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The Influence of Protégé-Mentor Relationships and Social Networks on Women Doctoral Students' Academic Career Aspirations in Physical Sciences and Engineering

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The Influence of Protégé-Mentor Relationships and Social Networks on Women Doctoral Students' Academic Career Aspirations in Physical Sciences and Engineering

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in Education

by

Yu Gu

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ABSTRACT OF THE DISSERTATION

The Influence of Protégé-Mentor Relationships and Social Networks on Women Doctoral Students' Academic Career Aspirations in Physical Sciences and Engineering

by

Yu Gu

Doctor of Philosophy in Education

University of California, Los Angeles, 2012

Professor Robert A. Rhoads, Chair

Physical sciences and engineering doctoral programs serve as the most important conduit through which future academics are trained and prepared in these disciplines. This study examined women doctoral students' protégé-mentor relationships in Physical sciences and engineering programs. Particularly, the study examined the influence of such relationships on this group of women's academic career aspirations.

A qualitative approach and ethnographic traditions were utilized to explore women doctoral students' mentoring activities in physical sciences and engineering programs. In-depth ethnographic interviews were conducted between 25 women doctoral students and 10 faculty members from both genders from a large research university in the western region of the U.S. Data was analyzed based on both a deductive approach guided by theory and an inductive technique that reflects the themes, which emerged from the data.

The major findings of this dissertation study relate to women's experiences, challenges, and coping strategies; and shed light on the current state of protégé-mentoring relationships in physical sciences and engineering departments at one research university in the western U.S. The findings highlight the nature of the protégé-mentor interactions and the influence such relationships have on women's decisions concerning the pursuit of academic careers. Further, though unexpected at the design stage of this study, the importance of community emerged as one of the major findings. The formation of communities of support seems a rather important strategy for women doctoral students in the process of graduate school socialization; this source of support appears critical to further developing protégé-mentor relationships, increasing one's ability to publish, engage in research collaborations, and advance one's career interests. It appeared to be the most important strategy that women doctoral students utilize when they experience dysfunctional advising relationships. Many women's career related concerns and their pursuit of helpful advice were provided by a meshwork of women scientists and engineers whom they met at conferences, cross-institutional research collaborations, and through a range of diverse channels and networks. In many cases, these included those developed during their undergraduate studies.

Informal socialization was very impactful when it came to women's career decision-making process. Yet, this is the aspect of protégé-mentor relationships that has been mostly overlooked by faculty in physical sciences and engineering departments at Western Research University (WRU). Women faculty interviewed for my study were more likely to be involved in the informal socialization process to mentor women doctoral students and address work-life balance concerns. Some male faculty expressed negative attitudes toward women doctoral students' non-academic career trajectories and tended to ignore work-life

balance concerns. They demonstrated these attitudes in daily interactions and research meetings with their students. This created an environment in which it was difficult for women to discuss their doubts about pursing academic careers with their faculty advisors.

This study revealed some hidden barriers that many women doctoral students face in the process of pursuing a doctorate and an academic career. These barriers took the form of implicit gender bias, complex and confusing environments for negotiating unequal treatment, dysfunctional advising, particularly in the areas of career development and work-life concerns, and subtle and covert forms of sexual harassment. Acknowledging these unique challenges that women doctoral students in physical sciences and engineering programs face is the first step to assist them, but more direct efforts also most be employed to create an environment more conducive to the success of women in science. Department faculty and academic leaders have a unique and important role to play in addressing such matters

The dissertation of Yu Gu is approved.

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Richard L. Wagoner

Linda J. Sax

Robert A. Rhoads, Committee Chair

University of California, Los Angeles

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I do genuinely appeal to the cordiality of those whom I have failed to name above, to thoughtfully forgive the oversight and continue to maintain our interaction.

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PUBLICATIONS AND PRESENTATIONS

Robert A. Rhoads and Diane Yu Gu. 2011. "A gendered point of view on the challenges of women academics in The People's Republic of China". *Higher Education* 63 (6): 733-750.

Diane Yu Gu. "On the fence: the influence of protégé-mentor relationships on women doctoral students' academic career aspirations in engineering" *American Society for Engineering Education conference proceeding,* 2012.

Luis Felipe R. Murillo, Diane Yu Gu, Reynal Guillen, Jarita Holbrook, and Sharon Traweek. "Partial perspectives in astronomy: Gender, ethnicity, nationality, and meshworks in building digital images of the universe and social worlds." *Interdisciplinary Science Reviews* 37 (1): 36-50.

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Diane Yu Gu, "On the Fence: The Influence of Mentoring Relationships on Women Doctoral Students' Academic Career Aspirations in Engineering" (paper present at the annual meeting for the American Society for Engineering Education, San Antonio, Texas, June 10-13, 2012)

Diane Yu Gu, Robert Rhoads, "A Gendered Point of View on the Challenges of Women Academics in The People's Republic of China" (paper presented at the annual meeting for the Association for the Study of Higher Education, Charlotte, North Carolina, November 16-19, 2011)

Diane Yu Gu, "Women Doctoral Students' Interactions with Faculty and Their Aspirations to Pursue Academic Careers in Engineering" (paper presented at the annual meeting for the Society for the Social Studies of Science, Cleveland, Ohio, November 2-5, 2011)

Diane Yu Gu, "Networks, Nationality and Confidentiality- Ethical Issues in the Studies of Women Engineers' Graduate School Socialization" (paper presented at the meeting for the International Network of Engineering Studies, Cleveland, Ohio November 1, 2011

Reynal Guillen, Diane Gu, Jarita Holbrook, Luis Felipe R. Murillo, Sharon Traweek, "Glocal Meshworks among Minority, Women and Foreign US based Astronomers" (paper presented at the annual meeting for the Society for the Social Studies of Science, Cleveland, Ohio, November 5, 2011)

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Diane Yu Gu, "Female Doctoral Students' Interactions with Faculty and Their Career Trajectories" (paper presented at the 21st annual Thinking Gender Conference, Los Angeles, California, February 11,2011)

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Diane Yu Gu, "Graduate Women Students' Socialization in Engineering and Their Career Decision, "The American Society for the Study of Higher Education conference (ASHE). November 2010, Indianapolis, Indiana, November, 2010)

CHAPTER 1: INTRODUCTION

A research project team member once asked me a seemingly simple question: "Why are you passionate about studies of women scientists and engineers?" Not until then, did I fully realize that the explanation mostly derives from my childhood and educational experiences. Due to my parents' demanding academic careers, I spent many after-school hours in engineering classrooms, laboratories, and conference preparation rooms. As a six-year-old, my fearless social skills helped me to make many friends in those settings, so I was not lonely. On one particular day, I looked around my mom's engineering lab and realized that she and I were the only women in the room of over 30 students. It was very late at night, but my mom was still working on some "mad" program that she needed for the next day. I remember this quite vividly because I always fell asleep in my mom's lab and would be carried home when she and my dad were done with work. I might have been used to the situation, but I vaguely remember that my friends back in grade school were amazed at how "boring" my family life was. They joked with me that if I spent any more time with those "engineering guys" I would turn out to be a "tomboy."

As my education progressed, I was fortunate to visit the campuses of many prestigious universities around the world through exchange programs, conferences, and research projects. I enjoyed meeting new people from all different disciplines. Interestingly enough, my major social circle has continued to be comprised mostly of scientists and engineers. As these interactions entail formal and informal meetings, I spent much time waiting for my colleagues/friends/interviewees in the hallways of many science and engineering departments. Although the combination of sharp noise from the electric saw and the awful smell from the

melting solder made the waiting periods dreadful, I very much enjoyed observing roster boards on the walls of the hallways. I got to know professors' and graduate students' names, divisions, research interests, gender, and sometimes race/ethnicity. However, it always struck me that the number of women students listed on the rosters was quite small; indeed, they were so few in number that I often got to know them quite well. I rarely recall seeing women professors.

Prior to the English philosopher of science William Whewell's coining of the term "scientist" in the 19th century, this group of people had been famously known and openly referred to as "men of science" (Rossiter, 1984). Although women's participation and contribution to science started to bourgeon in the late 19th century, their names and contributions were still included in directories named "Men of Science" (Rossiter, 1984). At the end of the 1920s, women earned 12% of doctorate degrees in science in the United States (U.S.) (Babco et al., 2002). Regardless of the statistical increase, women's achievements were offset by two patterns: "women students were often pigeonholed and thwarted in the curriculum and in campus life; and, most invidiously, those who completed advanced degrees encountered blatant discrimination in the academic job market" (Thelin, 2002, p. 143). Higher Education scholar Maresi Nerad (1999) referred to the barriers that early women academics faced and their marginalization as "the academic kitchen" in the U.S. higher education system.

The educational achievement of women has continued to surge over the past decades. A comprehensive report from the Commission on Professionals in Science and Technology (CPST, 2006) revealed that in 1980 women comprised 3.6% and 12.3% of doctoral degree recipients in engineering and physical/environmental sciences, respectively. By 2004, these numbers had grown to 17.6% and 27.3% in both fields. However, the number of women scientists and engineers who chose to enter academia upon receiving their doctorates did not increase

proportionally. The CPST report revealed that only 14.8% of all physical sciences[1] faculty members were female. This number was even smaller in engineering; women represented only 10.3% of all engineering faculty members. Further, women in engineering and the physical, mathematical, and environmental sciences made up less than 6% of full-time professor positions. Two decades ago, researchers projected that achieving occupational equity for women in science and engineering was just "a matter of time" -- time for increasing the number of female Ph.D. students and moving them through the ranks of academia (Fox 2001). However, the prediction that growing numbers of female Ph.D. students would lead to greater gender equity among the professoriate has yet to come to fruition.

