in mathematics, a lot of women might not have been interested because of environmental factors.

Rhea went on to theorize that one of the reasons women might not be as interested in STEM fields is because those fields were generally more analytical and "men's minds work in an analytical way much more so 'cause women have more feelings" (U1), a view that validates the somewhat common perception that feelings have no place in scientific fields. Wolfgang had a slightly different take on this same problem, though: He believed that "You have to take a broader view of what's qualified and what's computer science," and that the mismatch between feelings and CS identified by Rhea had more to do with the "latent bias" inherent in the field and the related industry, and not the match (or potential mismatch) between gender and field.

Wolfgang posited that "There are a set of personal characteristics that are not completely independent of gender … and then there are unfortunately a set of environments that aren't explicitly biased – there's sort of this latent bias – because there are characteristics that one gender responds to better than another." This discussion gets at the crux of why women are underrepresented in computer science. I believe it is interesting to note that both students – at least female students – and professors in the field are actively thinking about these issues.

Based on the responses I received in my interviews, the general perception was that men's greater experience with computers was often evidenced by a strong love of programming. Some of the women I spoke with really enjoyed programming, such as Leda, for whom doing programming projects was her favorite part of the classes she took, or Daphne, whose response to the question of what she wanted to do after graduation was "I want to program" (U1). However, this was not true for the majority of the participants.

In some cases people thought that their programming skills might not be the best, exemplified by Thalia's concern regarding internships that "I wasn't sure if I was good enough to be a programmer" (U1). In other cases people simply expressed a lack of interest in programming full time after graduation: "I think the work itself is very entertaining for me, but I felt like if I was going into algorithms or writing code … I would be less happy about it" (A-U2); "If I spend my days programming for more than a couple years after I graduate I will be very sad; if I spend more than a couple weeks doing a lot of programming I will be very sad" (C-U2). This attitude was unsurprising from Cassiopeia, given her take on programming as a whole: when asked early in our interviews what got her interested in programming she laughed and replied with "I wouldn't even say that I'm interested in it" (U1).

There was definitely a perception among the participants that "programming and being good at computer science are the same thing" (T-U2). Cassiopeia stated that "I associate computer science with programming a lot" (U2). Gaia validated this sentiment with her comment that "I'm not like a hardcore CS kind of person; I'm not really a – I don't call myself a programmer … I'm more like a designer" (U2). Not everyone bought into this perception, though – while she thought that coding was a necessary skill to have, Niobe believed that "You don't need to be the best coder ever. It's not all about coding" (U2). Similarly, Johann, who taught theory classes in the department, mentioned the "culture shock" that some of his students encountered when they realized that CS was *not* all about programming: "They've seen basically all programming, and now all of a sudden we've said 'oh, and CS is this whole lot of different math-like concepts.'"

Another difference between men and women in computer science is the gender-correlated gravitation towards certain sub-fields within computing. It is often the case that men pursue the more technical areas, whereas women incline towards the less technical areas. Igor outlined the issue as follows:

> Even within computer science there's this bad ratio – there's actually divisions within computer science which are somewhat less known but kind of equally unfortunate in that – some of these "softer areas" actually have really high percentages of women, and some of the "harder areas" have no women whatsoever.

This particular division is evidenced even among my relatively small sampling of people. Helen found that "I have never been passionate about networks or operating systems or anything like that, but HCI and software I can get passionate about" (U2), whereas Rhea, who gravitated towards the extremely technical areas within computer science, told me that "I'm a different girl, I think … I think more like a guy" (U2). While in some ways these predispositions might not be

problematic, Wolfgang pointed out that there is a tendency – even among women – to view the softer areas within CS as "peripheral areas." This reinforces the idea that men are the ones doing "real" computer science. Even the terms for the subfields themselves reinforce this innate bias – when Wolfgang was talking about it with me he referred to "core areas" versus "peripheral areas."

Minority Status

At the time that the participants were in the computer science department, women comprised just under 20% of the undergraduate CS majors at the university. People generally seemed to notice the small number of women, mostly in class settings or in the lab. Cassiopeia commented that "if you're in a class and there are only three women, like that's weird; you know, out of a class of 50, that's kind of bizarre" (U2) and Daphne said of late nights in the lab "you'll be in there and there'll be you and like one other girl and like ten guys" (U2). However, despite noticing the gender disparity, the women with whom I spoke were generally not bothered by it on a daily basis. Thalia indicated that she never felt singled out or pointed at personally, but that she found the small numbers of women in CS troubling because of what it implied about women's abilities: "it bothers me on the level of there being some idea that girls are just not as good at it" (U2).

Some people spoke of how they were used to and/or enjoyed hanging out with guys. Niobe had done math team in high school, which was also male dominated, and jokingly commented that "being around lots of girls is weird to me" (U2). Similarly, Thalia had grown up with two brothers and was used to being the only girl (U2). Andromeda and Rhea both enjoyed hanging out with guys, which they felt was good given the gender balance in their chosen field: "I think just in general my relationships are a lot better with men, which I guess is decent

because I am a minority here and if I don't know how to get along with the men then it's kind of a bad thing" (A-U2); "It doesn't bother me, because it's expected, you know I'm going into a field that's dominated by men … which is fine, guys are cool, they're easy to hang out with" (R-U2). Medea didn't spend as much time in the department as some students, given her other obligations, but found that when she did socialize with CS people it was "pretty much only with other guys" (U2).

In terms of socializing and project work, the women in my study were pretty evenly split between those who specifically gravitated towards other women and those who did not. As Helen said of her first computer science class, "There were three girls in this class, I simply don't know anybody, who am I doing to make friends with? I'll make friends with the girls" (U2). Likewise, when discussing group project work, Iris stated that "I usually work with other girls … I think we just click better" (U2). Later, referring to social interactions, Iris said that "it is nice to talk to the girls in the department, 'cause the guys don't really share feelings" (U2). On the other hand, Medea wasn't "necessarily interested in doing something with other people just because they're women" (U2) and Leda commented that friendships were based on more than just gender: "You are friends with certain people because … you have things in common, basically; you are not friends with other people because you don't really enjoy it as much, to hang out with them" (U2). Despite this mix of perspectives on socializing and working with other women in general, it is interesting to note that at least two thirds of the participants stated that they had a close female friend in the CS department.

Different people had different experiences and interpretations of the role that gender played in their progression through the CS major. Helen knew that because she was female "the department really wants me to succeed" (U2), Gaia, conversely, felt encouraged to initially

become a major but once she was in the department didn't think that her presence made any difference: "I don't feel special but I was not treated badly" (U2). Gaia saw this lack of encouragement as a positive sign, though: "I think the fact that they just treat you the same is evidence that they think you are just as competent" (U2).

Some of the women with whom I spoke preferred to avoid the classifications of gender entirely. Iris was "kind of against describing people as minorities or majorities, I think that's stupid to even make that distinction because if I want something I'm just gonna figure it out myself" (U2). Rhea didn't "put a lot of stock into gender" (U2) and Cassiopeia stated that "it's just people here, we don't need to worry about it" (U2). According to Medea, "It's not that interesting that I'm a woman" (U2).

On the other hand, though, several people felt that being the minority gender came with some advantages. Multiple women had attended a women-only recruiting trip to a large software development firm, which included dinner and a limo ride, and Gaia had received a free trip to the Grace Hopper Celebration of Women in Computing, something that probably would not have happened if there had been more women in the department: "The CS department actually sponsored every female who wants to go, so if you have more people – like let's say if you have 60% female – I don't think they can do that" (U2). Xenia simply said that the small number of women "made me feel like I'm special instead of feel like I'm discouraged" (U2).

Being the numerical minority had its downsides, though. Even though she was friends with a group of guys from the CS department, Helen commented that "It sucks … because to hang out with this group of guys I have to *be* one of the guys" (U2). Gaia felt similarly – her aforementioned thought that "CS is kind of a guy job" was based not on the ability of women, but rather on the fact that "the working environment wouldn't be something I want to get into,

because there's too many guys. There's nothing wrong about hanging out with guys, I just think that it's boring" (U2). A couple of women noted that they "get asked out a lot, which is kind of obnoxious" (C-U2); in our second undergraduate interview Thalia brought up the inverse problem, that it can be awkward for a guy to invite a girl to hang out because it might be construed as a date when that is not the intention. Being in the minority also made people feel representative of their gender: Andromeda felt "pressure to do well, just because I feel like if I don't do well I'll be one of those people that they're like 'ah, she's a girl, that's why she's bad at coding, you know girls are bad at coding'" (U2).

Multiple women received comments from their male counterparts in the computer science department that the women got special treatment, and there was often a perception that the girls had it easy (T-U2). Electra found that "the guys are really jealous … they get very upset, 'why are you girls going to nice places and parties and stuff like this?'" (U2). Several other women had men insinuate that their gender had directly impacted their academic pursuits: "oh, you're a girl, of course they let you into CS" (A-U2); "people occasionally will make comments like 'oh you got that 'cause you're a woman'" (C-U2). In Cassiopeia's case these statements came from people outside the CS department, because "everyone I know has total respect for my intellect … anybody actually in the department would never say something that dumb" (U2).

Due to these types of remarks, some women felt uncomfortable with the level of support offered to women. Leda felt that the efforts to encourage women were discouraging to men (U2), Andromeda thought that girls were "getting babied" too much (U2), and Helen stated that she "kind of feel[s] sorry for the guys, 'cause … they don't get that whole loving 'we'll take care of you, we'll give you anything you want, we'll give you special tutors'" (U2).

Gaia noted the distinction between supports for women that assume a lack of competence and supports for women that simply celebrate women in technology, noting that she'd been to a conference that was the latter. She pointed out that people's expectations of STEM fields are often related to stereotypes introduced early in life:

> People were raised up differently. People growing up thinking that there's nothing that you can't do because their parents just tell them there's nothing you can't do, but there are also people who grow up surrounded by the culture that have this stereotype that labs, engineers are men, women should do either biology, chemistry for science, or maybe med school … I think it's like those stereotypes that women can't do math, engineer, physics, that sort of thing. (G-U2)

Similarly, Wolfgang's goal was for people to "be conscious of the unintentional ways in which they create environments that aren't supportive of women." Thalia brought up the same issue:

> You need to be aware of the troubles, the challenges that girls face, but not cater to them – it should be just as hard for them, but it shouldn't be any harder for them, and I think that the problem is that sometimes it's harder. (U2)

Women's minority status did not go unnoticed in classes, either. In two of the nine class sessions I observed, people made some sort of gender-related comment. In one case, after I gave my two sentence introduction about why I was observing the class, the professor – himself a strong advocate for female students in the department – made a crack about how I was studying why CS was so unwelcoming to women. A male student promptly replied "Projects are due Friday for the guys, but tomorrow for the ladies, right?" (The class I observed took place on a Monday.) In a second class session, again right after my introduction, a male student – who was sitting next to one of my female participants – called out "Now for the new homework you want to make sure it's at least twice as hard for the women."[23]

Gendered comments by professors were also not unheard of among the participants. In one instance a professor referred to one of the women in his class as a "sorority girl" (H-U2). In

[23] It is worth noting that not all comments on my presence in class were necessarily gendered. In response to my introduction, Igor joked "That means we've got to hold a real class today."

another class a male professor called out that the girls were all sitting together and asked if it was because they were struggling (P-U2). Some women were more bothered by this type of commentary than others. Iris mentioned that one of her professors got a little vulgar sometimes and used sex analogies in class, but her take on this was "He's a guy" and that it was "refreshing to have somebody that's just who he is and teaching you" (U2).

The small number of women in classes also prompted some questions about representation. One of Medea's CS classes was being video recorded, and she and another woman (whom she did not know) were the only two women in the class. She found herself wondering "how we're going to end up in the video, like if they're gonna kind of skip over us, or if they're gonna keep showing us a lot – and here's Medea again, with a different hairdo, here's this girl with a different scarf" (M-U2).

While women did not generally feel marginalized because of their gender, other factors sometimes came into play. Niobe and Gaia both felt like less of a minority as women because they were Asian – "so it's like okay there's a lot of Asian girls, okay maybe I'm not so alone" (N-U2). Sibyl, on the other hand, felt like a minority not because she was female, per se, but because she was an international student from a more conservative culture and wore clothing that denoted that traditional culture (U2).

Hair color also came up as an affecting physical characteristic. In our second undergraduate interview, Helen told me that she felt marginalized by both gender *and* appearance: "as a female you become almost a representative for the women in the department because there are so few … I'm the blonde" (U2). Daphne, on the other hand, made a conscious effort to stand out, and since fall quarter had dyed her hair "green, blue, purple, blue again and some other colors" (U2). She did this as an impetus to herself to be more outgoing: "I

occasionally get frustrated with myself for being introverted and not going out and meeting people and whatnot, so I figured that I needed to do something that would kind of make me" (D-U2).

Career Pathways

The career interview with each of the participants took place four and a half to five years after our original conversations. At this point the women had been out of school for approximately three to five years. Their tenure in the "real world" depended on when they had graduated from college (as previously mentioned, some people were third year students, as opposed to fourth or fifth year students, when we first spoke) and when exactly I was able to schedule our interviews.

Despite their shared background in their undergraduate major, people's career experiences were much more diverse than their experiences in college had been. Additionally the conversations sometimes went in different directions depending on which aspects of her life each person considered most important and relevant to communicate. While some of the themes from the career interviews were similar to the themes identified in the undergraduate portion of the study, people's reactions to or interpretations of those themes often differed from their responses as undergraduates.

Post-College Careers

The women's careers were interesting and varied. Most people were – or had been – working in the information technology industry. At the time of our career interviews two of the women were working in academia, one as a PhD student in computational biology and one as a scientific programmer. Of the people who were currently in industry, ten were working as engineers of some sort, writing code on a daily basis; and two were technical product managers

(PMs), coordinating product development and release. Nine of the women – including the graduate student – had been at one company or institution since graduating from college (some of them had switched positions internally, but still stayed with the same employer). The rest of the women had switched jobs and employers one or more times for a variety of reasons, some voluntary, others not.[24]

In terms of their choices of careers, some of the participants had additional considerations regarding visas or residency. At least one person who ended up working for a large software development firm told me that she didn't do an extensive job search because "I feel like a lot of startups wouldn't consider international hire who didn't have a PhD for higher level because they have a limited quota of how many international hires they can have" (G-C1).

Most of the participants, even if they had switched positions or companies since graduation, were performing similar roles in similar environments in each of their jobs; two people, however, had made more drastic changes to their employment. Xenia started out as a software developer engineer (SDE) for a large software development firm in the Pacific Northwest. She worked at this company for two and a half years and very much enjoyed it, but then her husband's graduate studies took him to the Netherlands, so she moved there to be with him. After doing a small amount of freelance work she found a job as a scientific programmer at a local research university. As in her previous position, she was still writing code, but the audience for that code and the environment in which she was doing it were completely different. Instead of developing software for commercial use at a large corporation she was writing software to support academic research at an educational institution.

[24] Amusingly, after she had been in graduate school for a little over three years, Penelope's graduate advisor was recruited to work at her alma mater, so she ended up moving from Southern California back to the Pacific Northwest. She is still funded by the university at which she began her graduate studies and will be receiving her degree from that institution as well, but her daily life is taking place in the same building as her undergraduate studies in her biology major.