Critiques of women's conditions and participation in academic science and engineering has prompted a line of inquiry that ranges from pipeline issues (Lubinski and Benbow, 1992; Seymour, 1995; Springer, Stanne and Donovan, 1999), graduate education (Austin, 2002; Austin et al., 2009; Gardner, 2006; 2008; Geiger, 1997; Gold and Dore, 2001), the characteristics and nature of academic careers (Albach, 1995; Cole and Cole, 1973; Fox, 2000, 2008; Long and Fox, 1995), and mentoring and networking (Gersick, Bartunek, and Durron, 2000; Healy and Welchert, 1990; Ibarra, 1993; Traweek, 2000), among other factors. The issues are many, but perhaps the work of Fox is a starting point for considering the complex challenges that women face in pursuing careers in academic science and engineering. Among a large pool of literature, some works reveals the multifaceted barriers faced by women doctoral students. Fox (2000) studied over 3,000 women doctoral students' experiences in science and engineering programs via surveys and interviews. Her findings revealed that women are less likely to be “taken seriously” by their advisors, feel less comfortable speaking in research group settings, and are

[1] Physical sciences, as defined by the Merriam-Webster dictionary, refer to any of the natural sciences (as physics, chemistry, and astronomy) that deal primarily with nonliving materials.

less likely to receive effective help and feedback from their professors. Fox's work suggested that greater attention should be paid to understanding the experiences of women graduate students in science and engineering, with a particular focus on their interactions with faculty members.

A major research project that I conducted prior to this dissertation project was a study investigating the impact of faculty-student interactions on women engineering doctoral students' career aspirations. The findings from this research project and observations of women scientists and engineers revealed the influential effect that mentoring relationships have on career trajectories. Many of the participants expressed deep concern, even fear, about being able to balance their future academic and family lives. Some attributed this to the lack of female role models in their respective programs. Many of the women in my study reported disparities in work, networking, and funding opportunities compared to their male counterparts.

There already exists a large body of literature that touches upon the topic of mentoring doctoral students in the science, technology, engineering, and mathematics fields (Anderson and Swazey, 1998; Fox, 2001, 2006, 2010; Gardner, 2010; Golde and Dore, 2001; Johnson and Huwe, 2003; Maher, Ford, and Thompson, 2004; Paglis, Green, and Bauer, 2006; Tenenbaum, Crosby, and Gliner, 2001). These studies have deepened the understanding of the influence of mentoring on students' graduate experiences and career trajectories by focusing on graduate school satisfaction, job outcome rates, mentor-mentee ratios, graduate student socialization processes, and other issues. Despite this, two missing aspects currently exist in the literature that need to be addressed by future studies, and to which results of the present study contribute. The current literature regards the "mentor" to be the center of the nature of the phenomenon between a mentor and protégé, as in the "mentoring" relationship. However, the present study raises a

question about the naming and indeed the conceptualization of this phenomenon following the feminist theory tradition. Feminist theory suggests renaming it as a protégé-mentor relationship. First, by placing the word “protégé” prior to “mentor,” the term contributes to the reversal of the power typically ascribed to the mentor that, per the feminist theory tradition, needs to be questioned. Second, existing studies rarely focus on women doctoral students’ deliberations, considerations, and aspirations related to pursuing academic careers. Questions about these three factors are difficult to answer by most methods. However, ethnographic methods are best equipped to study a culture, which has "acquired knowledge used to interpret experiences and generated behavior" (Bogdan and Bilken, 1998, p. 6). Thus, an ethnographic method was determined to be the most sufficient method to employ in the case of the present study.

In Zuckerman, Cole, and Bruer's (1991) *The Outer Circle: Women in the Scientific Community,* the authors argued "science remains a domain dominated by men, not only numerically but in the exercise of authority, power, and influence" (p. 340). This thought-provoking statement puts future research about women in academic science in perspective. Studies about women in science cannot solely focus on the challenges and experiences that women face given the broader male dominated organizational culture. Researchers need to "study up," an idea advanced by Harding (1994) and upon which I will later elaborate further, starting with women's daily lives, while observing and revealing the power relations that exist in various levels of larger departmental, disciplinary, and institutional infrastructures.

Lastly, researchers need to be cautious of conventional "neutrality" and "objectivity" claimed by the science community and the question of whose "objectivity" the study is examining as well as how the rules and standards are defined. Along these lines, Zuckerman, Cole, and Bruer (1991) began a unique line of inquiry in studying women academics in science

and engineering by exploring such issues from four crucial perspectives: women's professional status, scientific productivity, cultural barriers, and theoretical explanations. Multiple interviews with famous women scientists and rich descriptions revealed severe barriers and disparities that women academics face today. This dissertation furthers the research on women academics in science and engineering by examining women doctoral students' protégé-mentor relationships and career trajectories within the context of the feminist theory.

1.1 Purpose of the Study

This study was conducted with the purpose of examining women doctoral students' protégé-mentor relationships in physical sciences and engineering programs; more specifically, I intended to examine the influence of such relationships on this group of women's academic career aspirations. Graduate school serves as the most important institution at which future academics are trained and prepared (Austin, 2002; Tierney and Rhoads, 1994), but institutional and disciplinary differences also play a major role in impacting the processes and outcomes of graduate education (Clark, 1987, 1993). Mentoring relationships are considered one of the most significant parts of graduate school education. However, this relationship is not necessarily beneficial to both mentor and protégées, especially when it comes to cross-gender mentoring (Kram, 1985; Long, 1997; Mertz and Pfleeger, 2002). To examine the chosen topic, I incorporated a feminist standpoint theory lens (Harding 1991, 2004; Haraway, 1988; Hartsock, 1983, 1998; Smith, 1974) that enabled the study to take into account a host of factors, such as power, gender, politics, and history. The answers to these questions contribute to the research of higher education from the perspective of women perceived as "gender-neutral." In addition, I also employed Kram's mentoring theory to conceptualize the meaning, complexity, and relational perspectives of mentoring. The work of Tierney and Rhoads (1994) on faculty socialization was

adapted to situate the research of women's mentoring relationships in the context of the academic career and socialization processes. My dissertation research was a qualitative study with ethnographic traditions guided by the following major research questions:

1. How do women doctoral students in physical sciences and engineering define and participate in protégé-mentor relationships?
2. How do faculty working with women doctoral students in the physical sciences and engineering define and participate in protégé-mentor relationships?
3. To what degree and in what ways does the gender of the faculty mentor influence the protégé-mentor relationships in the specific case of women doctoral students (protégé) in physical sciences and engineering?
4. How do the protégé-mentor relationships influence deliberations, considerations, and aspirations related to the pursuit of academic careers?
5. Does the gender of the faculty member influence doctoral students' interest in pursing academic careers?

1.2 Significance of the Study

Doctoral education serves as the bridge that connects students' scholarly skills and interests with the academic profession. Despite the constant barriers that women face progressing in the physical sciences and engineering related fields, the number of women doctoral recipients in these fields has increased over the past two decades. However, the number of women who enter the academic profession remains disproportionally low compared to the number of doctoral degree recipients. The significance of this study is the investigation of the effect of women doctoral students' mentoring relationships on their academic career aspirations in physical sciences and engineering departments. As part of a larger transnational and

interdisciplinary research agenda, this dissertation had the goal of contributing to theory and practice in the fields of higher education, women's studies, and science and technology studies. This study was primarily guided by the scholarship of feminist standpoint theory and was purposefully designed to intersect with science/engineering literature and work on faculty socialization with the intention of improving the theoretical gap in current studies of women in academic science settings through a feminist lens. The findings consist of multiple aspects, including the following: they (1) provide policy implications to various science and engineering programs in mentoring and preparing future women academics in the workforce, (2) offer insights to graduate education divisions in assisting graduate students in socializing into their programs, disciplines, and institutions, (3) assist science and engineering faculty as well as diversity and development offices in improving the processes and policies for women, and (4) offer insights to departments beyond the physical sciences and engineering in terms of enhancing the quality of faculty-student interactions and consequently students' career outcomes.

In the next few chapters, I provide a comprehensive overview of the literature on mentoring, doctoral education, and women in science and engineering. I then elaborate the theoretical framework. Next, I discuss the methodology employed in this study.

CHAPTER 2: THE CONTEXT OF WOMEN DOCTORAL STUDENTS IN PHYSICAL SCIENCES AND ENGINEERING

2.1 Mentoring

The origin of the word "mentor" can be traced back to Greek literature: Homer's (2004) *The Odyssey*. When Ulysses decided to go to war, he chose a trusted friend, Mentor, to serve as guardian and teacher of his son Telemachus. Given the long absence of his father, Telemachus received care, education, protection, and guidance from Mentor.

Research has taken great interest in the study and exploration of mentoring relationships. This enthusiasm has created a myriad of studies and forms of knowledge that broadly and imprecisely define the term "mentoring" or "mentoring relationship" (Bogat & Rednar, 1985). Along these lines, Healy and Welchert (1990) called for the community of mentoring scholars to "synthesize empirical findings into a coherent body of knowledge" to identify and explore unanswered mentoring questions (p. 17). Merriam (1983) regarded the mentoring relationship as "a powerful emotional interaction between an older and younger person, a relationship in which the older member is trusted, loving, and experienced in the guidance of the younger" (p. 162). Additionally, Kram (1985) brings the mentoring relationship to the working world where "a mentor supports, guides, and counsels the young adult as he or she accomplishes the important tasks of learning to navigate in the adult world and the world of work" (p. 2). The definition of the protégé-mentor relationship in the present study incorporates Merriam's definition of mentoring in adult development and Kram's definition of mentoring at work places. It is defined as a powerful interactive process where the experienced members of an organization provide psychosocial and career advice to guide new members in navigating the social and professional organization and accomplishing desired goals.