The other person who underwent a job change did so in a slightly different fashion. Unlike Xenia, whose second position involved similar work in a different environment, Thalia elected to change roles entirely within the umbrella of industry. After graduating from college she worked as a PM for an Internet-based travel website company. After a year or so she realized she was not happy with the work or the company, and decided to look around for other options. After two years as a PM, having not written code since college, she secured a position as a software developer for a large online retail company. Many people were impressed with this switch. Thalia told me in our interview that

> People were surprised and impressed … especially the fact that I was coming as a PM and then going to be a developer, I think people felt like that was a tough transition and so they were impressed that I was doing it. (C1)

It is interesting to note that the two people who were working in academia when I spoke with them for a career interview were the same two people who had been interested in a study area at the intersection of their two majors (both of whose second major was in the biological sciences). All of the women who had considered CS their primary major were working in some sort of position in the technology industry. Given how positions are categorized for workplace data statistics, the woman in graduate school, for whom "programming is essential to analyzing my data" (P-C1) would not be classified as working in a computer or technical field, whereas the women who were PMs in industry, who did not write code at all, *would* be. This phenomenon might account for some of the statistical post-college "attrition" seen in women who pursue computer science undergraduate degrees. It certainly prompts the question of whether or not using CS knowledge or skills to advance other areas or fields is just as relevant as using it to work in software development.

When asked what prompted them to pursue a career in software development specifically, some people indicated that it was what they had always wanted to do: "Oh, that was my plan. From the beginning" (L-C1); "Sitting in front of the computer and writing code was the thing that I wanted to do" (E-C1). Both Leda and Electra decided on their career pathway – they wanted to be programmers – and then studied the subject in college that would enable them to do that after graduation. Medea had a similar perspective – to her, working in software development seemed like the point of majoring in CS: "It kinda seems like that's sort of at the core of what a CS degree is about, at least that's what I felt it was about" (C1).

Other people, however, had a slightly different take on things. For many people, programming or working in the technology industry was not always their goal, but it was an easy path to pursue after majoring in computer science, given all the recruiting that occurred at the college level. As Iris, who was working as an SDE for a large software development firm, put it, "Oh, I didn't really think about a career path, I just kinda kept following steps that just naturally appeared to me" (C1). Similarly, Gaia said of her career choices "I wasn't sure what I wanted to do, there was an offer on the table, so I guess I just took it because I wanted to spend a bit more time trying to figure everything out" (C1). Cassiopeia "took the product management job because it seemed sexy, and now I've just been running with that for a couple years, and now I'm successful enough at it that it's actually quite fun" (C1). Interestingly, after she left her first job, Cassiopeia felt a little burnt out and considered leaving the tech field, but was inspired to give it another chance because of how good the compensation was: "I realized that I probably didn't give tech enough of a try for how good the benefits are, and so felt like I should probably give it another try" (C1).

In addition to the two people discussed above who made somewhat radical changes to their employment situations (Xenia and Thalia), several other people with whom I spoke had undergone one or more job changes since graduating from college. In some cases, this was voluntary. Cassiopeia, for example, worked at a large search engine company for two years. After discovering that it was not really her thing, she took a few months off of work. She then came back and worked at a small game company. A year or so later, she found a position doing product management work for a political candidate about whom she was very passionate, so she picked up her life and moved from the Bay Area to a large Midwestern city for a six-month job. In other cases, however, the job changes that the participants underwent were entirely *in*voluntary.

Before graduation, Niobe accepted a software development position with a small real estate website company with which she had interned the previous summer. She encountered firsthand the volatility of the technology startup market, though, when the company had to do layoffs and her position was eliminated three weeks before she was due to start working there. Since the startup community is close-knit, she was able to secure ten or so interviews with other startups, and from those interviews she received three job offers. She accepted a position with one of those three companies, and at the time of our interview was still working for that same company.

Helen also encountered problems with layoffs. She accepted a PM position with a small startup prior to graduation, and six months after she started working there the entire company folded. She went back to the CS department, and they put her resume into the college recruiting pipeline. At that point she secured a PM position at a large software development firm, the same firm for which Xenia, Electra, Iris, and Gaia all worked. Less than a year later, that company did

a round of layoffs, and her entire group was eliminated. After eight months of somewhat stressful unemployment, including some volunteer work at a local high school in a computer science class, she found a temporary contract PM position, a job at which she was so successful that she was hired full time when her contract was over.

Rhea encountered the only personal layoff of the people with whom I spoke. Due to family considerations, she accepted a job in a rural area of the state because that was where she and her husband and children lived, and where they wanted to stay. The specific job she took required secret clearance; she started the position with temporary clearance. Despite her eight year service in the National Guard, including 18 months on active duty in Iraq, a year after starting her job she was denied clearance, which basically meant that she lost her job. She found another job at a very small company, doing work directly at the intersection of her two engineering majors, and at the time that we spoke was greatly enjoying her current position.

Not everyone mentioned promotions or advancement at work, but most of the people who did seemed content with their schedule of promotions. At least one person mentioned that she "had my promotion a little bit earlier than the normal schedule" (X-C1) and even people who voluntarily switched jobs because they no longer wanted to be at a particular company, such as Cassiopeia and Thalia, received promotions at those companies prior to parting ways, which indicates that performance problems were not one of the issues they encountered there. One of the participants was avidly awaiting a promotion that should have come with her most recent review, which would have been her second. Her manager said he would do everything he could to get her promoted within six months, but at the time of our interview she was considering looking for positions at other companies. While several people who had been doing the same job

for multiple years mentioned having seniority or leadership positions on their team, only one person had specifically been promoted to a management position with people reporting to her.

A general consensus among the participants was an ongoing desire to keep learning. This became challenging when one had been doing the same job for several years. As Medea put it, "I do enjoy having a lead role, but I feel like I've only been in this industry a little bit over four years, and I would like to have people on my team that I'm learning from still, and that's not the case" (C1). Rhea, who was working for a very small company (less than fifteen people) with an even smaller development team (less than five people), also stated that "I would like to have a larger work environment – more people to learn from, more people to interact, more engineers" (C1). Iris considered herself a perpetual learner; when she found herself a little bored at work, she combated this feeling both by matriculating in a post-baccalaureate undergraduate Humanities degree program (funded by her employer) and by volunteering as a TA for a program where industry professionals taught computer science classes in local high schools (C1).

In terms of future plans, some people were considering options or actively planning to move on. Both Niobe and Iris were putting some thought into what they wanted to do with their lives – "I think two to three years is kind of on average for a startup life, that's kind of when people start getting a little antsy and starting to want to move on, and I'm kind of feeling the same way" (N-C1); "I am still trying to decide if this is my end goal career" (I-C1). The one person who felt that she hadn't been on a good path since graduation – "I feel like I didn't choose to do computer science because I wanted to do this [software development]" (G-C1) – was planning to start graduate school in the next few months in a field that was an amalgam of cognitive science and CS.

Generally, though, most of the people with whom I spoke were happy with their careers thus far and happy in their current jobs. People who had encountered challenges in their career progressions, such as Helen and Rhea, felt that they were in a good place as of the time of our conversations. Rhea told me that her current job is "the perfect job – I write firmware, I write software, I touch everything that I'm good at" and then later "I really do love my work" (C1). Helen stated that "My career has been a little bit – a rocky start, but I think I'm in a good rhythm now" (C1). Similarly, people who had wanted to pursue this career from the beginning were happy with how it was turning out: "I picked the right thing for myself. I realized this is exactly what I was looking for, and this is what I got" (L-C1).

Life in the "Real World"

One of the recurring themes in the participants' post-college stories was the ways in which their workplaces felt "real" as compared to college. Several people noted that the stakes were higher in the workplace than they had ever been when they were undergraduates. Cassiopeia spoke of how in school "there's no opportunity for you to fail" because nothing was riding on the work one did; however, with the jobs she had held, "your neck is on the line" (C1). Likewise Niobe commented that in college projects "there's no customer depending on you to get everything right, to get all the pieces together, to fix bugs" (C1). At least four of the participants were on call to fix problems with their particular software or service and carried a pager for a week at a time every 1-2 months. (How often they were on call depended on the size of their team.) Different teams had different on-call expectations, but for the woman who worked on the payments team for a large online retail company "if you get paged it means it's important enough that you have to drop whatever you're doing and start working on it and get them a response" (L-C1).

Company finances, especially for startups, came in to play for more than one person. Helen's entire first workplace folded due to financial concerns, and she was caught by a round of layoffs in her second position. On one occasion Rhea and Niobe each had to cut back their hours to four days a week to save their money for their respective companies. (Despite the reduction in hours, Rhea was told that she was supposed to be doing the same amount of work. She responded by being very careful not to go in on Fridays or weekends, which resulted in her being "the first to get put back on full time" (C1).) For Rhea, this situation brought home the reality of small business finances as compared to the more secure experience of studying at a major research university.

Many people commented on how the workplace was more professional than school. Helen thought the environment at her company was a lot like the CS department, but better, because the presence of an HR department required people to "maintain some level of professionalism" (C1). Similarly, Niobe stated that "what really struck me was everyone's so professional, and everyone had kind of this business-like manner" (C1). This professionalism wasn't always triggered by the company culture, either; sometimes people had that attitude going in to the workforce. Electra, for example, felt that "when you are in the workplace you try to behave more professionally" (C1). Gaia stated that while she was friendly with some people at work who were not on her immediate team, for her workplace interactions "I keep it very professional" (C1).

In addition to being more professional, several people found that their coworkers in the workplace were different than they had been in college. As Xenia put it, "the people who actually doing very good at their jobs I think are very communicative … they are less geeky than I would have expected, and less – feel less geeky than the computer science department as well"

(C1). A couple of people also noticed less gender stereotyped behavior post-college – Electra observed that whereas in college guys would often try to act smart, this did not occur at work and Sibyl thought that – unlike in college – men no longer talked more than women once they got to the workplace.

In a similar vein, Andromeda observed that her workplace, a major animation studio, attracted fewer obnoxious and unhelpful people because "even if they interview well, they don't mesh with the culture very well and they usually weed themselves out" (C1). Iris's team went so far as to specifically screen interview candidates for particular personal qualities. Her team's location in an open plan "team room" caused them to "screen[ing] people also in the interview process not only for technical skills but also their cultural preferences" to ensure that the people they hired were open to sitting in a team room, for "having one person in a team room who doesn't want to be there will ruin it for everybody" (I-C1).

Several people who had found college competitive at times thought that in the workplace that element of competition was gone. Andromeda spoke of how collaborative and helpful everyone at her company was, to the point where "if you're stuck on something for five minutes, you have to get up and go ask someone" (C1). Cassiopeia commented that "I think everybody wants to be really good at what they do, but I think everybody sees that as a competition with themselves, or something to push themselves on, not necessarily something they have against other people" (C1). Thalia thought this shift was due to a culture of mutual respect for intelligence among coworkers: "Everybody at the company just assumes that they're really smart, and that they know what they're doing, and that everybody else at the company is also really smart, and so you don't really need to prove yourself" (C1).[25]

[25] It is worth noting that this is the same sentiment espoused by several of the professors surrounding the CS admission to major process. In requiring an application for a competitive major, the department hoped to indicate to

Another common consideration was that people often had families. When asked about the difference between college and her current environment, Penelope's response was "People have lives. And babies" (C1). This sentiment of being surrounded by people with lives outside of the workplace, who were sometimes married and sometimes had children, was reiterated by at least half of the participants. Leda noted that the people "who have families … have slightly different interests" (C1) and Gaia commented that she found it harder to become close with people in such different life situations: "People here tend to be more mature, have family, and so I do not really become friends with them outside work" (C1). Sibyl, who had married and started a family since graduating from college, expressed a similar sentiment to Gaia: It was easier to hang out with people who had kids because "they will be able to understand a little bit better, right?" (C1). (While two of the participants, Rhea and Medea, already had one or more children when they matriculated in college, this wasn't a common component of the undergraduate culture in the CS department.)

Work/life balance was a consideration mentioned by several of the participants. Some people had to juggle more obligations than when they were in school – Sibyl sometimes found that "There is times when I don't feel like I'm spending enough time with my baby … and I don't think I can accomplish what I'm trying to do at work if I don't spend today or these four nights doing this stuff [i.e., work for her job]" (C1). Other people, however, had the exact opposite experience, and found themselves more free to pursue their social pursuits than they had been in college:

> School is something that you do 24 hours, it's part of your life. Work you don't need to do that – you work really hard during the work hour, if something need to be shipped soon, sure you might work overtime, but you do have your personal

all the students that everyone in the department was an equal and thus people need not be competitive with their peers.

> time, you do have your own time that you completely separate yourself from work. (G-C1)

Interestingly, one of the participants had changed her perspective on this topic. When in school, Thalia had had a distinct cut off point for her computer science work, but in the workplace she found that she had to be "intentionally cognizant … to really keep those boundaries" between work and home. Thalia attributed this difference to a sense of independence and ownership: "When you really own something, you're much more inclined to work until it's done, because you're much more excited about owning it ... that's just a very different mentality to a teacher telling you 'it's due on this day'" (C1).

For at least one person, her extra obligations came with some built-in benefits. Whereas in college she had had some friends but no family nearby, Sibyl now had more immediate family support in the form of her husband and daughter.

Usefulness of a CS Major

All of the women with whom I spoke with felt that it was beneficial to have been a computer science major. Some people felt that their degrees were more directly useful than others did. Rhea used her two engineering degrees "all the time" (C1) and Medea "couldn't do what I do without my major" (C1). Gaia, conversely, felt that "most of the classes I had taken they aren't really related to what I'm doing day to day" (C1). However, the general consensus seemed to mirror Sibyl's point that "The foundation does come from the college" (C1).

The most common sentiment among all of the participants was that the computer science undergraduate major was very good at teaching people "how to learn things" (N-C1). Andromeda thought that "before college I wasn't very good at learning on my own" (C1), but towards the end of her time in college she thought nothing of picking up a book on a new programming language and learning it in three weeks for a job interview. Electra said "Once you

know one language you can pick up another" (C1) and Iris commented that "The great thing about computer science is the fundamentals kinda stay the same, but everything on top of it changes" (C1). Thalia very much appreciated the way in which her CS education helped her "figure out your answers to the questions, like if you're doing programming and you don't know how something works, figuring out how to look it up or how to ask the right questions … like how to break a problem down" (C1).

Helen and Cassiopeia, the two people who were working in industry but not doing programming work, both felt that having a technical background was beneficial in their jobs. Helen's coworkers "get excited 'cause I speak the language, I understand what the devs are doing" (C1). This was particularly relevant in her case because the two PMs that had been there before her had been non-technical, so when she started at her current position her technical knowledge "was this huge advantage" (C1). Cassiopeia also commented that "Everybody knows I'm super technical, I'm super analytical, that I'm at the top of all of the chains as far as that goes, so it's not like I'm ever being questioned" (C1). Andromeda, who held a position that she thought of as "computer science-lite," specifically mentioned how beneficial it was to have a CS degree, especially given that so many people in the animation industry had self-taught programming skills: "It's really useful, I have a degree and I know proper programming etiquette, so just the ability to develop tools properly and correctly, I just – I know how to structure my code, and that's really useful" (C1).

A couple of people specifically stated in their career interviews that they thought the most useful things they did in college were the activities that they considered more "real." For Cassiopeia, this was her experience as a TA, and for Niobe, it was her computer science research, in which context she had to give presentations and be able to express her work and

ideas clearly. Sibyl, who was an international student and a non-native English speaker, also felt that her undergraduate experience helped her to communicate more clearly with people once she got to the workplace (C1). Leda believed that one of the real benefits of the CS major was the work ethic that it inspired – she spoke of "being organized, and getting the work done on time" (C1) – and Penelope thought that having a CS degree made her graduate work "so much easier" (C1). By and large, though, what people seemed to find the most valuable from their college experiences were the intangibles. While she didn't think any particular CS class was all that useful, Cassiopeia believed that "having a community and knowing a lot of smart people pretty well is helpful" (C1).

On a slightly different note, Niobe felt that it was beneficial to have had experience working with so many guys as an undergraduate, because it enabled her to deal appropriately with her male coworkers:

> And I think actually college did a really good job of preparing me for the work environment in terms of the male female balance and stuff, because I guess when you're working with a lot of men you've got to be able to – you've kind of gotta be able to dish it out, I guess. (C1)

At the same time, there were some ways in which people felt that college had not adequately prepared them for working life. Helen thought that "School kinda gives you a false sense of security that if you've met the requirements you know you're set" and that the amount of work that would earn an "A" in school would be equivalent to being approximately 20% done with your project in the workplace (C1). Similarly, Xenia noted that in her CS classes in college "you know there's a right answer" (C1), which was not always the case in "real life."

Despite the focus on group work in undergraduate courses, several people found that working as part of a team in the workplace was a very different experience. Gaia noted that "you don't have to be super diplomatic" with your groups in school, whereas diplomacy was key at

work (C1). Helen felt that the group work one did in college didn't really compare to what it was like to mesh with others in an actual work team:

> I think the thing you're not really prepared for is being one of a team. You come out of computer science and maybe you've done some homework assignments where you're in twos or threes or something, you're trying to get something done, but being part of a team – and sometimes that team is 12 people and sometimes that team is 200 people – but you're cog and even if you are the most amazing cog that does all their work, everything, writes a whole ton of code all by yourself, at some point you have to plug in with all these – you know, into the rest of the system and how it works and be – and contribute along with everybody else's contribution.[26] (C1)

While in general people seemed happy with the college-level recruiting process, one person who was in more of a niche field within CS felt that the recruiting options were more limited for people not going into straight-up software development: "There was a lot of job exposure if you wanted to be a software programmer, but if you wanted to do little offshoots of that [e.g., animation], I think it was a little difficult" (A-C1).

Some people noted that the CS major did not prepare students to work in or get ahead in a corporate setting; yet even people who made those comments did not think that college should or even necessarily could do that type of preparation: "I don't think school can prepare you [for work], because what you do is different from what you do at school" (E-C1).

Influential Individuals

As was the case with their pathways into and during the CS major, other people did have an influence on the participants' career progressions. While previously this influence was often

[26] It is worth noting that some classes probably prepared students better for this workplace experience than others. Andromeda's animation capstone, for example, in which the entire class worked together to produce a movie, was probably a closer facsimile of this team environment than many of the other computer science classes. However, given the structure of the CS major, only a small subset of the students in the CS department would likely ever take a class that required all of the students in the class to work together on one project.

informal – e.g., the family friend who bought Medea a computer when she was in high school (M-U1) – the workplace offered more opportunities for formal, often hierarchical, relationships.

People's managers at work ran the gamut from extremely supportive to extremely unsupportive. At the time of our career interviews, the women with whom I spoke had had as many as four managers (in one case, probably more, due to multiple job changes), often within one company or position due to internal reorganizations or job changes on the part of individual managers. Iris's manager was so in tune with her that he sometimes offered her advice before she even knew she needed it, and had "basically … made it his job to make sure I'm happy at my job" (C1). Similarly, Thalia's manager was very understanding and helpful, consistently communicating that people on the team always said really good things about her and were really confident in her ability and Niobe's manager was not only willing to fight for his team to make sure they received recognition with upper management, but was also very good about ensuring that his people were doing work that they liked. While many people spoke of similarly good experiences with managers, unfortunately not everyone's experiences were this positive.

Before starting a full time job after college, Electra had an internship with the same company she eventually went to work for full time. During her internship, her manager came to her office every three days and told her "But remember Electra, internship is like prolonged interview. After that we will decide whether we give you offer or not" (C1). Later, after she started her full time job, she had a manager who mismanaged the schedule to such an extent that she had to work on two projects while only having time in the schedule for one, which basically meant that she was sleeping in her office. In a similar vein, at one point during her tenure at work Gaia had to cancel a prearranged three-week trip to China with her boyfriend because her manager's manager "wasn't happy about it" (C1). While she could still have technically gone on

the trip, it was clear that it wouldn't have been a politically savvy thing to do: "This is part of the reality, part of working in corporations, you do have to be more careful, especially if you're not in the position where you can command more – I don't know – flexibilities" (G-C1).

Mentoring was another semi-formal work relationship that people sometimes developed. Interestingly, though, it did not seem to have a huge impact on these women's lives and careers. Some people spoke abstractly positively of their mentors, such as Iris, who talked to her mentor about logistical things like career moves, or Electra, who opted in to the mentor program to have someone of whom she could ask questions. However, most people either didn't have a mentor or simply opted not to mention that they had (or had had) one. In some cases mentors were assigned by the company, and given what I was told about company policy for at least one large company, it might be inferred that other people working for that same company – who did not mention a mentor – also had received mentoring at one time. (Five people in total mentioned having a mentor.) This inconsistency with regard to mentoring ties back to the point made earlier, that my conversations with the women often had different foci depending on what each person considered important and relevant to discuss.

Formal work relationships were not the only ones that had an influence on the participants' lives and careers. Another category of people that had a strong influence was family. Niobe, for example, had a very strong goal of financial independence after graduation because she knew that her parents "would not really consider me to be an adult unless I was financially independent" (C1). This desire prompted her to pursue a career in the tech industry, as opposed to music (her second major), because a job in software development would enable her to support herself. Helen's parents, on the other hand, didn't really understand her desire to work in engineering, but because it was important to her they were supportive. When she was

unemployed and job searching, they packaged up grocery gift cards for random holidays to enable her to continue living on her own.

Not everyone's family was supportive or encouraging, though, at least not initially. While her mother was fine with her career choices, Electra's dad "was very disappointed, because since I was a doctor in my home country and I didn't continue being a doctor here, he perceived me as a loser and a big failure" (C1). Even after she got her job in software development, "the first couple of years he was all the time waiting when I would get fired" (E-C1). Electra classified this as a cultural tendency that she had to work to overcome:

> That's just cultural, I think. Because that's the way I was raised, that you should not acknowledge the accomplishments of your child, you should kind of put him down so he will strive for more. I hate it, I think it totally doesn't work, it just ruins your self esteem. So I had to work hard on myself to overcome all of this. (C1)

At the time of our career interview, Electra stated that things had improved with her father, and that he was okay with everything now.

Both Sibyl and Andromeda continued to be positively impacted by their fathers. Sibyl got her initial interest in the computer science field from her dad's work with games and internet browsing; the year before our interview she had even started a company with him in her home country that builds software for cyber cafes there. Sibyl's father was very supportive of her career as a software developer, even though he was excited for her to return home some day: "He does say 'it's good if you want to take time to learn all the things that you can' but eventually I know that I'm going to be going back home sometime" (C1). Similarly, Andromeda indicated that "my father continues to be – like he's one of the guys that inspired me to actually do this … he kinda exposed me to all the stuff that got me into animation, so I continue to talk to him about it" (C1).

Parental support was not the only familial influence that the participants encountered. For Rhea, "My kids are my inspiration, because I want to be successful" (U2). Both Sibyl and Xenia spoke of how their husbands were very encouraging of and influential in their career choices. Sibyl's husband "would understand the reason why I would be doing a lot of readings, a lot of investigations on programming, taking a lot of online classes when I don't really need to, he would understand that, and he also bought some books for me" (C1); Xenia and her husband were "very close and we talk through everything" (C1).

In addition to family, friends – including friends from the CS department – and significant others were also important in these women's career pathways. Thalia and Cassiopeia were close friends, and discussed starting a company where Thalia could be the CTO and Cassiopeia could be the CEO. Additionally, Cassiopeia's success and happiness in the tech industry was part of what motivated Thalia to change jobs when she was unhappy in her PM role. Both Cassiopeia and Andromeda cited boyfriends as significant factors in their decisions not to move to a different geographic location for a job and Penelope's fiancé's father, who was himself a professor, was able to help her navigate the "academic realm" (C1). Niobe's piano teacher, who she started taking lessons with again a couple years after graduation, was extremely influential in her life; Cassiopeia found that she still contacted Wolfgang with questions (as she had done when she was in college); and Helen's former boss from her failed startup was one of the first people she called for advice when she had a change in her employment situation.

Job Satisfaction and Success

While some things had changed from their time in college, one thing that had remained consistent was the participants' ongoing desire to learn and be challenged. All but two of the women I spoke with told me that one of the things they valued most about their current position

was that it was "intellectually stimulating" (P-C1). While they sometimes used different words or phrases – "I get to learn a lot" (S-C1); "You're solving crazy problems" (H-C1); "I'm constantly learning new things" (C-C1); "I like the interesting challenges" (M-C1) – the sentiment was the same: They enjoyed being intellectually challenged. The two people who did not cite this as a valuable trait in their work still valued this type of mental stimulation, but felt that their jobs did not provide as much of it as they would like. Gaia encountered "a lot of drill work that you just have to do" (C1) and Iris thought her position "doesn't hit my ceiling of intellectual stimulation" (C1). (As previously mentioned, Iris had just matriculated in an evening post-baccalaureate undergraduate degree program "because I wasn't being intellectually stimulated on everything I'd like" (C1) and Gaia was planning to leave her position in a few months to go to graduate school.)

Several people indicated that while their jobs were currently "challenging enough" (L-C1), the lack of challenge in the past had prompted them to seek a change: "When I was on the previous team at some point I guess I was here just long enough working on the same team it stopped being as challenging … I thought 'okay, this is kind of getting old'" (L-C1). For Niobe, the decreasing challenge of her position was one of the reasons she was considering leaving – she found that she was working on "the same kind of types of things that I was doing a year ago" and wanted to find a job where she would be "working on different things" (C1). At least one person realized that this constant need for new challenges might someday become problematic: "I think this is probably going to be my problem in the long term is like any job is super fascinating for the first six months you do it, and then once you understand how it works it's actually not that fascinating" (C-C1).

For some people job satisfaction was tied to the societal impact of their work. Helen worked for a data storage company, and one of the things she most valued in her position was that the systems they implemented "affect these humongous business systems and affect literally everyone in the world" (C1). Likewise, Penelope was inspired by her belief that the research she was doing "will have some sort of long-term impact on our understanding of the world" (C1).

While not everyone had the opportunity to interact with customers, those that did generally felt that they benefited from this exposure. Sibyl commented that "sometimes it is challenging to understand the reasoning behind of a certain design, but if you get to talk to the customers it makes more sense sometimes" (C1) and Xenia liked the close connection she currently had with the people using the programs she wrote: "That's the part I do enjoy from the current part, where when I write programs, actually people using them are sitting next to me" (C1). One person even felt that she had avoided a round of layoffs because her team was "doing so much work for the customer" (N-C1).

Other things that people appreciated in their positions included flexibility – Sibyl was able to work from home on Fridays, which meant that her daughter only had to be in daycare four days a week instead of five – and having a transferable skill set – while her current campaign work environment was very different from the technology industry, "The metrics I'm trying to move are different, but the methods to moving those metrics are very similar" (C1).

While people generally seemed happy with their compensation and benefits, very few people stated this unprompted; if they did, it was usually the third or fourth thing they mentioned in the longer list of things that they valued about their jobs. This substantiates Rhea's point that what really matters is enjoying your work: "as I tell my kids, as long as you love what you're doing that's what's important, it's not how much money you make" (C1). Helen felt similarly:

"Honestly, nobody sees what's in your bank account, everybody sees what is on your e-mail signature, so I'd take a promotion over big money" (C1).

Unsurprisingly, people's coworkers had a big impact on their enjoyment of their jobs. Helen thought she felt as comfortable as she did in her current position largely because of the people she worked with – she referred to them as "your favorite people who are wicked smart" (C1). Iris also "had a lot of great coworkers" (C1). Andromeda loved that she worked with people who were passionate about the same things as her, and really appreciated the "crazier work environment" – her cubicle, for example, is a tiki hut (C1). Conversely, Cassiopeia felt that one of the reasons she didn't like her first job all that much was because the people took themselves "really seriously" and were "*really* entitled" and there was "no hangout culture that I wanted to be a part of" (C1).

In terms of success factors, people cited things like being a good communicator (Niobe), working well with others (Andromeda), having passion for your work (Gaia), writing good code (Electra), paying attention to detail (Helen), being a self-starter (Penelope), and growing your knowledge (Iris). Medea commented that "you need to deal well with ambiguity" (C1) and Thalia felt that individual responsibility was key: "If you break something you fix it, if you say you're gonna get something done you get it done" (C1).

For Helen, success in the workplace was very tied to "being recognized as a leader, being recognized as somebody who gets it, who understands, who when she opens her mouth that she has something valid – you know, valuable to say" (C1). (Helen commented that this external validation was especially important to her given the somewhat rocky career path she had experienced prior to her current position.) Cassiopeia also valued recognition and valued having "a set of skills where I can go into a new organization and within a week everyone's gonna be

like ‘oh my god, I’m so glad you’re here,’ ‘oh my god, you’re really good,’ oh my god, we need more product managers’” (C1). Sibyl thought that “Success is that you be able to influence a lot more people” (C1).

Two different people spoke of the necessity of being open to new ideas. Sibyl stated that you need to “understand the reasonings behind other people’s decisions” and that you can’t always “say that your point is the right one, that your argument is the correct one, you would need to understand where all the other suggestions or point of views are coming from and understand why” (C1). Xenia had an analogous perspective – in her experience you can’t just hold on to “a particular idea and think that’s the only way to get it to work” (C1). Interestingly, this ties back to a comment made by one of the professors I interviewed, that success in his class was dependent on not being “closed-minded” (Antonin).

Visibility was also seen as a key component of success. Gaia stated that “Visibility is pretty much everything” (C1). While visibility can be a positive factor (e.g., people know you by your good reputation or your contributions to your team and workplace are easily evident), most of the contexts in which the participants mentioned visibility were unflattering. Thalia commented that at her first company “The people who made themselves look good got credit” (C1) and Gaia observed that certain types of visibility are undesirable in terms of career progression. For example, dressing nicely will get you noticed, but

> Clothing is not going to be a good kind of visibility … It doesn’t send the right message, I think. Because I have red hair I got noticed, the girl with the red hair in the room, but it wasn’t being associated with her idea or her contribution to the meeting. (G-C1)

Thalia took a slightly different approach than many other people, and managed to reframe her definition of success to include the things that she was good at:

> One of the things that really made me successful was realizing what my strengths were, or what it was that I felt like I was good at or that I liked doing, and figuring out how to make that an integral part of my job … For a really long time, I had this idea of what it meant to be a programmer, and I tried to do that, and then I realized that I can be good at being a programmer in my own way, and incorporate the things that I'm good at, and emphasize those as the skills that I have. (C1)

Effects of Confidence

Self-confidence came up in several of my conversations with the participants, in different contexts for different people. When finishing up her undergraduate degree, Medea did a recruiting phone screen with a large search engine company for which she had not time to do any interview preparation. She was very nervous during the initial phone screen and in her words "totally bombed" – she had "no phone interview skills … [and] no idea of the kind of questions they were gonna ask" (C1). In hindsight, based on her experience interviewing people for her current programming position, as well as her past experience interviewing people for the restaurant business, she stated that having a lot of nerves is "not attractive in an employee quality" and that it "doesn't speak well about your confidence about your own position and so I think that was bad" (C1). Conversely, for her interview with her current company she "definitely felt relaxed and confident" (C1), a mindset which she felt contributed to the positive outcome of the interview.

Xenia's experience with confidence also came into play in her job interviews, but in her case it affected where she applied for jobs. She was intimidated by software development jobs, and "never thought that I had enough robust programming experience to apply for those" (C1). The one resume she gave to a large software development company occurred by chance, because the person at the career fair happened to be free. After receiving an offer from that company

(which she subsequently accepted), Xenia realized "hey, I should have applied to the other ones!" (C1)

Given her challenging career pathway, Helen also grappled with lower self-confidence in her first few years out of school: "By having two false starts, in a matter of a year and a half out of college, I was absolutely devastated, my confidence was totally shot" (C1). When she finally got her third job, her internal monologue was asking questions like "If you're hiring me, are you sure you're a good startup?" (H-C1). At the time of our career interview, though, Helen's good job experience had had a positive effect and she felt like she was in a good place in her career. She stated that for now "I think I want to stay on this track, and when I get off this track I'll be on a different track completely. This is fun" (H-C1).