Studies show that both the mentor and protégé benefit from the relationship. Levinson et al. (1978) found in their study of young men that mentoring is the most important relationship in young adult males' development. This finding suggests that young men not only benefit psychologically from the mentoring relationship, but mentors also help young men develop skills and intellect that will lead to advancement in their careers. Kram's (1980, 1985) longitudinal studies of mentoring relationships in large corporations revealed the benefits that mentors receive from the interaction included, but were not limited to, internal satisfaction, broader recognition in the field, and praise and respect from external parties. Regarding graduate school settings, mentoring is considered to be the most crucial aspect of the educational experience (Phillips and Pugh, 1994). Graduate students are likely to benefit from the mentoring relationships in various areas: professional identity, academic productivity, professional networking, graduate school satisfaction, and academic career advancement (Clark et al., 2000; Green and Bauer, 1995; Tenenbaum et al., 2001; Weil, 2001).

Levinson et al.'s (1978) study has been widely cited by mentoring scholars, making great contributions in connecting mentoring studies with adult development (Rose, 2003), but the study ignored two critical aspects. First, the positive influences of mentoring tend to be over-emphasized by the existing mentoring literature. Based on an extensive review of the published workplace and graduate school mentoring literature, Healy and Welchert (1990) asserted that many studies "used a tautological definition of mentoring that produced positively biased samples" (p. 19). The spontaneous association between mentoring and positive experience/relationships has misled many researchers to focus their research hypotheses on the protégées' positive experience, satisfaction, and outcome in graduate school. The second problem lies in the perspective of gendered mentoring. Several recent studies have identified

and addressed cross-gender mentoring problems by determining that not all mentoring relationships are beneficial to the people involved (Long, 1997; Mertz and Pfleeger, 2002; Waldeck et al., 1997). Eby, McManus, Simon, and Russell (2000) studied mentoring experiences from the protégé's perspective by surveying over 200 managers in a large executive development program and unveiled a series of unpleasant, and even harmful, mentoring experiences. They reported that this kind of negative experience is especially evident when the mentor's and the protégé's values and attitudes differ.

It is not surprising that Levinson et al.'s study conducted over 30 years ago focused primarily on the male protégé's experience in a mentoring relationship. Kram (1985) raised concerns regarding the stereotypical roles and sexual tensions that occur in a female protégé-male mentor relationship. Clawson and Kram (1984) argued that in the case of dealing with cross-gender relationships, mentors and protégés tend to rely on traditional roles learned from other settings, complicating the mentoring relationship. Noe (1988) similarly contended that most women protégés prefer interaction with mentors from the same gender. This phenomenon leads to a lack of mentor relationships for many young professional women as they enter a male-dominated field. A recent study based on a national survey (Clark, Harden, and Johnson, 2000) for clinical psychology doctoral students revealed different mentoring experiences between men and women, including "competitiveness between mentor and protégé, sexism by the mentor, a perception that the mentor favored male graduate students, and emotional or sexual attraction between mentor and protégé" (p. 266). An alternative approach to mentoring research is to completely neglect "gender" as a dimension. Ehrich, Hansford and Tennent's (2004) comprehensive review and analysis of mentoring literature in education contexts revealed a shocking number of studies that ignored gender factors in studying mentoring issues in education

(2.5% of all studies reviewed had "gender" as the work's focus). Given that cross-gender relationships may bring more complexities (Kram, 1988) and ethical concerns (Johnson and Nelson, 1999), it is important to conduct more research that specifically considers gender as an important facet of the experience.

Although a small number of recent studies have polarized an already limited understanding of cross-gender mentoring relationship concerns by concluding that no gender differences have been found in their studies (Rose, 2005; Tenenbaum, Crosby, and Gliner, 2001), the studies' samples were chosen from mostly the social sciences and humanities. To clarify the definition of mentoring in the graduate school context, Rose's study developed and employed the Ideal Mentor Scale (IMS) and surveyed over 500 doctoral students from two universities in the Midwestern region of the U.S. She found that women place more weight on the importance of the mentor's role-modeling and professional ethics functions than do men, while there are no gender differences in terms of the definition of an ideal mentor. Tenenbaum, Crosby, and Gliner sampled 89 graduate students from six departments and investigated their graduate school satisfaction, academic productivity, and mentoring outcomes based on both advisors and mentees' gender. They reported that gender differences appeared to be insignificant. Other than that male advisors provide slightly less psychological help, there was no significant difference between men and women advisors. However, the sample size of Tenenbuam et al.'s study was fairly limited and was designed in a way to measure advisor-advisee gender differences based on surveying advisees, who tend to be vulnerable in such a powerful dynamic. Rose's study focused on testing the definition of mentoring between men and women. Although her research results suggested that women and men doctoral students define their "ideal mentor" in a similar manner, nothing was found about real-life student-faculty mentoring relationships, protégé

graduate school experiences, or whether or not there was a gender gap in such a dynamic. More studies are advised to deepen our understanding of the relationship between graduate school mentoring and students' career outcomes from both protégé and mentors' points of view.

Despite the "gender-equity" in graduate school claimed by some studies, many large-scale longitudinal studies have revealed significant gaps between female and male students regarding student-faculty interactions at the undergraduate level. Sax (2007) analyzed 40 years' of U.S. college, entering student data, and found that 21st century women college students are facing many disparities in terms of their confidence and stress levels as well as financial situations when compared to their male counterparts. A 2005 study by Sax, Bryant and Harper suggested that female and male students may benefit differently from their interactions with faculty members. A more recent study by Kim and Sax (2009) about student-faculty interaction in research universities demonstrated that course-related student-faculty interaction could inspire students to pursue more advanced degrees. Yet, male students displayed stronger patterns of interaction with faculty compared to female students.

Many studies regarding student-faculty interaction at the graduate school level focus on graduate students in psychology and business programs (Ehrich, Hansford, and Tennent, 2004). Paglis, Green, and Bauer (2006) conducted a five-year study to investigate the benefits that doctoral students receive from their mentoring relationships during their training processes. This study resulted in a higher statistical correlation between mentoring relationships and doctoral students' research productivity, commitment to research careers, and self-efficacy. However, the majority of the sample in this study was male doctoral students and gender was not considered as a variable in the study.

A majority of studies focus on assessing or testing the mentoring issues based on the protégés' rating of their graduate school experiences (Rose, 2003), and consequently, little is known about the mentoring relationship from the mentor's perspective (Crosby, 1999; Mertz, 2004). Additionally, most mentoring literature tends to automatically consider graduate students' advisors to be mentors and runs the risk of equating the advising relationship with the mentoring relationship (Rose, 2005).

Maher, Ford, and Thompson (2004) investigated women doctoral students' degree completion progress and the corresponding relationship with their graduate experiences in an education program. Results showed that early-completing women doctoral students were more likely to receive stronger support from faculty mentors and sufficient funding opportunities. Utilizing data collected from both alumni and recent graduates, this study focused on the issue of women's doctoral completion rate and multi-faceted graduate school factors. Yet, the relationship between women's career outcomes and their graduate school experiences was not analyzed nor provided.

The present study was an investigation of women doctoral students' aspirations to pursue academic careers and the corresponding relationship with their protégé-mentoring relationships in physical science and engineering departments. Specifically, through ethnographic methods and feminist standpoint theory lenses, the influence of protégé-mentor relationships on women doctoral students' aspirations, deliberations, and considerations of the possibilities of pursuing academic careers was examined. Via aforementioned schemes, this dissertation was intended to contribute to the knowledge of mentoring, graduate education, women's studies, and science and technology studies in the following three ways.

First, this study challenged the traditional definition of the "mentoring relationship," which is based on the definition of the "mentor," and thus, the mentor is intrinsically assigned much of the power in the relationship. This study utilized feminist standpoint theory and conceptualized this kind of relationship as a "protégé-mentor relationship." By placing protégé first, the term contributed towards a better understanding of the power dynamics in the relationship between protégés and mentors by effectively lessening the amount of power typically ascribed to the mentor.

Second, previous literature rarely touches upon the influence of protégé-mentor relationships and academic careers amongst women doctoral students in physical sciences and engineering. Specifically, this study utilized ethnographic methods to capture and investigate women doctoral students' academic career aspirations, considerations, and deliberations, as well as how the mentoring relationship influenced such processes.

Third, gender was the major variable in the process of exploring and examining the influence of women doctoral students' protégé-mentor relationships on their academic career aspirations. Women students' protégé-mentor relationships and experiences were centered in the data collection and analysis process guided by feminist standpoint theory (Harding, 1991, 2004; Haraway, 1989; Hartsock, 1998; Smith, 1974).

Furthermore, the sample also included faculty mentors from physical sciences and engineering departments, and ethnographic interviews were conducted with faculty members to introduce the protégé-mentor relationships from the mentor's point of view. To protect the confidentiality of the participating protégés, I did not interview the faculty advisors of the protégés interviewed in this study. Meanwhile, I was aware of the potential limitations of the study design because the faculty members who agreed to participate in the study could already

be in a fairly good mentoring position with their doctoral students. The design of the research problems and interview questions focused on the full spectrum of psychosocial and career activities and incidents occurring among women doctoral students and their faculty mentors; in other words, this dissertation study investigated how the protégé-mentor relationships influenced women doctoral students' considerations, deliberations, and aspirations related to academic careers.

Given the dramatic differences in doctoral programs across various disciplines, the following section provides a review of the current literature on the topic of doctoral education, focused mainly on science and engineering. As such, it provides a solid foundation to properly place this study in the current intellectual debate.