Other people also spoke of changes in their confidence levels as their careers progressed. Cassiopeia was put on a very poorly organized project when she started her first job, but "kinda ran with it 'cause I was like at first they're not gonna give me a completely stupid project, obviously I should figure out what to do with it" (C1). In hindsight she realized her initial assessment was correct, and "if I was given that now I'd be like 'this is stupid, why are we thinking about this, this is not a meaningful project'" (C1). She attributes her increased belief in her own assessment to an increase in confidence, which is itself beneficial as a job skill: "Having the confidence, and knowing that I can actually do a reasonable analysis of these things, is really valuable" (C1).

Similarly, Thalia began her current job concerned that people "were going to figure out I had no idea what I was doing" and was thus hesitant to ask for help because she was afraid of being "found out" (C1). However, her confidence increased through her years as a programmer, and she is no longer as concerned as she once was about showing ignorance: "But that's less

now, I think that I've gotten more confident" (T-C1). She does find, however, that if she talks to her male friends about confidence issues "they don't seem to understand or relate to the lack of confidence, they just see it as the problem that needs to be solved" (T-C1).

For some people, confidence was necessary to even continue on their chosen path. Penelope felt that being in graduate school "kind of takes a little bit of unbelievable confidence in yourself or your advisor or whatever else" (C1). Similarly, Niobe thought that one had to "be confident" to succeed in the workplace (C1).

Iris felt underconfident in her technical ability and yet hesitant to ask technical questions because "I feel like, I'm a dev, I should be a technical, I should know all this stuff" (C1). This phenomenon has made her doubt whether or not she belongs in programming:

> The not-being-confident thing has really made me question whether this is the right career for me. Because it's not a natural – I don't feel like it's a natural career for me. It's interesting, I'm good at it, which is kind of how I fell into it, but it's not my passion, which because I'm not passionate about it I'm not taking the steps to improve my confidence, which is spending more time reading other people's code, or learning about new technologies and stuff like that, and so that's not helping my confidence because I'm not doing the stuff it takes to get there. (I-C1)

As can be seen from the above quote, Iris's lack of confidence ended up being a vicious cycle, in which lack of confidence begat lack of passion begat lack of interest in doing things to improve confidence. This concept will be discussed in further detail as it relates to gender later in this chapter.

Some people felt similarly to the way they had in college. Electra still struggled with the feeling that she knew less than her coworkers – "I think everybody knows everything around me other than me, so it's like it was the same thing in college, and the same thing now, I feel the same" (C1). Leda also still thought that sometimes it took her longer to figure things out – "When we have some project, maybe sometimes I have to research a little more how to get this

done, and maybe I think other people, some other people that I work with, they can know right off the top of their head how to do this" (C1). Leda realized that this feeling might stem from the fact that she had been the newest person on her team for quite a while, and acknowledged that she did not think that other people noticed her taking more time to work on things: "I don't think they know. Like because if I spend extra time, how do they know that I did?" (C1). Like Leda, Rhea also sometimes felt that she needed to spend more time on certain problems. In order to not "let on" to her coworkers when something was taking extra time, Rhea often did the work on her own time: as she put it, "sometimes it's nice to work without having to justify what you're doing" (C1).

Gender and the Workplace

Despite having experience as the minority gender in the CS major, at least one of the participants was shocked by the even smaller numbers of women in parts of the technology industry. When Thalia started work as a software developer, she was not only the only woman on her immediate team of four, she was the only woman in her larger organization of 50 developers, a situation "that I was really not prepared for. Even though at the university there had been – oh, I don't know, like 30% women – there was always at least one other girl in every class" (C1). Other people had similar, although less extreme, experiences. Xenia was one of two female developers on a team of 30, Electra was the only woman on her 20-person development team, Gaia was the only female engineer on a team of around seven people, and on Leda's first team she was the only woman on an eight-person team. (As Leda pointed out, though, it could be worse: "There are teams where there are no girls" (C1).) Even Penelope, who was in graduate school in a branch of the biological sciences, started out with only two women on her team of 25.

Rhea was also the only female engineer on her team, but as of the time of our conversation she comprised 33.3% of her three-person team.

Small numbers of women led to some awkward moments for the participants. Thalia's larger team had a monthly meeting with all the developers which, in her words, was "me and all these men" (C1). In that meeting "the director of the team, who's a great guy, I really like him, when I started he'd be like 'hey guys' and then he'd kinda pause and look at me and be like 'oh and – and girls'" (T-C1). Unsurprisingly "that made it worse, that made it more awkward" (T-C1). As in college, Thalia's primary frustration with the small number of women on her team – which at the time of our conversation was up from one to three, soon to be four, in her larger organization – was what it implied about women's abilities in technical fields.

Not everyone's situation was this gender disparate, though. Leda's current team had three females out of 11 people – as she put it, "almost 50%, right?" (C1) – and on Niobe's engineering team three out of eight developers were female. In fact, one of the reasons Niobe had taken the job in the first place was because she was impressed with the large number of women in leadership positions at the company: "There's these like cool women in leadership positions really running the company" (C1). Andromeda had a similar experience. While "it's definitely a majority men in the more technical departments," she noted that "a disproportionate number of women are actually supervisors and organizers and the people kind of leading these things" (A-C1).

Some people could not point to any particular impacts of gender on their work setting. When asked if she thought that gender might have impacted her work experience, Leda replied with "Probably, but I don't really feel it. I don't really think about it" (C1) and indicated that she had no reason to believe she was treated any differently than a man in the same position. Electra

had a similar perspective, stating that "I cannot say much about how gender differences – how much gender differences I see, because I don't see them … I mean, I don't perceive that I'm treated differently because I'm a woman" (C1). Andromeda, who had encountered a lot of differential treatment in college based on her gender, stated that gender "has really not even been an issue" at her current company, which she thinks is fantastic. As she put it,

> It's not something that I consciously think about anymore, which is kind of surprising because I feel like I've always thought that through my education "I'm a girl and it's hard for me" and I feel like … in the past few years, I haven't even given that a second thought. (A-C1)

As in college, some people believed that being female did have an effect on their work environment. Rhea felt strongly that the denial of clearance for her first job was a result of gender bias, and that she had been judged differently than she would have had she been a man. Iris thought that at her workplace there were "some things you have to watch out for" (C1). While she did not elaborate on specifics, one of Iris' comments indicated that remarks might be interpreted differently coming from her than they would be coming from a man: "I have to be conscious about some of the things that I say. The guys can all be talking about shit, but then if I said something sometimes it's not appropriate, it's just better if I just stayed silent on things" (C1).

Gaia felt that being female proffered an actual physical disadvantage at work: "I don't think gender impacts – intentionally impacts it – but … I think it's fair to say that having a bigger presence, deeper voice, taller, stuff like that, do help in meetings, and getting visibility" (C1). Medea, who worked on the fulfillment center team for a large online retail company, actually got yelled at once on a business trip when she had to tell people at the warehouse she was visiting that it wasn't possible to do what they wanted to do. She definitely thought this behavior was gender-related – as she put it, "I don't think they would have screamed at a man,

that's kind of fightin' words – if you stand up with a red face and yell at some guy, you might get hit" (C1). Based on her previous work experience, she was unfazed by this experience, simply observing that "wow, you're kinda out of control and inappropriate" (M-C1).

Thalia was told by her lead, who "tried to say this in a way that didn't sound sexist and then got so hung up on being sexist" (C1), that she made the team nicer. In her opinion, "I think part of it was they felt like they had to be a little bit on better behavior 'cause I'm a girl" (T-C1). After a merger which resulted in her team having 20% female developers, the highest percentage across her entire organization, Xenia also thought that "Once you have so many females in a group, even the males start getting more softer" (C1). Xenia's take on this was similar to Thalia's perspective: "The guys who are not soft spoken and like to use vulgar words or swear, they probably don't feel comfortable after a while, and they want to go find somewhere with a male lead. That's my guess" (X-C1).

Some participants believed that gender had the potential to impact work expectations. While Gaia hadn't experienced this phenomenon herself, she told me that "my friend who was involved in the hiring process said there has been instructions saying that if it's a female then kind of like make it slightly easier or something. So I think it happens" (C1). (Gaia did acknowledge after making this statement that "I don't think he actually get explicit instructions saying that, but – but he could have exaggerated as well" (C1). However, the point still stands that this type of behavior or commentary is not unheard of in the workplace.)

Sibyl had a more personal experience with this: She felt directly that the expectations people had of her were lower, possibly because she is female but also potentially because she is a minority. However, she recast this as an advantage, indicating that lower expectations made it easier for her to exceed expectations: "It helped me, because if you can give more than what

you're expected to, then you're in a good position of impressing people and getting a higher expectation the next time" (C1).

In several cases women found themselves typecast based on their gender, often in an organizational or secretarial role. Helen told me somewhat sarcastically that "We get picked to plan parties, because we're girls and girls like to plan parties" to which her response was "Do you realize how bad I am at planning parties?" (C1). Similarly, on one occasion Penelope brought a pen to her team's lab meeting, and thus ended up being "the one who put things on the calendars." In order to not perpetuate this scenario, she "intentionally didn't bring my pen in next week 'cause I don't want to be lab secretary" (C1). Iris, on the other hand, did a lot of planning for her team's group social events and laughingly stated that "I feel like I'm the social calendar" (C1).

On a related note, when Penelope's team moved into a new lab, the women ended up being the primary organizers, both in terms of setting up the fly incubators so that they would have flies to use in their future experiments and in terms of unpacking and organizing the lab itself. Penelope commented on how gender roles came into play in this experience:

> I feel like some of this stuff is just it's more second nature to me and another female in the lab when we have these kind of work parties to unpack stuff and find places to put them in the lab, we're basically building the lab, my labmate and I – she and I just kind of always found things to do, it seemed really easy, like of course we're just unpacking things, maybe we just moved a lot, I don't know, but the guys – you know some of the guys would just kind of stand around, like "what do I do now?" (C1)

Directly after saying this, though, Penelope acknowledged that while these actions seemed gender-related, "that might also just be them, or us, it's so hard to say. It's tricky" (C1).

In addition to stereotypes about organizational abilities, the participants also encountered gender stereotyped perceptions of women's technical interests or roles in the workplace. Electra

did not like working on user interface (UI) – as she put it, "Moving one button two pixels to the right and two pixels left just drives me crazy" – yet people on her team believed that women liked working on UI, and despite her protestations Electra was assigned more than one such project. Thalia, likewise, encountered a fair number of assumptions surrounding women and technical ability and career moves within the workplace. She spoke of the phenomenon of "PMing people" in which the general belief was that "Women tend to move from development roles to PM roles, because they're considered more people persons and not as technical, and it's always where their interests lie more" (C1). Given her own transition the other direction, from PM to developer, she found this tendency particularly frustrating.

At least one person noticed that she herself was exhibiting gender-stereotyped behavior. In a women's group Xenia had attended at her first job, one of the things discussed was the tendency of women to undersell their own abilities. Xenia had never thought of herself as weaker due to her gender, but after this meeting became more aware of her own actions:

> There was one lesson I learned from the whole thing which I still use – I constantly think about it, but it's the person says that we – women tend to undersell ourselves, and I find myself lots of times doing it. I never really thought about me being a female developer being weaker or anything but this particular quote that I heard was very true to me, and recently my supervisor asked me saying that I'm doing a good job, you could even take my position, things like that, and purely by habit I totally dismissed – "oh, I cannot do that" – then I remember the quote saying that the guy tend to be more ambitious and take on the position even though they know they are not qualified for, and women will simply say "oh I'm not qualified therefore I'm not going to take it" and I feel like I'm doing that pattern. (C1)

A couple of people mentioned self-confidence in our discussions of gender in the workplace. Iris noticed that the men she worked with tended to be more confident in their technical ability than were the women, herself included: "Guys are way more confident than girls … they just feel really confident in their skills and abilities, whereas I don't" (C1). Niobe,

conversely, felt that working with men actually triggered confidence: "You've gotta be able to stand up for yourself, and be confident" (C1).

Some people encountered borderline inappropriate comments or behaviors in their workplaces, a couple of which were work-related. Rhea, who worked for a very small company, ran into an assumption of incompetence based on her gender when her boss "once made a comment something about that I had changed his opinion on women engineers; changed his opinion meaning like that I was good, and that 'wow, maybe a woman *could* be technically savvy'" (C1). Rhea, who self-identified as very laid back about political correctness, stated that "He's lucky that I am who I am" (C1). Helen noted that one of the directors at her company was "a little bit on the traditional sexist side" and would make comments like "well, you're cute and blonde, of course they're gonna try and work hard" or, after she got married, joke about her getting her "MRS degree" (C1). While she felt that this director was generally nice and just kidding around, Helen still found that "it rubs me the wrong way too, and I really don't like it" (C1). At the same time, though, she did not feel comfortable confronting the director in these situations, preferring instead to simply move the conversation along, a behavior which may well tie back to her previously identified issues with confidence.

A couple of other such situations were not specifically work-related. Iris's coworker, when he was going through a separation from his wife, told Iris that his wife had accused him of having an affair with her, which came as a complete shock to her. While the situation didn't impact Iris' work, per se, "it is something being in this environment that I've had to deal with that I normally wouldn't have had to deal with" (C1). Xenia's experience was slightly less personal: In an office shared by the IT guy and several other programmers in the university's technology center there was a sexist poster of the female star of the Transformers movie up on

the wall. She thought that if someone had put this up in her first workplace, the large software development company, they would have been talked to about it, but in her current workplace there was no way to anonymously address the issue without "raising some eyebrows" (X-C1).

In terms of the impact of gender on management, the participants' experiences were mixed. Rhea described her boss as "kind of a good ol' boys club type" (C1) but did not feel like this had particularly impacted her work. At her first job, Cassiopeia had had a female manager that she thought was terrible, but "she wasn't terrible because she was a woman, everyone just agreed she was a terrible manager" (C1). Sibyl had a very positive experience with a female manager, though, given the similarities in her and her manager's life situations: "Because she also has a family it becomes more flexible … she understands me a little bit more compared to the male managers" (C1).

Two people received feedback on performance reviews that may well have been gender-related. Medea, who felt that she'd had a few bumps "because I'm a woman and because I have a very strong personality" (C1), was asked to be softer and more considerate of people's feelings in meetings, as opposed to being blunt and direct, which has always been her personality. While gender was never specifically mentioned, Medea believed that the person who gave her that feedback thought she was behaving inappropriately *for a woman*. She noted that "I've been in a lot of meetings with men and have never had men dance around other men's egos the way that I feel like they wanted me to," subsequently pointing out to her manager that "I really don't think if I were a man you would be asking a man to be nicer when he disagreed with somebody" (M-C1). Because these gendered comments had affected her compensation, Medea asked her manager to fix it with HR, which he did. Had he not done so, she "might have considered suing

them. Because some of the comments to me were so inflammatory and really I don't think anyone would say that to a man" (M-C1).

Electra was reserved in her demeanor at work, and received feedback on more than one occasion that while there was no problem with her performance, people were concerned that she did not like what she was doing because she did not show enthusiasm for her work. The reasons for Electra's seeming lack of enthusiasm were twofold. Firstly, she felt that "When something works it's – I always think that 'yes it's supposed to work, because I'm working on it'" and secondly, she felt that one should act more professionally in the workplace:

> When I was at school, right, and working on the project, we are sitting in the lab, and something works, we are shouting, screaming, jumping around, but when you are in the workplace you try to behave more professionally, right? So I didn't jump around and obviously didn't do high fives with my teammates. (E-C1)

Electra conducted an experiment and found that acting super happy and positive and jumping around convinced her manager that she was enjoying her work, at which point she thought "Really? Seriously? You needed me to act like a monkey in the zoo for you to understand that I enjoy the project?" (C1). Electra's current manager thought that perhaps the difference in approach was cultural. While once again gender was not specifically mentioned, it seems not unreasonable to suppose that, as in Medea's case, there are certain expectations of how women are supposed to behave, and when people don't meet those expectations it can cause consternation.

Several of the participants commented that they made a conscious effort to dress up for work. Xenia didn't want to "fall into the part where saying either you're a nerd or somehow if you dress well you cannot be a good developer" (C1). She wanted to be both a woman and a developer at the same time: "I'm not just a developer but I also have other things, I'm still also a female and care about my dress, care about my hair, care about my makeup" (X-C1). Thalia,

likewise, used to enjoy being one of the guys, but now dresses up more because "it was important to me to be accepted for who I was … I didn't want to have to try to be somebody else to be successful … I really didn't want to feel like I had to be one of the guys to do well" (C1). Interestingly, Xenia found that dressing nicely worked to her advantage when interacting with her male colleagues.

Medea had a slightly different take on her work attire. For the first few years she was at her job, in order to subvert any potential male/female tension, she dyed her hair darker, didn't wear makeup, and dressed plainly. This didn't really seem to help, though, for "I still got asked out and I've had awkward moments with coworkers actually wanting to e-mail me or cross that line" (C1). Now she simply dresses how she wants to, "which is more feminine than the first couple years I worked there" (M-C1), and sometimes wears a fake engagement ring to work.

Despite the somewhat questionable interactions described above, not all events related to women in the workplace were negative. Thalia participated in a monthly women's lunch for all women who worked under her vice president; in her first job Xenia attended several seminars and events for women at her company, as well as a women's group for her larger organization, which her lead encouraged her to go to during work time. Additionally, Medea, Gaia, and Iris all mentioned that their employers had sent them to a "women in computing" conference.

The two people who were PMs actually felt that their gender was an advantage in their work. It made them stand out, but in a good and memorable way:

> It is good to be a woman in this position in a company full of men, because it is easier to hold the attention of a bunch of unmarried 20-something year old guys … So you stand out, and standing out is a good thing. I think it very very much helps me in my job, I don't blend in to the crowd, I don't have to stand out, I don't have to prove worth. If you were a guy in my position, I think they have to prove that they're smart enough to be – because I'm the girl and I'm the PM and stuff it's fine, they're like whatever, it's like a given. (H-C1)

As in college, Helen still stood out as the blonde. Unlike in college, though, this was no longer a negative. This opinion was corroborated by Cassiopeia, who felt that being a woman in a male-dominated industry "just kinda made you stand out a little bit more, and I think it was probably actually a benefit … people remember me because I'm slightly different than most of the other people doing my role" (C1). Similarly to Helen, Cassiopeia felt that "dudes like talking to girls" (C1). Since the two women who explicitly felt that their gender was an advantage in their work were the two women in non-programming positions, this again raises questions about expectations of gender roles in the technology industry.

While the participants all persisted and completed a major in the same department, their experiences leading up to that time in their lives and their experiences as CS majors were interesting and varied. When they moved beyond college, their experiences became more widely varied still. Despite this variation, however, the experiences I discussed with the participants in our interviews still yielded some common themes, as I elaborate on further in the Analysis chapter.

Chapter 5: Analysis

In this chapter I identify and analyze the themes I noted as they relate to existing academic theories, both those described in my conceptual framework and others that came up in the course of my analysis.

Examination of the results yielded some interesting themes and prompted some interesting questions. Focusing on the participants' experiences with computers, the computer science major, and careers allowed me a glimpse into their backgrounds, as well as their present work environments, through the lens of their own perspectives. This enabled me to understand the reciprocal nature of their interactions with their environment, and how they were impacted by the situations in which they found themselves. Additionally, this focus on experience allowed me to compare and contrast the ways in which the participants navigated similar situations (e.g., the computer science major) as well as different situations (e.g., their post-college careers).

Entering in to this study, I had existing preconceptions about what I would discover during my research. Having spent over seven years in the technology industry as a software tester, and having a strong technical background myself, I thought I would find one of two things: women who enjoyed being "one of the guys" or women who found that their gender was advantageous and reveled in being "the only girl." While aspects of both of these "types" showed up in the course of data collection and analysis, unsurprisingly the women's experiences were much more complex and multifaceted than allowed by either of these two stories.

Using the conceptual framework and corresponding theories that I started out with provided an informative avenue via which to begin to explore these women's experiences, but it by no means explained everything about their stories. This is exemplary of the entire purpose of

the study design – that people's experiences are unique, and you cannot anticipate what you will discover in the course of analysis.

Discussion

Sponsorship

It was often the case that the participants' initial interest in computer science was prompted or encouraged by another person or persons. This relates back to the theoretical construct of sponsorship, which purports that the actions of someone external can influence a person's path or outcome relating to the acquisition of a particular skill (Brandt, 1998).[27] While this might seem like an obvious conclusion in the context of this study – if a woman is encouraged to study CS she is more likely to do so – I would argue that the concept of sponsorship is much more far-reaching and complex than the aforementioned scenario would suggest. To explain the interesting and different variations I saw in sponsorship, let me use some examples from my data.

Andromeda encountered what might be considered a very traditional version of sponsorship. Both of Andromeda's parents were engineers, and her father "pushed computer literacy since I can remember" (U1). If at any time she ever considered pursuing a different field in college or beyond, Andromeda's dad would continually steer her back towards CS: "each time that I wanted to stray from computer science my dad would try and find something to keep me interested" (U1). In this case Andromeda received direct positive ongoing encouragement from someone close to her. However, based on my data set, it seems clear that all of these characteristics of sponsorship can and do vary. The influence received could be direct or it could

[27] While sponsorship was prevalent in the participants' stories, mentoring – somewhat surprisingly – was less so. This is discussed further in the *Future Research* section of the Conclusion chapter.

be indirect; it could be positive or it could be negative; it could be ongoing or it could be a one-time occurrence; and finally, it could be from a close relative or friend or it could be from a complete stranger.

Helen was encouraged in her programming skills by her AP Psychology teacher in high school, who asked her to create a class web site. While direct and positive, this encouragement was by no means ongoing in the way that Andromeda's father's influence was. It was also from a person that Helen knew somewhat well, as opposed to being either a stranger or someone close to her. Conversely, Penelope (whose dad worked in the computer industry) grew up surrounded by computers and computer technology, yet she received no specific suggestions to study computer science: "Computers were kind of there, and I didn't think of them as something I wanted to study necessarily" (U1). Penelope's sponsorship can be classified as indirect, although in every other way it was very similar to Andromeda's.

Medea's story was illustrative of what might be seen as one-time direct *negative* influence, in this case from a stranger. When the recruiter from the satellite campus came to her community college to advocate for the CS program at his university, he was de facto discouraging students from pursuing the program at the main campus. This very act, however, was what triggered Medea's interest in that particular program. Electra, meanwhile, displayed a very clear example of *indirect* sponsorship – her former boyfriend worked in software development and was so passionate about his job that he inspired her to pursue that for her career as well, purely because she wanted to be that passionate about her own work.

Some people's matriculation in the university level computer science class that fostered their interest in CS was at the direct suggestion of a peer. In Cassiopeia's case this peer was her boyfriend, in Thalia's case it was Cassiopeia, and in Daphne's case it was a coworker at her

after-school teaching job. All three of these women were already majoring in another STEM discipline at the time of the suggestion (interestingly, it was the same STEM discipline in all three cases); Thalia and Daphne added CS as a second major, but Cassiopeia actually switched from her other major to computer science, citing a dislike of the other department as her reason for leaving.[28] This type of sponsorship was even the trigger towards CS for one of the professors with whom I spoke: Felix was encouraged to take his first computer science class in college by a friend who thought he would enjoy it. Clearly he did, given where he ended up.

Several people mentioned parents, usually fathers, who were supportive but not pushy when it came to using computers and studying computer science. Leda's father bought the family a laptop at a time when it was pretty uncommon for people in her country to have computers; when she showed interest in it he "would actually bring some certain books that are related to computers in general home" (U1) and point out things that she could do using the computer. Likewise, Sibyl's father bought her a computer when she was around age 10 or 11, at a time when computers were not really that big in her country, and introduced her to Visual Basic a few years later. When she expressed interest in attending college in the U.S. to study computer science, Sibyl's parents always tried to buy her the relevant books, even if they were really expensive. Similar to Penelope's experience, I would classify this type of encouragement as indirect, in that both Leda's and Sibyl's parents made computers available and were encouraging of computer use and interest but were not overtly encouraging the study of computer science. The fact that the primary parental influence that the participants encountered was male – also true in Iris's case, in which her father "really encouraged pursuing math and science and

[28] In Cassiopeia's case her boyfriend's sponsorship had prompted her to take the *second* course in the two-quarter introductory CS sequence. She had not cared for the first course, but between taking that course and the course suggested by her boyfriend, she had realized her other major was not a good fit and was more open to other fields of study.

engineering" whereas her mother "just wants us to be happy" (U1) – is exemplary of Zeldin and Pajares' (2000) finding that "women did not recall or require exclusively female role models" (p.240).

At times the participants found that there was a fine line between sponsorship and pressure. Niobe's parents didn't tell her where to go to school or what to study, but "they definitely wanted me to get a career, like you go to college to get a career, it's an expectation" (U1). Thus while she chose computer science because of "all the cool things that you could do … I really like applications and like building things," Niobe also chose it because of the variety of opportunities it afforded post-graduation: "with computer science you can – there's tons of jobs you can do pretty much anything or work in different fields" (U1). This feeling of pressure played out in Niobe's job choices, too – her decision to pursue a job as a programmer in the technology industry was partly prompted by a desire for financial independence, for she knew that her parents "would not really consider me to be an adult unless I was financially independent" (C1).

Helen felt pressure from other people once she was in the major, but in her case it was mostly pressure to leave computer science: "I felt pressure to quit" (U1).[29] As was the case with many computer science majors, Helen spent a lot of time working on her CS classes, and the women in her sorority espoused the attitude that "you don't have to work this hard in college, why would you choose to work this hard in college when there's so many other things you could do? … Do what makes you happy and obviously if you're working hard you're not happy" (U1). However, as in Medea's case, this negative sponsorship did not have its desired effect, because Helen ended up staying in the CS major and eventually leaving her sorority.

[29] While Helen's experience in this case did not technically prompt her study of computer science, I found it an interesting example of the fine line between sponsorship and pressure.

Stereotype Threat

Most of the sponsorship these women encountered steered them – in one way or another – towards studying computer science. However, once they matriculated in the major, sponsorship became much less of a driving force behind their persistence in CS. Once immersed in CS, the women became more exposed to gender stereotyped behavior and negative stereotypes surrounding women, particularly women in computer science. Interestingly, though, these stereotypes did not deter the participants from studying computer science. Indeed, in some cases, the women with whom I spoke even managed to turn the tables and ensure that negative situations relating to their gender resulted in positive behaviors and outcomes for them. I start by outlining some of the gender-negative situations that the participants encountered and continue on to describe some of the ways in which they framed these situations in a positive manner.

Several people spoke of how they felt that their ability to "do" CS was lacking, especially in comparison to the men in the CS major. Thalia stated that "There are so many other guys, and you're not as smart as them, and you haven't been programming as long as them" (U2), a feeling which left her concerned that she couldn't "hack it" in the workplace as a developer: "I wasn't sure if I was good enough to be a programmer" (U1). (As discussed in the Results section, Thalia pursued a career in program management for two years before switching to a position as a software developer.) Similarly, Iris thought she was "a little bit slower and not as quick as some people" (U2). At the time of our undergraduate interviews Iris did not think that this feeling was related to being female, per se. However, by the time we spoke for the career interview, she had started to notice a definite gender correlation in terms of people's self-perceptions, and commented that "guys are way more confident than girls … they just feel really confident in their skills and abilities, whereas I don't" (C1).

These feelings of inferiority made people hesitant to ask questions or show any sign that they weren't getting the material for fear of looking stupid, a classic example of Steele's (1997) stereotype threat. Leda stated that "With guys, I don't know, I feel like – well, I can't look completely dumb, 'cause then I don't know, they'll think I'm this girl that's not very smart" (U2). Likewise, Helen likewise was loath to tell anyone when she got a bad grade in a class: "I was absolutely humiliated that I'd done bad, because there's this whole culture that everybody is so smart and everyone's getting good grades and I didn't want to tell anybody" (U2). Margolis, Fisher, and Miller (2000) observed that the phenomenon of "not getting it" in computer science was compounded in women by a feeling of also being representative of women in general: "Men who face difficulties with course work do not struggle under the additional burden of the presumption that they are somehow inferior by virtue of their gender; nor do they have the pressure of feeling that they are representative of their gender" (p.115).

People were "fearful of confirming the stereotype" (Margolis et al., 2000, p.118) in other ways. Helen, for example, expressed concern about being perceived as a "whiny little girl" if she didn't act like her fellow male students – in other words, do absolutely everything she could think of to solve her own problem before consulting a professor in office hours: "I think that they [professors] are much quicker to write off a whiny little girl that comes to see them as opposed to some guy who goes 'I'm really trying, I've been coding, I've been doing research'" (U2). Based on my conversations with the professors, though, I believe that they would have welcomed people coming to see them in office hours, even with more basic questions. Johann commented that he often gets questions in office hours that he wishes people would have asked in class. Ludwig indicated that he actually felt greater satisfaction when his female students succeeded than when his male students did, primarily because of the often greater differential between their

starting points and ending points, in terms of technical knowledge and in terms of confidence. However, Wolfgang's experience that "No matter how open and encouraging you are for people to come see you, you sit here during your office hours and nobody comes by" once again speaks to the perceived stereotype behind Helen's sentiment: it is likely that at least some students didn't come to office hours because they felt that they were not knowledgeable enough even to seek help.

Medea encountered a different stereotype surrounding women's ability to work in groups. In our second undergraduate interview, she mentioned that some of her partners "have told me that they only work with women in the department as partners, 'cause then they don't have the sort of ego conflict that they have from working with other guys." While initially this might not seem as negative as being considered "stupid" or a "whiny little girl," I would argue that the implication here might actually be just as bad, if not worse. If a man has ego conflicts with another man, it likely results from both parties having strong opinions; consequently, a lack of ego conflicts infers that other people in the group (i.e., the women) do *not* have strong opinions. This ties back to something that Thalia said regarding women and passivity: she felt that girls are "a lot used to being more passive, especially in arguments, we're more likely to be the ones who are like 'well, you could be right'" (U2).

Several women also felt the effects of negative gender stereotyping in their classes. In one of Penelope's classes the professor called out the fact that the girls were sitting together and then asked if it was because they were struggling, a statement which bulk categorized the women as less capable. Similarly, Helen spoke of how a professor repeatedly called a friend of hers "sorority girl" (U2), a term which itself had unwelcome and unpleasant connotations, despite the fact that her friend had repeatedly asked him to stop. Helen's overall perspective on being the

minority, particularly in classes, was that "it can also have a very negative side in that it's very easy for someone to pick you out" (U2). However since she felt that the behaviors she had encountered from professors never crossed the line to sexual harassment, "your choice is either go to lecture and deal with it or not go and hurt yourself for your grades" (H-U2). Even in one of the class sessions I observed, the professor put up a picture of an elderly lady labeled "Grandma" as an example of a typical clueless computer user.[30] (While this might not have made any of the women in the class feel specifically threatened, because none of them were elderly, the point still stands that the default clueless user was thought to be a woman.)

Comments such as this were not unheard of in the workplace, either. Both Iris and Niobe alluded to gender-based comments (although interestingly, neither of them went into detail, which prompts the question "why not?"). Helen spelled out some sexist comments made by a particular director in her workplace (not her manager): At one point, shortly after she married her boyfriend from college, who also happened to work for the same company, this director "accused me of once of getting my MRS degree because I'm here" (C1). Helen was one of the people who self-identified as less confident due largely to her shaky career progression, and thus rather than confronting the person in question tended to simply try to move the conversation on. Interestingly, in the case of this particular comment, one of her coworkers "called him on it when he did that, like 'whoa, not cool'" (H-C1). While Xenia's experience with the sexist poster in the office of some coworkers wasn't a comment, per se, she was definitely left feeling that that office contained "lots of masculine energy" and that she wouldn't be welcome to share that office: "They also kind of don't want a female there" (C1).