2.2 Doctoral Education in the United States

Before delving into a brief overview of the historical context on doctoral education in the U.S., a seemingly simplistic, yet crucial, question needs to be answered: What is the purpose of the Ph.D.? The establishment of the first Ph.D. program in the U.S. prompted this question, but scholars have still not reached a consensus. A widely referenced definition offered by the Council of Graduate Schools (1995) states "the Ph.D. program is designed to prepare a student to become a scholar, that is, to discover, integrate, and apply knowledge, as well as communicate the disseminate it" (p. 10). Doctoral programs are designed to train the next generation of scholars to be capable of conducting independent, original, and innovative research (Mendoza and Gardner, 2010). However, with the emergent influence of the global knowledge economy, doctoral education is also viewed as a knowledge factory that equips students with skills to participate in the new knowledge industries (Jones, 2003). The latter point is especially explicit in career paths among science and engineering doctoral students.

Following the German model of postgraduate education, the founding of Johns Hopkins University in 1876 set an historical milestone marking the beginning of graduate education in the U.S. (Gumport, 2005). Following Johns Hopkins's objective of connecting scientific research and graduate education, many graduate schools emerged in different forms all across the country ranging from newly established universities (e.g. Stanford in 1891 and the University of Chicago in 1892), adding graduate components to existing research universities (e.g. Harvard and Columbia), to expanding research functions of state universities (e.g. the universities of Wisconsin, Michigan, and Illinois) (Gumport, 1993). The implementation of the Morrill Acts of 1862 and 1890 further prompted the development of graduate education in the U.S. and "by 1900 the number of Ph.D. granting institutions had grown to fourteen, awarding a total of 300 Ph.D.s" (p. 228). Graduate education thrived due to strong government involvement, philanthropic support, and organized, active research (Geiger, 2004; Thelin, 2004).

By the 1970s, due to government financial deficits and inflation, the growth rate of funding for academic research started to slow and global markets began to play a greater role (Slaughter and Leslie, 1999). The concerns of college access for the baby-boomer generation outweighed the interests in scientific research. The emergence of student movements in the 1960s and 1970s also encouraged universities to conduct more "practical" research, the results of which could be used directly for society. Due to the increase of undergraduate enrollment and the societal needs for practical research, universities presently face an increasing number of difficulties toward supporting graduate education (Geiger, 1993). People have raised questions about the quality of graduate education, the increasing amount of pay faculty receive less basic research funding, and the job market for junior faculty members, which has become dismal. Many scholars regard this situation as the indicator of the end of the "golden age of American

higher education" established in 1960s. More and more universities have shifted from a basic research paradigm to applied research projects (Gardner and Mendoza, 2010; Altbach, Berdhal, and Gumport, 2005). The relationship between research universities and industry has become more intimate, especially in the fields of engineering and applied sciences to attract more funding (Geiger, 1993).

The increasing number of doctoral students, decreasing support in graduate education, shifting demographics, and dramatically shrinking academic positions pose serious labor market issues to present doctoral education (Austin and Wulff, 2004). The increasing interest and demand for doctoral education from consumers resulted in the growing enrollment of science and engineering doctoral students and ever-increasing numbers of doctoral programs. Geiger (1997) pointed out that a "prestige hierarchy" existed among various science and engineering doctoral programs leading to an disturbing phenomenon: "The Ph.D. as it stands today represents too much training for many potential consumers of graduate education; yet it is too little training for its traditional role of preparing future faculty" (p. 249).

An authoritative and large scale national study conducted by the Committee on Science, Engineering, and Public Policy (COSEPUP) in 1995 triggered an outcry for reshaping and reforming U.S. doctoral education to "meet the country's varied needs for scientists and engineers" in the rapidly changing global political economy (p. 3). Golde and Dore's (2001) large scale, interdisciplinary survey study on doctoral students' experiences revealed problems in today's doctoral education. The study found that "the training doctoral students receive is not what they want, nor does it prepare them for the jobs they take" (p. 3). On the students' part, the study showed that "many students do not clearly understand what doctoral study entails, how the process works, and how to navigate it effectively" (p. 3). In *Paths to the Professoriate*, Austin

and Wulff (2004) summarized the current challenges that doctoral education faces: it fails to effectively fulfill its responsibilities to employers, it does not sufficiently prepare students for the world in which they will work, and it does not efficiently meet changing societal, national, and global needs.

Although the aforementioned challenges face all doctoral programs and institutions, they vary drastically among disciplines due to the goal of training students to be independent scholars and researchers. In Clark's *The Research Foundations of Graduate Education* (1993), Gumport emphasized the disciplinary differences in achieving these goals of doctoral education. She stated "different disciplinary interpretations of research training prevail. Most common are the laboratory-intensive apprenticeship model of the sciences and the library-intensive individualistic model of the humanities" (p. 263). Under the principles of the apprenticeship model, science and engineering doctoral education is characterized by two major factors: (1) doctoral students' active and frequent participation in professors' research projects and collaboration with other professors, researchers, and fellow students, and (2) abundant research funding to ensure the "hardware (research labs, facilities, and equipment)" and "software (computing software, doctoral student funding, team collaborations)" for productive and time-sensitive research.

Gardner's (2010) study of 60 doctoral students from six different disciplines in humanities, social sciences, physical sciences, and engineering revealed fairly common themes of students' socialization experiences: support, self-direction, ambiguity, and transition. However, "the degree of dynamics of the experience discussed varied by departments with higher or lower completion rates" (p. 69). Gardner found that, as students of the departments with "lower completion rates," Mathematics and Engineering doctoral students were more likely

to depend on faculty members for support. She then argued that these two departments happened to have a high percentage of international students and that international students were more likely to seek help and directions from faculty members rather than peers. While finding that supportive student-faculty mentoring relationships was one of the major reasons for high and low completion rate at department levels (Golde, 2005), this study failed to establish the direct nexus between mentoring relationships and students' socialization experiences. Additionally, socialization experiences caused by gender differences were not a consideration in the study's design. As women doctoral students are more likely to encounter difficulties and challenges in their graduate school socialization process (Turner and Thompson, 1993; Maher, Ford, and Thompson, 2004; Herzig, 2004), more research on this topic is needed.

In Herzig's (2004) study on doctoral women in mathematics, both women doctoral students and the department faculty members were interviewed. However, the findings showed that all women had negative or limited relationship with faculty. These relationships took various forms such as "feeling invisible, needing guidance, wanting better teaching, lacking moral support and wishing to be mentored" (p. 384). The interviewed faculty rarely discussed interactions with women graduate students. Herzig simply concluded the reason for this was that "they [the faculty interviewed] had so few [women doctoral students]" (p. 383). Given that the data for this research is drawn from a larger research project, it is constrained by the design, conceptual framework, and interview questions directed by the larger study. The faculty's interviews failed to sufficiently support the author's conclusion, and the data collection was limited to one-time interviews with six women doctoral students. More literature on women in Science and Engineering will be discussed in the next section.

In a mixed-methods study of over 200 women doctoral students in Education, Maher, Ford, and Thompson (2004) found that four major factors contribute to women doctoral students' degree progress: viable and stable funding, the presence of an involved and supportive advisor, opportunities to participate in major research projects, and health, family, and marital stability. The first three factors have also been identified as the key to Science and Engineering graduate education (Clark, 1993; Fox, 1998; Golde and Dore, 2001; Gumport, 1993; Nettles, 2006). Stolzenberg (2006) found that among doctoral students from various disciplines, engineering doctoral students (28%) were the least likely to choose an academic career, felt significantly more exploited, and received significantly less positive feedback from their faculty advisors. She also suggested that qualitative research on this topic could "add depth to studies on the personal and professional aspects of the advising relationship (p. 185)." Given that my dissertation study was conducted within the realm of Physical Sciences and Engineering doctoral programs, the following section will discuss important literature focusing on women's issues in science and engineering, as well as the current literature gap.

2.3 Women in Academic Science and Engineering

Examining the current conditions of women in Science and Engineering requires a brief history of women's participation in U.S. higher education. Prior to the 1890s, women had no access to graduate education (Thelin, 2004). Women later made drastic progress in pursing advanced degrees, so much so that in 1929, women earned 12% of doctorates in Science (Babco et al., 2002). However, Hollenshead et al. (1996) noted that up to the 1970s, there was "no record of the numbers of women in engineering" (p. 127). Today, the number of women in Physical Sciences and Engineering has grown, but not in a linear progression. At the undergraduate level, although women outnumbered men at the beginning of this century, the

number of women who choose to enter science and engineering still appears to be minimal. Astin and Astin's (1993) national study revealed that the number of freshmen who choose to enter or remain as science and math-based majors has declined. They found that from freshmen to senior year, the loss rate of students in science, mathematics, and engineering has reached 40%. Sax's (2008) study on gender and college students drew our attention to two important perspectives of students' college experiences that influence their academic outcomes: student-faculty interactions, and peer culture.

At the graduate level, the number of women doctoral degree recipients has increased steadily. Based on a report from National Science Foundation (NSF), the proportion of science and engineering doctoral degrees earned by women has risen considerably in the past several decades reaching 40% in 2006 compared with 8% in 1958 (NSF, 2008). Despite these increases, the number of women scientists and engineers who entered academia upon receiving their doctorates did not increase at the same rate. The CPST report (2006) showed that only 14.8% of all Physical Sciences faculty members were female, while only 10.3% were members of engineering departments. The CPST report further illuminated another interesting phenomenon: the unbalanced ranking distribution among women physical science and engineering academics. In 2003, the number of full-time women professors in these fields was too small to be included in the report. The majority of women faculty members are concentrated in assistant and/or part time instructor/lecturer levels: 55.5% for physical sciences ,and 58% for engineering.