[30] It is worth noting that when I brought it up in our interview, the professor in question was entirely amenable to understanding and talking about the inherent gender assumptions behind the use of this picture in this context.

However, not all examples of stereotype threat left people feeling underprepared or inferior in some way, because several people managed to recast gendered negatives in a positive light. Electra, during her time as a computer science major, freely acknowledged that women were open to admitting ignorance in a way that men were not: "We are girls, we can not know that … so what, that's us" (U2). While on the one hand this might be seen as perpetuating the stereotype that girls know less, I would instead see it as an example of someone taking a negative stereotype about a group she belonged to and nullifying it so that it was no longer threatening. Based on her interpretation of the situation, Electra made it acceptable for herself and the other women in the department to ask questions about something they didn't understand, as opposed to feeling a need to keep quiet and thereby not get clarification on something relevant to their coursework.

Andromeda had a similar approach in college. She stated that she had "run into people that don't wanna work with me if they know I'm in a sorority and whatnot," which made her "feel pressure to do well, just because I feel like if I don't do well I'll be one of those people that they're like 'ah, she's a girl, that's why she's bad at coding, you know girls are bad at coding'" (A-U2). However, instead of being intimidated by this, she took it as a challenge and thus felt "pressure to succeed, just because it's like I need to do better than you in order to have any sort of pull, then you're just kind of indifferent towards me rather than hating me" (U2). Interestingly, she later stated that people not wanting to work with her in school "ended up helping me in the long run because I learned more" (C1), thus Andromeda's desire to prove herself resulted in an increase in her own knowledge, more so than had she not felt compelled to succeed on her own.

Gaia commented that any negative stereotype she might encounter as a woman was counterbalanced by her ethnicity – people expected Asian women to excel at STEM fields. She acknowledged that "I guess if you were blonde and white you might get another attitude than being an Asian woman" (G-U2). Sibyl also believed that her ethnicity came in to play in her workplace: because of her gender but also possibly because she was a minority, she felt that the expectations of her were lower than they were for her peers. In her estimation, though, this was a benefit, because it enabled her to more easily exceed expectations and impress people: "but when you can actually prove yourself, that you can actually be as good or better than the expectation or the others [i.e., your peers], so that's kind of like a positive impact on my situation" (S-C1).

One interesting side effect of the stereotype threat that the participants encountered, at least in college, was that it had a tendency to make people feel guilty for the extra resources devoted to women. Leda, Helen, and Andromeda all made comments indicating that the extra support for women in the department did not seem fair to men. This phenomenon highlights the fact that the perception of girls having it "easy" is itself a negative stereotype that women have to overcome in CS environments that are particularly supportive of women. Thalia did not see these types of supports as unfair. She rather thought of them as simply an attempt to level a non-level playing field: "You need to be aware of the troubles, the challenges that girls face, but not cater to them – it should be just as hard for them, but it shouldn't be any harder for them, and I think that the problem is that sometimes it's harder" (U2).

Not everyone mentioned examples of stereotype threat in our interviews, which may say more about its relevance to their life situation at the time of our conversations than about whether or not they ever encountered it. It could be the case, for example, that by the time I spoke with them during their senior year of college, the participants had encountered negative stereotypes or

stereotype threat early in their tenure in the CS department but either forgotten it or disregarded it due to increased self-confidence (discussed below).

Self-confidence

Self-confidence – or more often, its lack – is a well-documented phenomenon in the literature surrounding women in STEM (e.g., Margolis & Fisher, 2002; Wigfield, Battle, Keller, & Eccles, 2002; Powell, 2005; Dentith, 2008; He & Freeman, 2010) and any study concerning women in computer science would be remiss not to mention it. In fact, it is important enough that an entire section of the Results chapter is devoted to the effects of confidence in these women's career experiences. However, even though lower or lacking self-confidence is often seen as culpable in women's attrition in computer science, self-confidence – both its lack and its presence – also plays a role for women who persist in computer science.

Many of the women with whom I spoke encountered lowered self-confidence, particularly when they first matriculated in the computer science major. Usually this manifested itself in feelings of being unprepared, particularly in comparison to their male peers. This occurrence is supported by Nichols' (1989) assessment that "judgments of our own competence depend on the competence of others" (p.109). Even people who felt they had a natural aptitude for math and computer science, such as Leda or Iris, often felt that they had to "study for it a little more" (L-U2). This lowered confidence at the beginning of the computer science major seems to go hand in hand with its nature as a relatively unfamiliar environment. This point is touched on by Gustav, who observed that CS classes are much less common in high school than, for example, biology classes. For women such as Johann described, who come in "confident in their intellectual abilities but … uncertain about the material" it can be confidence shaking when others in the department seem to know much more about the subject at hand.

An added complicating factor in terms of self-confidence was people's responses to grades. Medea commented that "My whole time at community college I very rarely got anything other than a 4.0," but when she matriculated in the computer science major "I started getting things like 60's on tests" (U2). Medea's final grade for that particular class ended up being around a 3.5, given the curve in the CS department. However, research studies such as Crocker et al.'s (2003) work, which examine the relationship between grades and self-esteem, conclude that drops in self-esteem upon receipt of bad grades is "especially greater for women in engineering" (p.514). This ties back to Helen's comment that she was "humiliated" when she got a bad grade, because "everybody is so smart and everyone's getting good grades" (U2), again illustrating the underlying belief that everyone else in the CS department was more prepared and doing better.

Despite these problems, it is definitely the case that participant confidence grew throughout the women's tenure as computer science majors. This happened for a variety of reasons. For some people particular projects or classes acted as confidence boosters – Niobe, for example, found that her computer science research project triggered an increase in confidence, both because she loved the project but also because having her own project was confidence building. For other women, such as Iris, it was simply the realization that all the people who seemed supremely knowledgeable were not necessarily so and were often "just goofing off" (U2). Similarly, Medea's own increase in ability as she progressed through the major helped to build her confidence – while she initially felt that it was frustrating to be expected to know things that she hadn't been taught in her computer science classes, once she got used to learning things on her own this expectation of untaught knowledge increased her confidence because she knew she could figure out how to use or do just about anything on her own.

I would argue, though, that simply spending time in the computer science department and really becoming familiar with the environment was also partly what enabled these women to gain confidence. Matriculating in the CS major helped them to develop the understanding that they themselves were not so different from everyone else in the program, and indeed, that they were just as capable, even at the potentially unfamiliar field of computer science. Penelope's observation about some men who seemed "totally on top of things" but in reality "got a way lower score than you on homework" (U2) is exemplary of this; while at first glance it might have seemed like others were more "with it," upon closer investigation this turned out to be a false perception. Thus one can infer that – at least in this case – familiarity bred confidence; as they realized that they were not being outsmarted, so to speak, the participants' insecurities tended to fade.

Even though people's confidence generally increased throughout their tenure in college, when it came time to seek a job confidence issues once again came into play, usually related to programming ability. When discussing why she accepted a position as a PM as opposed to as a developer upon graduation from college, Thalia commented that she thought that she "wouldn't be good at it, that it would be really really hard for me, and that I just didn't have the programming ability to either get a job as a developer or excel in that role" (C1).[31] Similarly, Xenia didn't even apply for software development positions in general because she thought she didn't have "enough robust programming experience" (C1). It is worth noting that in both of these cases, these fears were unfounded – Xenia was very successful at her software development position, getting promoted slightly earlier than was average, and once she switched

[31] One might surmise that Thalia's lack of confidence in the interview process during her senior year of college was partly responsible for her ending up in a position that was not a particularly good fit. I don't think this can be concluded, though, given that Cassiopeia, who was very confident about interviews, also secured a job that she did not like.

to being a software developer, Thalia commented that "It's really funny, because now that I'm a developer, I love it, and I don't know why I spent all this time being a PM" (C1). This feeling of under confidence in technical positions is documented in the literature: Rosser (2000), in her chapter on female scientists and physicians, observed that "females tend to be less confident of success than males in science-related professions" (p.18).

Once in the workplace, several people felt similarly to the way they had in college. Rhea, Leda, Iris, and Electra all expressed the sentiment that it still sometimes took them longer than other people to figure things out, and Thalia was concerned about being "found out" for her lack of technical knowledge (C1). Thalia did specifically mention that her confidence had increased the longer she had been working as a developer, though, which lends credence to the aforementioned supposition that familiarity with a particular position or place breeds confidence in one's ability or fit in that position or place. Iris, on the other hand, still admitted to feeling less confident in her technical ability in her workplace. It is worth noting, however, that Iris had been working the shortest amount of time of any of the participants (a little over two and a half years) due to her college graduation date.

Based on the participants' successes at their jobs, it can be inferred that while lower self-confidence in technical matters may impact people's perceptions of how they are doing at work, it does not necessarily impact their actual performance at work. One possible reason for this is the concept of a "natural talent" for computer science or STEM in general. Iris, who was not interested enough in programming to spend hours doing it outside of work, commented that "the fact that I am successful in my job right now, without putting in the extra effort, I would kind of chalk that up to natural talent" (C1). Later, she indicated that she thought this natural talent could only take her so far, and that "when that runs out and when it's not good enough anymore, that's

when I'm going to have problems" (I-C1). Not all of the participants believed in this idea of innate talent, though, and it is unclear whether any kind of natural aptitude is actually necessary to do well in a computer science career.

A couple of people mentioned confidence problems relating to their self-presentation, as opposed to their technical ability, at work. Xenia commented that she tended to discount her own abilities in conversation, a practice she had been alerted to by a women's group at her first job and that she was trying to be more aware of in general. While these actions did not directly impact her work, it stands to reason that they had an indirect influence – if someone tells their manager "oh, I cannot do that" (X-C1) they are potentially less likely to be asked to take on more responsibilities in future. Helen also felt uncomfortable asking the director at her company to stop making sexist comments. Again, this did not have a direct work impact, but did have the potential to impact the way she was perceived by people in her workplace; and given her position as a PM, perception was somewhat integral to her job. Self-confidence can be a complicated issue for women in the workplace, though, because too much of it can at times be perceived as "inappropriate." This idea and its ramifications are discussed later in this chapter.

Motivation

Another conclusion that can be drawn from this data is that the participants generally possessed some sort of personal motivation to progress through the computer science major and their subsequent careers. Ryan and Deci (2000) define motivation as being "energized or activated toward an end" (p.54). In this case, the end in question was to persist in the field of computer science as a major, and subsequently, in a chosen career. Motivation is interesting, though, because it can be defined not only by its level but also by its orientation – in other words, it is not just about *how* motivated you are, but also *why* you are motivated (ibid). An additional

consideration with regard to the type of motivation is whether or not the reason or goal is intrinsic, i.e., "inherently interesting or enjoyable" or extrinsic, i.e., "it leads to a separable outcome" (ibid, p.55). Given that my study tracked women's persistence in computer science, and none of the women I studied ceased doing CS-related work after graduation,[32] what is more interesting and relevant in this context is the "why" of motivation. As it turns out, the study participants were motivated for a variety of different reasons, both intrinsic and extrinsic.

An example of intrinsic motivation is the way in which the participants engaged with the computer science major *because* it was challenging. (While not every single person is referenced in the results, it is worth noting that every single person did indicate that they felt challenged by the CS major.) This feeling also translated into the workplace. In their careers, people continued to be motivated by the ongoing challenge and the constant need and/or opportunity to learn new things. When asked what she most valued about her position as a software developer, Medea stated that "I like the interesting challenges. I value that it's kind of constantly changing and challenging" (C1). Likewise when Leda stopped being challenged by her first job, she took that as a sign that it was time to switch teams: "I thought 'okay, this is kind of getting old'" (C1).

Nichols (1989) ties this type of engagement in the face of challenge to a desire to prove competence in comparison to one's peers, surmising that smart people will generally choose more difficult tasks:

> People who are ego-involved and have high perceived ability … are likely to prefer tasks at or above (depending on how able they believe they are) moderate difficulty levels. After successes at any level, they can gain in perceived ability by attempting more difficult, effortful, and personally challenging tasks. (p.109)

Interestingly, Nichols' findings can be directly correlated with Medea's experience of wanting to pursue the more challenging computer science degree program and Andromeda's

[32] The one woman who was not working in a CS-related field after graduation was enrolled in a graduate program at the intersection of Biology and computer science and continued to use her programming skills in her research.

aforementioned desire to challenge herself in the face of negative stereotypes surrounding women in CS. This not only indicates the interconnectedness of many of these findings; it also shows us that negative perceptions of ability – both gender-related and gender-neutral – can themselves be positive motivators.

Motivation in the face of challenge does not necessarily relate solely to work tasks. It could be argued that people who had experienced somewhat challenging career progressions, such as Helen, also persisted because they were motivated by challenge. Similarly, people who encountered non-work-related challenges at their workplace, such as some of the negatively stereotyped situations described earlier, might also be seen as persisting at least partly *because* of the challenge. One can infer from this that motivation is integral to women's persistence in computer science, especially given that being female in CS is not always an easy path.

While people sometimes mentioned friends who were supportive, only one person mentioned a friend who actually acted as a motivating force in her career progression. When unhappy in her program management job, Thalia was inspired to increase her own enjoyment of work by changing careers at least partly because of her friend Cassiopeia's happiness and success in her own career. As Thalia stated in our career interview, "I love Cassiopeia, but she's not *that* much smarter than me, I could probably do that, too; and so that definitely motivated me to be like 'look, she's doing it, I can do better than what I'm doing right now.'"

Medea and Iris also spoke of intrinsic motivation, but in a more abstract manner, indicating that a lot of what engaged them was purely their own independent thinking. As Iris put it, "I kind of am more self-sufficient, I encourage myself to keep going kind of thing, I don't really have any outside influence telling me to do this" (U2). Similarly, in our career interview Medea stated that "I think all my influences are internal."

The prestige of the computer science department acted as a motivator for several of the participants. Depending on the person, this motivation could be classified as intrinsic – people gravitated towards a top tier program because it would result in the most rewarding challenges in terms of learning – and extrinsic – people were interested in the department because of the resulting intellectual capital and status conferred on its students. At least three people came to the university specifically because of the CS department and how highly regarded it was. Andromeda and Rhea moved to the Pacific Northwest to attend this particular computer science program, and Sibyl was an international student whose government scholarship required that she study at one of the top ten CS programs in the United States.[33] Even one person who lived locally and was directly admitted from high school was swayed by the reputation of the department. Helen struggled somewhat in her first year but "stuck it out because I figure you don't just give up your spot in the CS department" (U1). Helen later commented that having been directly admitted from high school made her feel special, which itself encouraged her to persist: "Definitely the fact that I was already given a spot and so I already … felt a little bit special and a little bit like this is an opportunity really worth looking into, that was huge" (U1). (Several people who had had to go through the application process also indicated to Helen that "well, you know, you got a really good spot so you'd better not quit" (U1).) Interestingly, among the women mentioned here, those who came to the university specifically for the CS department (Andromeda, Rhea, and Sibyl) seemed to struggle less than the person who was applying to the university anyway and chose CS because she felt she needed to do something practical with her life (Helen).

[33] Interestingly, some people found that this prestige was unique to college. Once she left school and started working, Rhea didn't feel quite as special as she had as an undergraduate: "The CS department is – it's very – it's kind of an elite program … you're really special" (C1).

Several people expressed career-related motivations, which are obviously extrinsic. While some people were simply motivated by the career possibilities in general – as Helen put it, "I always felt really happy that I was getting trained in something, instead of studying for four years and getting a fluffy degree that you then either have to go to grad school to apply it or get trained on the job" (U1) – other people had more specific career aspirations. Andromeda's initial motivation to study computer science was so that she could pursue a career in a subfield she was passionate about, namely animation. Niobe felt motivated to pursue a career in computer science not just because she would be able to *find* a job, per se, but also because of the *type* of job she could procure as compared to the other option she was considering: "it's more of a conventional job than being a musician, where you kind of have to make your own career path yourself" (C1). A programming position "was safe and it was stable" (N-C1). Cassiopeia was also motivated to persist in a computer science career, despite a dislike of her first job, due to the "really sweet benefits" (C1). After quitting her job and semi-exploring other career options, Cassiopeia realized that "I probably didn't give tech enough of a try for how good the benefits are … because there's really nowhere else that you're going to get paid six figures two years out of school kind of sucking" (C1).

Gendered Expectations of Behavior

After embarking on their careers, several of the participants encountered gendered expectations of female behavior in their workplaces, both related to work and to demeanor. It is interesting to note that even though they were matriculating in male-dominated work environments, which have not always been particularly welcoming to women, the expectation was that women would still demonstrate "feminine" behavior. This phenomenon has been well documented in academic literature (e.g., Rudman, 1998; Heilman, 2001; Rudman & Fairchild,

2004). Heilman, Wallen, Fuchs, and Tamkins (2004) discuss it specifically in the context of women working in traditionally male-dominated work environments:

> When a woman is acknowledged to have been successful at performing male gender-typed work, she is, by definition, thought to have the attributes necessary to effectively execute the tasks and responsibilities required. But it is these same attributes that are in violation of gender-prescriptive norms. So, although there is a good fit between what the woman is perceived to be like and what the job is thought to entail, there is a bad fit between what the woman is perceived to be like and the conception of what she should be like. (p.417)

These types of expectations relating to gender sometimes had an effect on the actual work assignments that people received. The general belief among Electra's team members was that women liked working on user interface (UI). Despite repeatedly saying that she disliked UI and did not want to work on UI as part of her programming work, Electra was assigned more than one UI project. This begs the question of why: Did people not believe she didn't like that type of work? Did somebody have to do it, but the other male members of the team refused the project? Or was there some other reason?

In a similar vein, Thalia's discussion of the tendency to "PM" people also reflected a societal expectation, even within the technology industry, of women's work preferences. Thalia stated: "Women tend to move from development roles to PM roles, because they're considered more people persons and not as technical, and it's always where their interests lie more" (C1). This assumption of women's non-technical nature relates back to the gender stereotyping discussed in the context of stereotype threat, in which women are assumed to be less good than men at technical tasks like programming. Thalia's own switch the other direction, from program management to development, indicates that this stereotyping is not always true and indeed has a tendency to backfire. It does make one wonder, though – will women have to continue to prove

not just their technical ability but also their technical interests when they enter the technical workforce?

Rhea encountered gender role stereotyping in her second workplace, also regarding women's assumed technical abilities. Her supervisor there "once made a comment something about that I had changed his opinion on women engineers; changed his opinion meaning like that I was good, and that 'wow, maybe a woman could be technically savvy'" (R-C1). Clearly her manager's expectation (based either on past experience or on stereotypes, it is impossible to know which) was that female engineers, as a group, were *not* normally technically savvy. (While this might be considered an example of stereotype threat, I would argue that it is not, because Rhea in no way felt threatened: she had no concerns about her own competence prior to – or indeed after – her manager's comment.)

Sometimes behavioral expectations did not apply to work, specifically, but to women's behavior and attitudes in the workplace. Medea's experience of being asked to be "softer" and "nicer" in meetings seemed to imply a double standard for men and for women, especially since the men on the team did not behave the way she was being asked to: "I've been in a lot of meetings with men and have never had men dance around other men's egos the way that I feel like they wanted me to" (C1).[34] Heilman (2001) elaborates on exactly this phenomenon in her discussion of prescriptive stereotypes:

> The prescriptive aspect of gender stereotypes dictates not what women as a group are like, but rather what women as a group *should* be like. Women who prove to be competent and to have succeeded at "male" work violate this normative prescription and therefore arouse disapproval and are penalized; they are regarded

[34] It is worth noting that not everyone at Medea's workplace shared this opinion. Medea's first manager felt that the quality of the work should take priority – "he was like 'I wanna do the right thing, let's be direct, may the best idea win. Something's wrong with this, I want to know. You voice your opinion, let's not put out crappy software, let's not make a mistake, if something's wrong, tell me'" (C1). Her second manager, however, held the attitude that "'if something's wrong, tell me in a way that doesn't hurt my ego'" (C1).

very differently than men who engage in the precisely the same behavior. (p. 670-671)

Thalia lost her temper a few times at her first job, and she indicated that people in her workplace did not like that. Similarly, Electra did not express enthusiasm about her work and this came up in her performance review in a somewhat negative fashion. These scenarios prompt one to wonder if men would receive the same feedback in comparable situations. Thus it might be inferred that even though women are in some ways supposed to "be one of the guys" (H-U2; T-C1), they are not actually supposed to *act* like men, because that sort of behavior from a woman is jarring to people's sensibilities. Heilman and Okimoto (2007) agree: "When women behave in ways that are typically reserved for men in our culture, they are less liked and found less socially acceptable than men who behave in a similar manner or than women who behave in more stereotype-consistent ways" (p.81).

Rhea also felt that she encountered expectations of personal behavior based on her gender. She indicated in our career interview that she believed her denial of clearance at her first job was directly related to her willingly disclosed extramarital affairs, and that the commander making the decision thought it was not okay for a woman to cheat on her husband. (On the official paperwork, her affairs were listed as one of three reasons for the denial.) While there is no way to verify this, it is worth mentioning that Rhea was one of the participants who didn't "put a lot of stock into gender" (U2) and generally didn't think that gender had impacted her undergraduate experience at all.

Further gender typecasting can be seen in Helen and Penelope's respective experiences of being picked to plan parties or of being tasked as the lab secretary. Neither of these women particularly connected with these roles, nor did they welcome being saddled with them. At least one person, though, did not seem to mind this sort of typecasting – Iris felt like the "social

calendar" (C1) for her team, but seemed to enjoy that role. This illustrates once again that different women are different from each other. I would thus argue that there is no specific problem with a woman performing the role of social calendar or party planner in a work context; rather, the problem is with that being the *expectation*. Imagine the outcry if a man were tasked with such a job by default.

Conversely, though, those people who dressed and acted "appropriately" for their gender did not encounter these types of problems, and were often able to use it to their benefit. Helen and Cassiopeia each commented on how their gender was an advantage in their role as a PM, and Helen very specifically stated that being a woman didn't just *equalize* the playing field – indeed, she thought it was actually *better* to be female in her job: "If you were a guy in my position, I think they have to prove that they're smart enough … because I'm the girl and I'm the PM and stuff it's fine, they're like whatever, it's like a given" (C1).

People's perceptions of the "appropriateness" of a woman's behavior, specifically in male-dominated positions like software development, might well have been tempered by the presence of particularly feminine appearance markers. Thalia, who when she started work as a programmer was the only woman on a larger team of 50 men, had a self-confessed "strong personality" (C1), yet she never received any of the same type of feedback as Medea or Electra. One possible explanation for this is that Thalia made a specific effort to not look like one of the guys – she tended to dress up for work and felt that she had become more feminine since graduating from college. Xenia, similarly, was complimented by her manager for being forthright – "The first real positive feedback I got back is from my lead saying that it was very nice to see you stand up to our decision and be able to argue with other people about you know, you think this is right, and persuade other people" – yet she also tried to "dress professionally in

a way that is still very female" (C1). Sibyl held a comparable position as a software developer, yet she also wore traditional clothing that was distinctly feminine – as she observed in our first undergraduate interview, this marked her as being from a different culture and made people think she was "more conservative." Based on these examples one might infer that women who seemed more feminine came across as less threatening. Heilman and Okimoto (2007) note something similar, namely that if women in male gender-typed domains display communality, which they define as "attributes that demonstrate concern for others, such as being kind, sympathetic, and understanding" (p.81), it can counteract the negative responses often triggered by their success in these situations.

Transformational Resistance

Despite the situations outlined above, the women in my study were undeterred in their career progressions by gender issues – or indeed, any other kind of issues – in the workplace. Even if they were bothered by some of the gender stereotyping or expectations, none of the women I spoke with allowed these events to sway them from their chosen career path. They continued to act the way that they wanted to rather than conform to people's expectations, whether those expectations demanded more – or in some cases, less – stereotypically feminine behavior. Thus these women's ongoing presence in the workplace evidenced Brayboy's (2005) definition of transformational resistance, namely "that actors display agency by opposing assimilation, accommodations, or other structural (and structurating) rules" (p.195).

Other Considerations

Computer science, while different in content from many fields, is still very similar to other fields in terms of what people need or want from it in their daily lives. The participants found that it was important to enjoy what they were doing, to get positive feedback, and to be

intellectually challenged in their work. Those participants who pursued careers in software development generally found them rewarding, and those participants who pursued careers in which they used their computer science knowledge and skills in other ways also found those careers rewarding.

Chapter 6: Conclusion

In this chapter I discuss the implications and conclusions of my research, as well as potential advantages and limitations of my study design. I also propose some suggestions for future research that arose during the course of my study. Lastly, I outline some recommendations for undergraduate computer science departments based on my findings and offer some concluding thoughts.

Implications

My research questions were far-reaching, but I believe that my study did help me to understand both what encouraged women to persist in an undergraduate computer science major and what women did with their computer science degrees after graduation from college. Understanding the ways in which different people's experiences as undergraduates impacted their respective careers was an ambitious goal. However, upon analyzing my data, it became clear that experiences the participants had as undergraduates, specifically surrounding self-confidence and stereotype threat, definitely impacted their reactions to situations in their workplaces. Thus understanding the pathways and perspectives the participants had in their undergraduate major was key to understanding their experiences in their corporate or academic workplace post-college. In this section, I will firstly recap my research questions and then state the basic conclusions that can be drawn from the discussion in the previous chapter.

1) What are the factors and experiences that encourage women to persist and graduate with an undergraduate Computer Science and Engineering degree from a major research university?
2) In what ways – if at all – do these "successful" women use their Computer Science and Engineering degrees post-college?

3) In what ways do these women's experiences as "successful" Computer Science and Engineering majors contribute to their post-college career pathways? Do different types of undergraduate success stories lead to different career pathways?

One of the primary factors encouraging women into computer science is other people. Once they are in the major women often have the support of at least one close female friend in the CS major that they can talk to or of whom they can ask questions.

Lower or lacking self-confidence does have an impact on women's pathways, both in the computer science major and beyond, but it does not stop women from persisting, either in the major or in their careers. Additionally, self-confidence is likely to build as one progresses through an undergraduate CS major or stays in a job for a few years. In both undergraduate and career settings, as familiarity builds, so does self-confidence.

It is likely that women in computer science will encounter negative stereotypes about women, specifically women in CS. This occurs more in college than in the workplace, but it is evident in both situations. Being able to deal with these stereotypes in a positive way is very helpful. Those women who were able to turn negative gender stereotypes into some sort of positive, either in terms of their own outlook or in terms of the behavioral outcome it triggered, found this a useful skill to have.

Fundamentally one needs to have a reason for persisting in computer science; one needs to be motivated. The reasons for this motivation are variable, and it is clear from the participants' stories that different motivators worked well for different people.

Finally, as indicated by their comfort and laughter and self-possession in our interviews, the study participants did not lose their sense of self while persisting in computer science and

related fields. This illustrates that you do not have to give up who you are or what you believe in to be a woman in computer science.

Study Design

Advantages

The nature of my interview questions was to be open-ended. This format enabled me to easily insert a follow-up question if any particular answer to a question prompted an additional question. Additionally, in talking to actual people and getting actual stories, I was able to generate my conclusions and my recommendations based on a detailed understanding of the computer-related experiences of actual people.

My own gender was advantageous in conducting this study, for it allowed the participants to be more open than they might have been when talking to a man. Penelope commented that "It's easier for people of the same sex to bond, you know, just be completely relaxed and just be open and whatever, just because socially it's okay to do that, like you know I could tell you something that I wouldn't just tell some random dude" (U2). Additionally, my experience with computer technology and working in the technology industry, which I generally shared with people as part of my initial introduction, probably also helped some people feel more comfortable.

The women with whom I spoke were generally interested in the topic of women in computer science. When asked about how gender had impacted her experiences post-college, Cassiopeia declared that "I think about this a lot" (C1). Likewise, Penelope commented in our second undergraduate interview that she was really interested in the topic of women in CS. People who have interest in a particular topic are going to be more amenable to sharing their

stories for a study whose purpose is to understand that topic; thus the participants' own interest in the study's focus enhanced the result.

Limitations

People are a product of more than just one subset of experiences, thus any study that asks solely about one type of experience in a person's past is going to suffer from some amount of tunnel vision. Experiences outside of computers were no doubt relevant to women's persistence in the field of computer science. While my interview questions were specifically designed to be broad enough to accommodate this fact, they still had to be focused enough to allow me to understand the participants' backgrounds with computers. Thus I do want to acknowledge that while I gathered very interesting stories from the participants, there was no doubt more that could have been learned from them.

Following on from this, the open-ended nature of my study design often yielded different foci in interviews. The particular focus of a given interview varied based on the priorities of the person with whom I was speaking. While this could be seen as a benefit, in that I got to hear about the topics that were most important or relevant to the participants themselves, it also meant that some conversations were not entirely consistent with each other and thus not entirely comparable with each other.

Since I was initially talking to seniors who self-selected in to my study, my sample of participants might have been somewhat biased. Because they were seniors the participants might have forgotten to mention things that were no longer relevant to them, such as examples of stereotype threat from early in their tenure as computer science majors. Because they self-selected in the participants might have comprised a particular subset of women, such as those who were overall more confident, or perhaps those who were interested in the topic of women in

computer science. While the participants did seem like a diverse group of women, there is obviously no way for me to know what the people I did not talk to were like.

Future Research

One thing that stood out during data analysis was that most of the participants had scientific leanings even before they began college. Thus it would be interesting to understand the relationship between pre-college science interest and the study of computer science. Is scientific interest generally a prerequisite for majoring in CS? If so, how is this interest initially triggered? Gustav commented that "We're not very aware of … things that make us good or bad at stuff over the years"; understanding what causes women to gravitate towards STEM, and indeed, how relevant this interest is in women's pursuit of a major or career in computer science, would be an interesting avenue of further exploration.

Talking to women when they were seniors was informative, but did not fully get the picture of their entire undergraduate experience. Similarly, talking to women when they had been out of school for a number of years also relied on their memories to fill in gaps from the preceding four years. Talking to women every year of their undergraduate experience, as well as every year after their college graduation, could yield more comprehensive results. These results could aid researchers in understanding how women feel at each stage of their undergraduate experience and also each stage of their careers, which could potentially help to fill in some of the gaps or varied responses in terms of gender stereotyping or mentoring, for example. (One potential problem with this strategy, especially in the undergraduate setting, is that there is no way to predict which students are going to persist in the major and which are not. Thus conversations with freshmen might yield some students who pursue a computer science major

and others who do not. Any study designed with yearly interviews throughout college would need to acknowledge this possibility in its design.)

An interesting gap in my results has to do with mentoring. As discussed in the literature review, many people have observed links between women's persistence or success in workplaces and the presence of a professional mentor (e.g., Noe, 1988; Dreher & Ash, 1990; Blake-Beard, 2001; Downing, Crosby, & Blake-Beard, 2005). However, for the participants in this study mentoring did not overall seem particularly relevant – a few people mentioned having a mentor, but most didn't, and those who did mention mentors often did so in passing, not as a strong influence in their careers. One possible reason for this is that the women I spoke with were not "the typical CS girl" (A-U2) and thus might benefit less from mentoring overall. Another possibility is that mentoring would become more relevant later in these women's careers. Thus it would be interesting to do a further investigation of mentoring in the computer science workplace to understand its effects, and women's perceptions of it, both in the short term and in the long term.