These statistics posed a provocative question that interested many scholars from the early 1970s: where did all the women physical scientists and engineers go? Any examination of this problem requires much more than merely looking at the statistics (Hollenshead et al., 1996). While much of the early research focused on pipeline issues and undergraduate women (Brush,

1991; Leslie, McClure, andOaxaca, 1998; Nauta, Epperson, and Kahn, 1998; Seymour, 1995), researchers suggested that graduate school is a crucial stage for academic careers, (Austin, 2002; Golde and Dore, 2001; Tierney and Rhoads, 1994), especially in Science and Engineering (Austin et al., 2009; Barber, 1995; Fox, 2000; Holenshead et al., 1996). The purpose of the present dissertation was to examine women doctoral students' mentoring relationships and their impact on the students' academic career aspirations in physical sciences and engineering. Thus, the focus of literature review was on graduate education in science and engineering and its relationship to academic careers.

Breaking the traditional research approaches of assessing "threshold effects" that might keep women out of graduate programs or glass ceiling effects that might distance women from promotion and advancement, Etzkowitz et al. (2000) examined women's experiences in Ph.D. programs and early faculty careers, finding that women face difficulties at all stages of the academic ladder due to differentials in socialization, advising patterns, and marriage/family responsibilities, as well as implicit biases in the androcentric science infrastructure. The study's mixed methodology examined women doctoral students and junior faculty members in physics, chemistry, engineering, and computer science, highlighting four major barriers that women face in science and engineering: entry barriers, socialization barriers, academic advising barriers, and career barriers. With respect to career choices, a majority of women graduate students in Etzkowitz et al.'s study reported that they were more likely to pursue an industrial rather than an academic career since it is "more compatible with family life" (p. 6).

Women doctoral students' concerns with balancing family and career is not surprising given many studies on women academics revealed the constant struggles between academic and family life due to the "greedy natures" of both (Ward and Wolf-Wendel, 2004, p. 243; Grant,

Kennelly, and Ward, 2000). Ward and Wolf-Wendel conceptualized “greedy natures” of both academic and family life as "a workload that never ends, never having enough time in the day, the ambiguities of tenure expectations, and the expectations for working a 'second shift' at home" (p. 243). In the study of 30 junior women faculty from nine research universities, Ward and Wolf-Wendel found that women faculty are more likely to have a difficult time managing the "second shift" at home and balancing academic productivity for tenure promotion with childcare responsibilities. Although this study was not conducted among physical science and engineering faculty only, other studies suggest similar patterns occur among women professors in science and engineering (Fox, 1998; Toutkoushian and Conley, 2005; Xie and Shauman, 2005).

Fox investigated the issues of women academics in Science and Engineering from faculty members' perspectives. In her (2000) study on organizational environments and their relationship to women doctoral students' progress in Science and Engineering, Fox found that although many Science and Engineering programs showed an improvement in the percentage of degrees awarded to women and a higher level of women's participation/performance due to enhanced organizational infrastructure and leadership, "departments leave untouched the core of graduate education: the advisor-advisee relationship" (p. 57). Fox's (2010) more recent quantitative study of tenured and tenure-track faculty in prestigious research universities revealed two additional pressing concerns: (1) "women may remained outside of the heated discussion, inner cadres, and social networks in which scientific ideas are aired, exchanged, and evaluated" (p. 1007), and (2) women are more likely to face bidirectional interference between academic work and family/household responsibilities.

A series of large-scale longitudinal studies conducted by the Committee on Science, Engineering and Public Policy (COSEPUP) examined various concerns in the U.S. Science and

Engineering community, most recently focusing on fulfilling the potential of women in academic science and engineering. The comprehensive study involved Science and Engineering professors, doctoral students, administrators, and policy makers. This 2007 report, *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*, identified four major barriers for women academics in science and engineering today: persistent discrimination, implicit bias, insensitivity of evaluation criteria, and implicit patriarchal academic organizational structures (COSEPUP, 2007).

The findings from this national study are extremely valuable in the examination and investigation of issues concerning women in academic Science and Engineering, despite alternative studies that underestimate the significance of this topic by presenting an optimistic view that women are not facing any barriers in their scientific careers. In the mean time, the COSEPUP (2007) report also contended "the problem is not simply the pipeline" (p. 2). This suggests new research should be directed away from studying the comparative statistics of undergraduate science and engineering education on which an overwhelming amount of attention has and continues to be focused upon. Additionally, the majority of existing studies are focused on either women graduate students' perceptions of mentoring or women faculty's evaluation of their jobs. This approach cannot provide an effective tool to capture and examine women doctoral students' "lived experience" in physical sciences and engineering programs, as well as their aspirations, considerations, and deliberations of academic careers in their protégé-mentor relationships. The graduate school experience is regarded as an important component of this study because graduate education is the "anticipatory socialization stage" of academic careers (Austin, 2002; Tierney and Rhoads, 1994). Most importantly, protégé-mentor relationships, conceptualized as the most crucial component of graduate education, have not been studied from

the protégé's point of view that is based on lived experiences in physical sciences and engineering programs. Given the importance of "academic careers" in this dissertation study, the following section provides a comprehensive view of this concept and how it was positioned in the design of this study.

2.4 Academic Profession

Many scholars consider graduate school to be the initial stage of academic careers (Austin, 2002; Austin and Wulff, 2004; Fox, 1999 2006; Tierney and Rhoads, 1994). An important aspect of this dissertation study was to examine the doctoral students' socialization into academic careers. Thus, it is important to understand relevant literature on the nature of the academic profession.

Millett (1962) characterized American academics as a group of professionals at the service of others, holding high knowledge and technical skills, and obeying a code of ethics. Some major characteristics of the academic profession include scholarly devotion, required doctoral training, hierarchy of rank, and academic freedom (Millet, 1962). The academic profession has many similarities with other professions; however, the conceptualized definition of "profession" is not always clear. In his (1982) social study of American medicine, Starr provided a comprehensive definition for profession as "an occupation that regulates itself through systematic, regulated training and collegial discipline; that has a base in technical, specialized knowledge; and that has a service rather than profit orientation enshrined in its code of ethics" (p. 15). Clark departed from this definition and undertook a series of groundbreaking studies (1987, 1989, 1997) on American and European academic life, offering many insights into the special position that the academic profession holds in the larger spectrum of the professional world. In *The Academic Life. Small Worlds, Different Worlds,* Clark argued that while academic

occupation certainly fits the "scholarly concepts of profession" (1987, p. 22), defining the academic profession from a general approach tends to overshadow the complexities brought about by disciplinary and institutional differences.

The growing gap between disciplines draws researchers' attention to the specific disciplinary characteristics that academic careers entail. Clark (1989, 1997) identified major differences in the nature of academic work between Humanities professors and Medical professors. Humanities professors generally have lighter teaching loads, flexible office hours, and administrative responsibilities. They normally interact with a large number of undergraduate students in lectures and a small number of graduate students during graduate seminars and dissertation committee work. However, Medical professors interact frequently with patients, nurses, students, and laboratory assistants. Their schedules are tightly planned and can extend to over 10 hours a day, 7 days a week. Even for tenured professors, salaries are highly influenced by research funding they secure and the changing policy of the medical care industry. Long and Fox (1995) suggested four dimensions in studying women's career attainments in academic scientific communities; they stated that organizational location, professional rank, research productivity, and recognition by peers are especially important in evaluating scientific career attainment. These indicators are especially significant in studying women's careers in physical sciences and engineering due to the special award system, demanding workload, and laboratory based research.

Another major factor that influences the nature of the academic profession is institutional differentiation. Clark (1997) asserted "as powerful as self-amplifying disciplinary differences have become in dividing the American professoriate, intuitional diversity now plays an even more important role" (p. 26). Only one third of all professors in the U.S. work at doctoral-

granting research universities, presenting a diverse range of characteristics across institutions, but with some striking commonalities. Compared to professors from other sectors, research university professors normally spend at least half of their time researching with their doctoral students, research staff, and colleagues. They have fewer teaching responsibilities and are more likely to interact with graduate students. For leading research universities, Clark's research found that "institutional and disciplinary cultures converge" for the faculty due to the high-level reputation of scholarship produced by cutting-edge departmental and disciplinary research. Given the nature of the research site for this study, a large leading research institution, it is especially crucial to note the key characteristics of academic life in this sector of postsecondary institutions.

At the turn of the new millennium, the significant number of retirements among the baby-boom generation of professors posed a brand new question: "how can we prepare the next generation of faculty?" (Austin, 2002, p. 94). Searching for the answer to this question has stimulated a wave of research that reevaluated the new characteristics of academic profession under changing socio-economic and political environments. Growing diversity among student populations, emerging technology, increasing faculty workload and global networking are key facets of the new American academia (Austin, 2002; Menges, 1999; Rice, Sorcinelli, and Austin, 2000). Conversely, the over-supply of Ph.D.s across disciplines and the shrinking number of tenure-tracked positions have largely limited new doctorate recipients' career trajectories. Jobs are no longer abundant in the form of full-time tenure track positions.

In 2004, according to the U.S. Department of Education, 36% of the U.S. Science and Engineering faculty were employed part-time. This trend is especially explicit among women faculty: 44% of women science and engineering faculty are employed part-time. A national

study on diversity in Science and Engineering faculties at research universities by Nelson and Rogers (2004) revealed that there are few tenured and tenure-track women faculty in most Physical Sciences and Engineering departments and the "percentage of women among recent Ph.D. recipients is much higher than their percentage among assistant professors." While Nelson and Rogers' study clearly defined current problems and barriers that potential women and minority faculty might face based on large-scale survey results, they did not provide sufficient explanation of the reasons for and solutions to the problem.

Clark's widely cited (1987) work on American academic professions coined "small worlds, different worlds" to describe the uniqueness of professoriate in the U.S. context. When academic professions first emerged over seven hundred years ago, it only consisted of a few subjects and small group of professionals (Clark, 1987). Academe is composed of many unique academic groups- small worlds- and that there are fundamental differences. The concept, "different worlds," perfectly portrays the disciplinary, subject and institutional differences across the academic profession. Clark also acknowledged the complexity of studying American academic professions and suggested that researchers should adopt various organizational approaches to focus on specific context under such diverse structural and cultural settings.

Although scientists usually perceive science as a field that is free from any bias, culture and misunderstandings, its knowledge, practice and interpretation of scientific calculations are deeply embedded in culture that is formed by the people who are practicing it, the funding agencies, a nation's political environment and other power relations (Nader, 1996). The findings from many anthological and ethnographic studies of science have "contradicted the ubiquitous images of Western science as pure, independent form politics" (Nader, 1996, p. xiii). Science is considered by many people as culture-free, yet numerous studies of science culture and practice

suggest otherwise. Anthropologist and historian Sharon Traweek studied high-energy physicists who were trained in the same field but are from two different national cultures- Japanese and American. She found that this group of physicists demonstrated various levels of differences in the practice of doing science and their perceptions of leadership, risks, and conflicts that are deeply influenced by nationality, gender, race/ethnicity, class, and educational background (1988). In a later writing, Traweek (1993) further emphasized the importance of studying the culture of science. She asserted that the practice and knowledge of science is deeply imbedded and shaped by society. While science indicates the systematic knowledge produced by people who are trained in certain scientific disciplines, the study of science and its culture is a process by which historians, anthropologists, and sociologists examine the practice of science and reveal that it is not autonomous and independent from society. As Laura Nader discussed in her *Naked Science: Anthropological Inquiry into Boundaries, Power, and Knowledge:*

> Physicists who observe themselves with some candor may refer to ideas and behaviors that are irrational, workplaces that are undemocratic, dissent that is not tolerated, and cultural practices that are in conflict. While others idealize physicists' behavior as more rational, less subjective, and more advanced than the lay public, physicists interested in moving beyond the meaning of idealized versions of science explore how science and scientists have been affected by military and corporate interest, the primary sources of funding, and the users of the discoveries of physics. Introspection by physical and biological scientists provides anthropologists with useful commentary for understanding the way cultures of science are formed and institutionalized (1980, p. 9).

Pickering (1992) further operationalized the terms “culture” and “practice” in the study of science and society. The process of doing science requires many fields of resources. In the rest

of this dissertation, "culture" is defined as "the field of resources that scientists draw upon in their work", and "practice" denotes "the acts of making (and unmaking) that they perform in that field (Pickering, 1992, p. 3)." Pickering further cautioned his readers that we should not regard "culture" and "practice" as synonymous given that "practice" refers to the actual act while "culture" entails the resources and tools and necessary networks that scientists utilize to produce the final products.

Traweek (1993) identified over twenty disciplines that study the culture and practice of science, technology, and medicine. Each has its own theoretical and methodological traditions that guide the design and practice of its particular studies. Among the major categories of studies of science and technology, this dissertation falls under the realm of "gender studies of science, technology, and medical practices" (p. 13). The design and research analysis of this study are closely related to three out of five subfields of gender studies of science by examining: (1) "the processes for excluding women from scientific, medical, and technological work and the processes by which women decide not to pursue work in these fields" (the research questions and goals of this study); (2) "the effects of gender bias in scientific, medical, and technological research" (the findings of this study demonstrate strong implicit gender bias within physical sciences and engineering doctoral programs); and (3) by identifying "how sciences, medicine, and engineering can be practiced in ways that are not based on sexist assumptions" (the use of feminist standpoint theory and how it shaped the design and data analysis of this study) (Traweek, 1993, p. 14).

The present study utilized qualitative approaches with ethnographic traditions to develop complex understandings of the meaning-making processes that women go through in making decisions, based on their interactions with their mentors, about whether or not to pursue an

academic careers. For example, what kinds of considerations do women make as part of the decision making process towards pursuing an academic career? Only by studying people in their natural settings with a focus on their lived experiences, can we employ data collection tools flexible enough to examine such complex and changing aspects of the doctoral experience.

CHAPTER 3: THEORY AND METHOD

This study was an examination of the influences of mentoring relationship on women doctoral students' aspiration to pursue academic careers in physical science and engineering. My focus was on the kinds of deliberations and considerations women give to the possibility of pursuing an academic career and the manner and form of how their mentors assist or hinder such deliberations. The conceptual framework guiding my inquiry was drawn from feminist standpoint theory, mentoring theory, and faculty socialization as a cultural process theory. These three conceptual frameworks provided a comprehensive and coordinated guide to the design of my study. I will elaborate on how these three theories inform the theoretical construction of my dissertation study.

3.1 Feminist Standpoint Theory

Since its emergence in the 1970s, feminist standpoint theory has provided a valuable critical framework to explore, investigate, and examine women's lives and activities in contemporary political, sociological and scientific terrains through the reconstruction of existing relations between "the production of knowledge and practices of power" (Harding 2004, p. 1). A wide array of intellectual traditions, such as Marxism, critical theory, sociology of science, and philosophy of science, have informed and shaped the development of feminist standpoint theory. Harding (2007) noted that standpoint theory "provides guidelines for future research" through offering "empowerment" to the historically oppressed groups (women) in the androcentric institutional power and production of knowledge" (p. 45). She (2004) further suggested the advantage of using feminist standpoint theory is "to create oppressed peoples as collective 'subjects' of research rather than only as objects of others' observation, naming, and management" (p. 3). Haraway (1988) similarly argued that feminist standpoint theory challenges

the hegemonic conceptual framework of "research subject" and "object" where problems and objectivities are developed and defined based on men's lives and experiences. One of the key standpoint theorists, Hartsock, noted the advantage of feminist standpoint theory by stating, "a standpoint carries with it the contention that there are some perspectives on society from which, however well-intentioned one may be, the real relations of humans with each other and with the natural world are not visible" (1983, p. 285). Given the complexity of feminist standpoint theory projects, the following will delineate some key ideas that help the understanding of feminist standpoint theory and its nexus with my proposed study.

3.1.1 Theoretical Origins

Feminist standpoint theory was based on theoretical roots from Marx and Engels'theory on proletarian standpoint. They argued that to fully understand the way the class system works, one could not start by investigating the experiences and problems from the viewpoint of its beneficiaries. Instead, Marx and Engels argued the importance of starting the research/investigation from the lives of the working class and defining the research problems based on their experiences to fully understand the complex class dynamics.

The emergence of feminist standpoint theory is closely associated with the women's movement of the 1960s and 1970s and is also indebted to the "antipositivist histories, sociologies, and philosophies of science then emerging in Europe and the United States" (Harding, 2007 p. 45). Political scientist Hartsock (1983) criticized the way that knowledge production is claimed to be "objective" in legal, medical, natural sciences and other disciplines although it is generated by traditionally male dominated organizations and policies. She noted "a standpoint is not simply an interested position (interpreted as bias) but is interested in the sense of being engaged" (p. 285). Thus, standpoint theory is engaged in the commitment to goals of

exploited groups. By noting the essence of "standpoint," Hartsock (1983) suggested that feminist standpoint epistemology can allow us to "understand patriarchal institutions and ideologies and perverse inversions of more humane social relations" (p. 284). Feminist standpoint theory provides researchers with a powerful theoretical tool to begin with women's lived experiences as the center of the research problems as well as to challenge the patriarchal system of knowledge production and further analyze gender as well as organizational and social relations.

Smith (1974) focused on the field of sociology and criticized the traditional sociological knowledge produced by men's experiences and interpretation of the world, which generally ignored women's conditions in and understandings of social relations.[2] She rejected the idea of simply adding women's voices as an "addendum" to the existing sociological conceptual frameworks (p. 7). This rejection reflects a significant concept of "situated knowledge," a concept coined by Haraway (1988). This concept will be revisited in the following section. To guide later standpoint projects and research, Smith (1974) suggested that researchers acknowledge their own situatedness to develop research questions from research subjects' lived experiences:

> What I am suggesting is more in the nature of a re-organization which changes the relation of the sociologist to the object of her knowledge and changes also her problematic. This reorganization involves first placing the sociologist where she is actually situated, namely at the beginning of those acts by which she knows or will come to know; and second, making her direct experience of the everyday world the primary

[2] An interesting topic was touched upon during my discussions with Sandra Harding on the language used in Standpoint Theory. She pointed out that Smith uses "women standpoint theory" while other theorists, such as Hartsock, tend to use "feminist standpoint theory". Smith's approach in phrasing the "standpoint theory" adds a sociological spin to applying such theory to a broader social studies of science context.

ground of her knowledge.... The only way of knowing a socially constructed world is knowing it from within (p. 11).

The theoretical origins of feminist standpoint theory demonstrate that the approach to the study of women cannot follow the traditional so-called "neutral" and andocentric structure of dominant knowledge production frameworks. Rather, it is crucial to recognize what objectivity really means in the construction of social reality and how to examine women's experiences through their daily lives.

In my study, I placed women's narratives and their lived experiences at the center of my analysis in order to better understand how their daily graduate school experiences are informed and shaped by the protégé-mentor relationships especially as they pertain to considering academic careers. In Harding's (1991) term, this is a "study up" approach where social relations, organizational hierarchy, power infrastructures are examined through starting out the research from women's daily lives, experiences and interactions. In a later (2001) writing of Harding's, she pointed out that "study up" strategy is only the start not the end of the studies of the lives of the oppressed groups, which have very distinctive cultures and knowledge. The goal of utilizing standpoint theory is to "identify otherwise obscured features of dominant institutions, their cultures, and their practices (p. 517)." In the case of this dissertation, the effort was intended to examine the lived experiences of 25 women doctoral students in physical sciences and engineering within a large research institution, and analyzed the data collected from both women doctoral students and female/male faculty mentors who had close interactions with doctoral students in physical sciences and engineering. The design and data analysis of this study were closely guided by the theoretical framework of feminist standpoint theory. The findings and discussion chapters go beyond identifying the reasons why women doctoral students in physical

sciences and engineering avoid academic careers. Instead, further analysis and discussions are provided regarding the larger disciplinary, departmental, and institutional culture and infrastructure and how they influence these women's career decision-making processes.