Another future area of research was suggested by one of the study participants herself. Gaia felt that "in school there's not that much difference between being girl or guys, but I guess when you actually start working there's a big difference" and that "sometimes being a mother kind of screws a lot of things up" in the workplace (U2). She felt this was largely due to time considerations – people with children generally want to spend time with their children. While several of the participants were already parents while in college (Medea, Rhea) or had become parents after graduating from college (Sibyl), they all seemed to have found acceptable schedules related to family considerations. At the same time, though, Helen mentioned a friend from the computer science major who had quit her high-tech job as soon as she had children. Given the

variation in people's perspectives on this topic, it would be interesting to explore the differences in experiences for women with children and women without children in CS-related workplaces.

Suggestions for Computer Science Departments

While it might seem odd to recommend any courses of action based on a sample size of 15 participants, there were nonetheless a few things, both specific to these women's particular computer science department and applicable to all computer science departments, that do seem worth mentioning.

One obvious common theme is that women don't want things dumbed down for them. Gaia's observation of the distinction between two types of support for women – those that assume incompetence and those that celebrate women in technology – is exemplary of this. Extra support for women is often good, but it needs to be presented in such a way that it doesn't compound existing negative stereotypes about women's abilities in computer science and/or promote the idea that women need "extra help" in CS.

The women I spoke with never indicated that they thought computer science was a boring field. They felt no need to make it more "fun" or more "relevant" for them as women, which seems to be a common trend these days, particularly in introductory CS courses. The participants in this study might be an exceptional sample of women, in that they did not require these kinds of supports to persist and graduate with an undergraduate degree in computer science. However it is worth noting that the enjoyment these women got from studying computer science generally had to do with the problem-solving aspects of the work and the "prize" of getting a program to compile and run, and less to do with the specific class for which they were writing the program.

A related point, brought up by one of the professors with whom I spoke, is that not all computer science classes lend themselves to "interesting" applications and "engaging" teaching

methods. Changing some classes and not others in this way runs the risk of setting expectations in an unrealistic way for all classes in computer science. This in turn has the potential to exacerbate the existing gender differential for subfields within CS, particularly if the classes that do not lend themselves to these engaging teaching methods are in the more "hardcore" areas. Gustav commented on this in our interview:

> I think there are a lot of classes, especially in engineering, that don't quite lend themselves to you know team up with a partner and spend 15 minutes working on some little class project to kinda break the monotony of a 50-minute class. I think – yeah, you can figure out some way to do it, but then at the end of the day you have to ask yourself, "Did we achieve our educational goal?"

Another common theme among the participants was that women often felt underprepared in classes and in the computer science department in general. Structuring classes so that they do not optimize for pre-existing knowledge from students or – if possible – trying to ensure that pre-existing knowledge does not specifically aid in successful completion of any given course could help to offset this feeling. This in turn could help to promote confidence among women who are new to computer science and programming. Being prepared is not the same as being smart; making that evident to students in classes could help to offset women's – and other students' – feelings of underpreparedness.

One person expressed that the computer science department was great with general recruiting but wasn't as good with helping people find jobs outside the scope of the traditional trifecta of software development positions – software development/software testing/program management (colloquially dev/test/PM). While this person was admittedly in a niche field within CS, it makes sense that if departments do offer specializations such as animation or robotics, they could also offer job placement support to those students who are graduating with a focus in those areas.

For smaller computer science departments around the country, it could be helpful to find a way to put CS majors into recruiting pipelines for large companies, both for internships and for jobs. Several of the participants commented that there was as shortage of good people applying for technical jobs; perhaps those good people are graduating with computer science degrees from smaller universities and colleges around the country that don't have the recruiting or placement resources of a large research university.

Perhaps one of the most important things that can be done, which could also be done in the workplace, is to help people understand what constitutes negative gender stereotyping. Several of the examples of gendered comments mentioned by the participants, such as Medea's experience that men preferred to work with women because they had fewer ego conflicts with women than with men, would not be seen by many to be negative, yet still carried negative connotations. Likewise the professor who said of women that "they just kinda seem like regular students and I joke with them like regular students and interact with them like regular students" (Igor) meant no harm, and yet indicated by his very words that he did not consider women "regular students" in computer science. Likewise Thalia's team at work, to whom she had to explain why blonde jokes were "adding to this culture that women aren't as smart as men" (C1), also likely would not have considered themselves biased against women in the CS workplace. These are all evidence of one of Thalia's primary frustrations: "Sometimes I see people, both men and women, just do things that are I feel contributing to that idea that women don't belong in CS" (C1). In terms of what to do to countermand this, Wolfgang offered a starting point: "Part of it is just having people be conscious of the unintentional ways in which they create environments that aren't supportive of women."

Closing Thoughts

In general, all of the women I studied were very open to talking about their experiences. Even though I was a relative stranger, they were willing to speak with me about their perspectives, and they were all very interested in seeing the results of my research. This indicated to me a belief in the power of change. These women understood that change was possible, and that more women could be encouraged to participate in computer science, and they were interested in being a part of this process.

One thing that shone through for all of the participants was that they never lost their sense of humor, even in the face of potentially troublesome situations. The sheer amount of laughter that occurred during our interviews was testament to this fact, and indicated that these women had not lost their ability to find humor in difficult situations while pursuing a major in computer science and a career in a male-dominated field, be it technology or science.

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

This research study detailed the stories of 15 women who made the computer science major work for them, both in college and after college. In so doing, these women illustrated that "girls *can* do CS." Thus my hope for this study is that it is interesting, informative, and useful to college and university computer science departments and to women who wish to pursue a degree and potentially a career in computer science. Computer science can be an equalizer, a shared

language that connects people, as opposed to something that segregates them. Let's work towards that as a common goal.

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Appendix A: Participant Chart

Participant	Major	2nd Major	Where From	Class Year	CC[35]	Grad Date	Age
Andromeda	CS	N/A	out-of-state	3rd year	no	Spring '08	average
Cassiopeia	CS	Art field	in-state	4th year	no	Winter '08	average
Daphne	CS	STEM field	in-state	senior	yes	Winter or Spring '09	average
Electra	CS	N/A	international	senior	yes	Spring '09	older
Gaia	CS	N/A	international	4th year	no	Spring '07	average
Helen	CE	N/A	in-state	4th year	no	Spring '07	average
Iris	CE	STEM field	in-state	3rd year	no	Winter '09	average
Leda	CE	N/A	international	Senior	yes	Spring '09	average
Medea	CS	N/A	in-state	Senior	yes	Spring '07	older
Niobe	CS	Art field	in-state	4th year	no	Spring '08	average
Penelope	CS	STEM field	in-state	5th year	yes	Spring '07	average
Rhea	CE	STEM field	out-of-state	senior	yes	Spring '07	older
Sibyl	CS	N/A	international	4th year	no	Spring '07	average
Thalia	CS	STEM field	out-of-state	4th year	no	Spring '08	average
Xenia	CS	STEM field	international	senior	yes	Summer '08	older

Notes:

- Double Major field was updated following the Career Interview, when possible
- Those participants who only attended one class at a community college are listed as a "no" in the CC field
- For most of the participants who attended community college, determining their "year" in college was challenging, thus those participants are simply denoted as "senior"
- Grad Date field was updated following the Career Interview, when possible; since Daphne was not included in the career portion of the study, her graduation date was projected during her undergraduate interviews

[35] CC = community college

Appendix B: Undergraduate Interview Protocols

Interview 1:

1. Tell me about your pre-college experience with computers. With programming.
2. How did you first become interested in computers? In computer programming?
3. What first triggered your interest in computers? In computer programming?
4. Were there people in your life that prompted or facilitated your interest in computers and/or computer programming? If so, who were they and what role did they play in your life (parent, teacher, friend, etc.)?
5. Why did you choose computer science as a major? Was it your first choice of major?

Interview 2:

1. Tell me about life as a computer science major.
2. What is the structure of the university's computer science program like?
3. How is relevant information disseminated to computer science majors?
4. Is the major challenging for you? Easy? Somewhere in between?
5. What does it take to be successful in your Computer Science classes?
6. Do you feel that the professors are supportive of students who are majoring in Computer Science? What about the department as a whole? What sort of support structures are in place to help you through your major?
7. Have you felt encouraged in your major since declaring Computer Science?
8. When – if ever – have you felt discouraged about your choice of major?
9. Has there been a time when you struggled? If so, what happened? Do you think that most people in the program encounter challenges?
10. In what ways do you feel that gender has impacted your experience as a Computer Science major?
11. Do the Computer Science students work together and/or help each other out? Is the environment competitive or cooperative? Somewhere in the middle?
12. Do you tend to socialize with other students from your department outside of classes?

Interview 3 (to take place after class observation):

1. What is the function of the class I observed (required class, elective class, etc.)?
2. Was the class session that I observed typical of that specific class? Typical of your courses in general? If not, what about it was different?

3. Was the class that I observed typical of the type of courses you normally take? If not, what type of course do you normally take? What is your favorite type of course (seminar, lecture, hands-on programming, etc.)?
4. Do you know the other students in the class? Are they people with whom you've had many other classes? With whom you feel comfortable being in class?
5. Were the student responses typical of the responses in that particular class?
6. Were the student interactions (with you and with other students) typical of the interactions in that particular class?
7. Did you notice any differences in participation between men and women in your class?
8. Do you notice any differences in general between men and women in that class?
9. Do you feel that the curriculum materials are equally accessible to all people in the class? (Spend some time going over curriculum materials.)
10. Was there anything notable about the class session I observed that you would like to call out?

Appendix C: Classroom Observation Guide

Field notes will be recorded during observation of class sessions of Computer Science classes. Field notes will record the following kinds of information:

- Setup of classroom (discussion table, computers in rows, computers against the walls, etc.)
- Style of class (lecture, seminar, etc.)
- Type of material covered in class (textbook information, student opinions/creativity, etc.)
- Role of professor in class (facilitator, lecturer, etc.)
- Role of students in class (passive listeners/observers, active participants, etc.)
- Nature of student participation in class (engaged, distracted, etc.)
- Nature of focal student(s) participation in class (engaged, distracted, etc.)
- Discourse patterns in class (professor to student; student to student; small and large group interactions; focal student to others)
- Inclusion/Exclusion patterns through classroom talk (who is included in and excluded from the classroom discourse and why?)
- Inclusion/Exclusion patterns through content covered (is the class material accessible to all students; why or why not?)

Appendix D: Faculty Interview Protocol

Interview 1 (to take place after class observation):

1. What does it take to be successful in your course?
2. What kinds of students do well? What kinds of students struggle?
3. What kinds of questions do you often get from students?
4. What qualities do you value in your students?
5. What do you most want your students to learn?
6. How do you engage your students in the material?
7. What attracts a student to Computer Science, in your experience?
8. Have you worked with or advised female Computer Science students?
9. When women are successful in Computer Science, in what ways do they stand out from other students?
10. What is the function of the class I observed (required class, elective class, etc.)?
11. Was the class session that I observed typical of that specific class? Typical of your courses in general? If not, what about it was different?
12. Was the class that I observed typical of the style of courses you normally teach? If not, what style of course do you normally teach? What is your favorite style of course to teach?
13. Is this particular class section similar to other sections of the same course you have taught? If not, in what ways is it different?
14. Were the student responses typical of the responses in that particular class?
15. Were the student interactions (with you and with other students) typical of the interactions in that particular class?
16. Did you notice any differences in participation between men and women in your class?
17. Do you notice any differences in general between men and women in that class?
18. Was there anything notable about the class session I observed that you would like to call out?

Appendix E: Career Interview Protocol

Interview 1:

1. Tell me about what you've done since you graduated from college.
2. In what ways have you used your college major(s)?
3. What made you pursue your specific career pathway? [What made you switch jobs/careers/schools since graduation?]
4. Are there people in your life who have been important/significant in your post-college career choices? If so, who were they and what role did they play in your life (parent, friend, advisor, colleague, supervisor, etc.)?
5. Why did you choose your specific career pathway? Was it your first choice of what to do after graduation?
6. Tell me about where you work/go to school (location, environment, culture, etc.). In what ways does your current environment differ from the environment you experienced in college? From the environment you experienced as a CS/CE major?
7. What is your specific position? What are your specific responsibilities?
8. Tell me about your daily life.
9. What do you most value about your position?
10. Do you find your position challenging? Easy? Somewhere in between?
11. What does it take to be successful in your position? Do you feel that college prepared you for this position?
12. Is your workplace a learning/teaching environment? In what ways?
13. Do you feel like your supervisor is supportive of you? Of your colleagues?
14. Do you feel like your colleagues are supportive of you? Of each other?
15. Do people in your work environment work together and/or help each other out? Is the environment competitive or cooperative? Somewhere in the middle?
16. Do you tend to socialize with other people from your workplace outside of work?
17. Have you felt encouraged about your career choices since college?
18. When – if ever – have you felt discouraged about your choice of career?
19. Has there been a time when you struggled? If so, what happened? Do you think that most people in your position encounter challenges?
20. In what ways do you feel that gender has impacted your experience in your current position? [In your former position?]
21. Are you happy?

Appendix F: Excerpt from Audio Transcript and Student Interview Spreadsheet

Okay. Um, so how did you first become interested in computers? You mentioned fifth grade, was that sort of that time, or was it?

That was my first scholastic introduction to it, but I think um my father probably pushed computer literacy since I can remember – that was definitely my first introduction to it was "you will be computer literate now" and uh having two engineering parents it's kind of it was just kind of like "well, obviously she HAS to be computer literate, it's like she's been bred into it"

<laugh>

How do you feel about that?

Well, it's been um – that's a lot of the reason I didn't want to come to this school, is because my father went here and he was one of the first PhD students out of their computer science program, so um I think my first two years I spent trying to get the computer science professors to know me as like my own name rather than my father's daughter.

Yeah. <laugh>

So, um, that was – I guess I kind of saw that as a setback, 'cause I didn't want to be like "oh, she's some sort o like child prodigy and she's got to be good at this" but I'm definitely taking a different route with it, so I guess it was a little daunting to have parents that were good at this and then just people kind of assumed that I should be good at computer science as well, but um I guess I kind of wanted to do it my own way, so after after high school my parents or, like, throughout high school my parents started backing off kind of like letting me figure out my own thing, but definitely when I was younger "oh, here's what you do here," so they were kind of very hands on with getting me into kind of more uh computer related things.

	A	B	C	D
1	**INTERVIEW 1**	**1. Timeline. [Important events] [Computer-related events]**	**2. When you were little, what did you want to be when you grew up? [Ever think about that now?]**	**3. How did you first become interested in computers? In computer programming? [Experiences] [Programming]**
	Andromeda (2007)	Prior to 5th grade, had tons of exposure b/c both parents were engineers at Silicon Valley engineering firms - "I've had a computer since I can remember… exposed to the internet as soon as that was becoming popular…e-mail prior to 5th grade" (1:23). 5th grade - Basic programming at private school. Interesting but difficult to follow b/c of the concept of variables w/no algebra experience. Confused by it but knew she liked it. (end 2:18) Programmed a little on own. Elem, mid, & HS used word processors, laptops in classrooms, so v. comp. lit. All presentations, reports, etc. were typed. Really interested in computer graphics, video games - parents brushed it off 'cause she was young. Soph/Jr. HS joined robotics team - CAD for mech eng. Sr. yr 3D studio max doing short animations. Visited UW jr & sr years, saw comp animation capstone in progress. By then definitely decided wanted to do something like computer animation.	Always wanted to be doing something with graphics & animation. Sr. year HS - definitely determined that's what she wanted to do. Tiny detours before then but always came back to graphics - doctor, architect, chef, etc.	"My father probably pushed comp. literacy since I can remember…you will be computer literate now" (8:10). Two engineering parents it was obvious that she had to be comp. lit, she's been bred into it. Father went to school here, wasn't sure she wanted to come to school here. "I guess it is a little daunting to have parents that were good at this and then people just assumed that I should be good at computer science as well" (9:15:4). Parents backed off during & after HS, let her figure out her own thing. Parents hands on for getting her into computer related things (use, programming, dad taught PERL).