3.1.2 Strong Objectivity

Women's lives need to be centered in the study of their experiences in given cultural, organizational, political and social relations. This standpoint approach challenged the traditional construct and production of objective and neutral scientific knowledge. Harding (1992) questioned the objectivity and neutrality claimed by traditional knowledge production in natural and social sciences. She further argued the problem that "the dominant views remain the purportedly neutral standard in the process of scientific knowledge production" (1991, p. 93). In physical sciences and engineering, the neutral standards and policies are usually set by men who have historically dominated the fields, not to mention their hegemony in developing and advancing the basic normative patterns of the university. Thus, Harding (1991) maintained that feminist standpoint research must identify and emphasize "strong objectivity". "Strong objectivity" emphasizes the significance of starting research from the lived experiences of those who have been traditionally been excluded from the knowledge production process to produce more objective and relevant knowledge that otherwise could not be produced (Harding, 1991; Naples, 2007). Harding contended, "all human beliefs—including our best scientific beliefs—are socially situated, but they also require a critical evaluation to determine which social situations tend to generate the most objective knowledge claims" (1991, p. 142). Thus, feminist standpoint theory provides researchers with a critical theoretical lens to investigate social and gender relations as well as knowledge making processes outside of the traditional so-claimed "objective" infrastructure of science and social science inquiry.

Harding's strong objectivity concept enables researchers to criticize the traditional notion of neutrality and carve out unique theoretical perspective that guides research to focus on women's problems and social relations. In the case of my study, I began with women doctoral students' daily interactions with their faculty members and examined how relational dynamics influenced this group of women's career decision-making process. These women's challenges, concerns, problems, and dilemmas were the focal point of my investigation.

3.1.3 Situated Knowledge

"Strong objectivity" empowers researchers to generate knowledge from the experiences and voices of women's lives. Yet, this concept does not simply suggest, "add[ing]" an individual woman's experience to the knowledge production process. Instead, Haraway (1988) posited that this kind of feminist objectivity means "situated knowledge." She emphasized the importance to situate investigation at a certain social, disciplinary, organizational, or historical angle:

> Situated knowledges are about communities, not about isolated individuals. The only way to find a larger vision is to be somewhere in particular. The science question in feminism is about objectivity as positioned rationality. Its images are not the products of escape and transcendence of limits (the view from above) but the joining of partial views and halting voices into a collective subject position that promises a vision of the means of ongoing finite embodiment, of living within limits and contradictions— of views from somewhere (p. 590).

Harding (2004) concentrated on the disciplinary debate side of situated knowledge and argued that "carrying out standpoint projects within disciplines is a crucial task since a main objective of standpoint theory and research is precisely to map the conceptual practices through which particular institutions, such as disciplines, serve oppressive forms of power" (p. 12). A

feminist standpoint analysis of doctoral women's protégé-mentor relationships in physical sciences and engineering may need to take into account a number of questions about discourses such as, power (Who determines the problem?), gender (What is the gendered perspective on the faculty-student interaction?), politics (Who are the stakeholders in women's career decision making process?), and history (How does the traditional male-dominated conceptual framework still exist and affect women's experience in a subtle way?) that shape this group of women's knowledge production and decision making processes. The concept was not to single out women's voices and demonstrate their problems in the research process. Instead, the goal was to analyze the group of women doctoral students' graduate school interactions with their mentors from a framework that centers on these women's daily lives and experiences. In the meantime, it was necessary to observe the influences brought by the disciplines of physical sciences and engineering, the traditional androcentric knowledge production infrastructure, and the so-called forms of "objectivity" that typically frame such fields. Particularly, how can a feminist standpoint illuminate women doctoral students' academic career aspirations and the complex ways in which they may be shaped by protégé-mentor relationships?

3.2 Mentoring Theory

The mentoring relationship is considered to be the most important factor to an individual's personal growth and career development (Burke 1984; Kanter, 1977; Kram, 1985; Levinson, 1978). Given the rising attention to mentoring, a plethora of studies have been conducted on the topic of mentoring in both workplace and academic settings. However, the use and definition of mentoring remain unclear and perplexing, not to mention the fact that the discourse itself tends to support the reproduction of power imbalances among protégés and mentors. Bogat and Rednar (1985) argued that one major shortfall of extant literature is the lack

of "a comprehensive yet functional" definition of mentoring. Kram produced large-scale research projects that provided the most accurate and comprehensive definition of mentoring to date. Kram (1983) studied 18 developmental relationships at a large northeastern public utility and defined the four phases of the mentoring relationship: initiation, cultivation, separation, and redefinition. Two years later, Kram (1985) conducted her landmark study on the functions of mentoring and expanded O'Neil's definition of the personal function of mentoring to both psychosocial and career. Kram's theory has been employed in various fields of study (Clark, Harden, and Johnson, 2000; Dreher and Ash, 1990; Ibarra, 1993; Johnson and Huwe, 2003) and is considered to be comprehensive and reliable (Tenebaum, Crosby, and Gliner, 2001; Burg, 2010). The following text will delineate the use of Kram's mentoring theory and how it guided the design of this study.

3.2.1 Mentoring Functions

Allen and Eby assert in *The Blackwell Handbook of Mentoring* that Kram's model of *mentor functions* "brought heretical clarity and programmatic research efforts to the field of mentoring" (2010, p. 52). By systematically and operationally defining a large number of mentoring concepts, Kram's (1985) work helped researchers to differentiate mentoring from other types of developmental relationships (Crosby, 1991).

Kram (1985) posited mentoring functions are "those aspects of a developmental relationship that enhance both individuals' growth and advancement" (p. 21). After conducting multiple studies on organizational behavior and mentoring relationships, Kram defined two broad categories of mentoring functions: career and psychosocial. Career functions are directly associated with the hierarchical movement of individuals in their organizations, while psychosocial functions are closely related to assisting individuals on personal levels by shaping

their new identities, both in and out of the organization. Kram (1985) emphasized the importance of the interconnected relationship between the two mentoring functions by stating, "together these functions enable individuals to address the challenges of each career stage" (p. 22). Additionally, many studies of socialization consider graduate school as the initial stage of the academic career (Anderson and Swazey, 1998; Austin, 2002; Golde and Dore, 2000; Tierney and Rhoads, 1994). Thus, adopting Kram's mentoring theory is crucial for the design, data collection, and analysis of the present study due to its operationalization of the mentoring functions and the interrelated relationship between these mentoring functions and career advancement. The following table summarizes career and psychosocial mentoring functions, as well as the relevant sub-categories that shape the mentoring relationships.

Table 1

Career and Psychosocial Mentor Functions based on Kram's Model

Function	Description
Career functions	
Sponsorship	It involves individuals at senior positions supporting young individuals. It is crucial for newcomers' advancement in an organization. Sponsorship takes the forms of nomination for the promotion of a younger individual, and is proposed by a senior member.
Exposure and visibility	Senior members assign tasks and responsibilities that allow newcomers to broaden their connections and to network with key personnel in the organization. The newcomers' connections to and evaluations by key personnel set a solid foundation for lateral movement in the organization.
Coaching	Senior members guide young individuals with specific strategies for achievement of professional goals, work objectives, and recognition.
Protection	In case of controversial situations, senior members volunteer to take the credit and blame. If necessary, senior mentors will also intervene in the circumstances where young individuals are ill equipped to fulfill assignments.
Challenging assignments	Experienced members provide junior colleagues with training and ongoing feedback, enabling professional competency.
Psychosocial functions	
Role modeling[3]	This is the most frequently observed aspect of psychosocial functions. It implies an experienced member's performance, attitudes, values, and behaviors serve as a model for the newcomers to follow.
Acceptance and confirmation	As the junior member develops competency and skills in the organization, senior colleagues provide encouragement and support.
Counseling	It allows an individual to discuss and receive feedback on personal concerns that might interfere with positive performance and professional identity at a new organization.
Friendship/mutuality	This function implies the enjoyable social interactions that lead to the exchange of work or non-work related experiences in informal settings.

The above-mentioned mentoring functions make up the most significant characteristics of developmental relationships in organizations (Kram, 1985). Through sponsorship,

[3] Role modeling appears to be extremely complex in the case of cross-gender relationship as indicated by Kram (1985). This notion will be further explored in the section on "the complexity of gender mentoring".

exposure/visibility, coaching, protection, and challenging assignments, the senior members assist newcomers in learning the norms and values of organizational life, ultimately preparing them for career advancement. Simultaneously, young colleagues begin to develop professional identities, confidence through role modeling, acceptance and confirmation from the organization, and possibly friendships. The broad areas of the mentoring functions efficiently guided the design of interview protocol for both faculty and students, and also the development of major codes at the beginning of the data analysis process. For example, the following represent some of the initial codes during the data analysis process: transition support, exposure and networking, challenging tasks, validation, counseling, and informal interactions.

Further, the mentoring experience is bidirectional in both corporate settings (Kram, 1983, 1985) and academic settings (Tierney and Rhoads, 1994). By gaining recognition from peers, cultivating young talents, experiencing self-satisfaction, and receiving technical support from the new members, senior members of the organization benefit from mentoring the younger generation (Kram, 1985). They can also be affected by the influence of their protégés (Tierney and Rhoads, 1994).

Yet, the mentoring functions described above cannot be used as either a chronological or a complete guide to researching mentoring relationships. These relationships are ongoing and evolving processes, characterized by fluctuation in both the quality and quantity of the mentoring functions over time (Levinson et. al., 1978; Philips, 1982). Subsequently, I will introduce Kram's (1983) four mentoring phases and their roles in guiding this study.

3.2.2 Mentoring Phases

Kram's (1983) model for studying mentoring relationships starts with the *initiation* phase. *Cultivation* occurs after all applicable mentoring functions reach their apex. *Separation* is triggered by significant structural or organizational change and/or psychological changes within both mentor and mentee. The final phase—*redefinition*—takes shape when the mentoring relationship either transforms into a new relationship or completely ends. These four phases of mentoring shed light on predictable patterns and themes in developmental relationships and may be used to guide mentoring studies.

3.2.3 The Complexities of Gendered Mentoring

The examination of mentoring relationships is complex in nature due to the various personalities and behavior patterns among protégés and mentors, as well as the complexities of organizational culture. Organizational culture, which is defined by much management literature, refers to "the specific collection of values and norms that are shared by people and groups in an organization and that control the way they interact with each other and with stakeholders outside the organization" (Hills and Jones, 2001, p. 381). The complexities increase dramatically when the relationships involve cross-gender mentoring, which is inevitable in today's working world (Kanter, 1977; Kram, 1985; Noe, 1988). Kram (1985) regarded two major categories of challenges that cross-gender mentoring relationships need to face: internal and external. The internal relationship refers to the interaction between mentor and protégé, while the external relationship indicates the "boundary" between individuals and boundaries within the entire organization (Clawson & Kram, 1984). Studies show that, from an internal relationship standpoint, cross-gender relationships are likely to suffer from stereotypes and misunderstandings (Kanter, 1977; Kram, 1985; Noe, 1988; Schmader and Johns, 2003), unsatisfactory role modeling (Kanter, 1977; Dreher and Ash, 1990), and intimacy and sexual

tension (Kram, 1985; Noe, 1988). Additionally, Kram argued that cross-gender mentoring relationships are especially vulnerable to the external environment in the form of scrutiny and suspicion. Due to the objective of this dissertation which inevitably involves complex cross-gender mentoring relationships, it is crucial to maintain these complexities in the design, data collection, and analysis of the study. A special focus on cross-gender protégé-mentor relationships in physical sciences and engineering and their influence on academic career considerations illustrated anther unique aspect of this study's contribution to the existing literature.

Many scholars have pointed out that mentoring relationships are not simplistic and unidirectional processes. They are influenced by many complicated organizational factors and individual characteristics. Van Maanen and Shein (1977) emphasized the importance of acknowledging organizational and occupational differences when it comes to the examination of mentoring relationships and socialization processes. Kram (1985) corrected this by stating that "mentor relationships vary across organizational settings in terms of the range of the functions provided, the length of time a relationship endures, and the level of intimacy and commitment achieved" (p. 197).

To better conceptually guide the purpose of this study, I also employed Tierney and Rhoads' (1994) work on faculty socialization, which considers graduate school socialization as part of the academic career preparation process. This theory aided in further conceptualizing the design of this dissertation by zeroing in on various aspects of student-faculty relationships in graduate school. The following section will elaborate the use of this theory.

3.3 Faculty Socialization as a Cultural Process

Academia, similar to other organizations, consists of various policies, values, norms, decision-making, and socialization processes. Tierney and Rhoads (1994) refered to "these shared understandings and the formal and informal processes used to develop understanding and meaning" as organizational culture (p. 17). Further, they analyzed existing literature on academic life and suggested that more recent and future studies should “treat the institution itself as a culture— an organizational culture” (1994, p. 21).

Inspired by Geertz's (1973) work on interpretations of culture, Clark's (1987) study on the academic life and professorate, and Van Mannen’s work on occupational and organizational socialization, Tierney and Rhoads (1994) proposed an effective model that regards faculty socialization as a cultural process. They categorized faculty socialization into implicit and explicit actions and pointed out:

> Socialization occurs through implicit and explicit actions. For faculty, implicit socialization may occur around the coffee machine, in the locker room, or at a wine and cheese party. Implicit socialization is difficult to observe and analyze, for it occurs spontaneously and unobtrusively. Explicit socialization involves clearly delineated cultural structures such as faculty development programs and the promotion and tenure process (p. 22).

This model proves crucial to this study for three interrelated reasons. First, the connection between culture and developmental relationships is bidirectional since culture shapes and is shaped by interactions (e.g. mentoring) within an organization (Geertz, 1973). Second, doctoral training is considered to be the initial stage of the academic career as graduate students are "exposed to the norms of the professorate" (Tierney and Rhoads, 1994, p. iii). 3). Third,

given that the focus of this study is on women doctoral students' protégé-mentor relationships and how they influence academic career aspirations, it is important to examine how professional, disciplinary, and institutional cultures intersect within this group of women's graduate school socialization processes.

Before I further elaborate on faculty socialization and academic culture, I will delineate the reasons why a qualitative approach with ethnographic tradition is the best-suited method for the present study. As stated by the texts above, it is important to treat institutions as cultural entities, especially when it comes to faculty and graduate student socialization. Wolcott (1975) views ethnography as "the science of cultural description" and thus suggested that researchers utilize ethnography in educational research (p. 112). He pointed out two major contributions of anthropological ethnography in the context of education: " (1) the means by which people organize themselves into interacting social systems, what the anthropologist studies as social organization, and (2) the shared systems of beliefs and attitudes, the ideational systems, that the anthropologist examines as ethos or world view" (p. 123).

In a groundbreaking study of a group of prominent international high-energy physicists in Japanese National Laboratory, anthropologist and historian Traweek (1988) utilized a cultural framework and ethnographic approach, which revealed many interesting findings regarding the physicists community's formal and informal organization, communication, socialization, transmission of knowledge, and funding infrastructures, as well as how physicists created a particular culture in the national labs as a discipline.

3.3.1 Academic Profession and Culture

Tierney and Rhoads (1994) asserted that four cultural forces shape the socialization process in academic careers: the national culture, the institutional culture, the disciplinary

culture, and the culture of the profession. Building upon the work of Clark, Tierney, and Rhoads added a fifth cultural facet to the academic career: individual cultural differences. In other words, the experiences of male professors are likely to be different from female professors, and those of minorities are likely to differ from those of members of the majority. When it comes to the examination of faculty socialization processes in the U.S., Tierney and Rhoads (1994) placed more emphasis on the influence of the culture of the academic profession, disciplinary, institutional, and individual cultures; this is quite logical given that any study situated within one national context would thus be controlling for cultural differences operating at the national level (i.e. faculty life in China is different from that in the United States). They went on to operationalize these four cultures:

> Professional influences derive from general notions related to what it means to be a member of the professorate. Disciplinary influences, of course, drive from one's disciplinary affiliation. Individual influences include, for example, age, class, race, and gender. Finally, institutional influences relate to the institutional culture with which a faculty member becomes associated (p. 9).

With these four cultures in mind, many scholars argue that the nexus between faculty identity/socialization and disciplinary culture is stronger than its connections with institutional culture, especially amidst the myriad of individual cultural differences (Kuh and Whitt, 1988; Tierney and Rhoads, 1994). This stronger tie between faculty and disciplines largely occurs at research universities where more "cosmopolitans" exists (Clark, 1987). Clark (1987) argued that the notion of "locals [professors] " and "cosmopolitans [professors]" are antithetical. "Cosmopolitans" are highly concentrated in large research universities and are more likely to value and relate to the "canons of scholarship and research" defined by disciplinary cultures (p.

134). Given that my dissertation was a qualitative study with ethnographic traditions and situated at one large research university, it is important to clarify how the work of Tierney and Rhoads informs my study. I view three aspects of Tierney and Rhoads' model as being especially useful in guiding this study: the way they treat the culture of the profession (professorate), disciplinary culture (physical sciences and engineering culture), and institutional culture (a large research university). The culture of the academic profession is based on the concepts of collegial governance, education of the young, academic freedom, scrutiny of existing knowledge, service to the society through knowledge production, etc. (Clark, 1980; Kuh and Whitt, 1988). Across disciplines and types of institutions, dissemination of knowledge, autonomy in conducting research, and collegiality are the three common values shared by all faculty members (Kuh and Whitt, 1988; Tierney and Rhoads, 1994).

Austin (2002) identifies socialization within one's specific field/discipline as another important aspect of graduate student socialization. Disciplines vary drastically in terms of "individual behavior and group action" (Clark, 1989, p. 5). Biglan (1973) built on Snow's (1959) work on organizational culture and proposed a threefold classification for all disciplines as "hard-pure", "pure-applied", and "life-system vs. nonlife system." In his study on the relationship between subject matter characteristics and various university disciplines, Biglan reported a large degree of differences between "hard" and "soft" disciplines, including research activities, research sources, scholarly output, and teaching and research commitment. The disciplinary culture intersected with institutional and departmental culture to provide a backdrop for examining the socialization process for future faculty members in Physical Sciences and Engineering.

Tierney and Rhoads (1994) categorized faculty socialization into two stages: anticipatory and organizational. In light of socializing into an academic career, the anticipatory stage mainly occurs in graduate school where potential faculty recruits are extensively exposed to the lifestyle and norms of the professorate. The concept of anticipatory socialization and its relationship with the design of this study will be further elaborated in the following sections.

3.3.2 Anticipatory Socialization

According to Merton, anticipatory socialization refers to the process in which newcomers take on the values of the organization that they aspire to join and becoming acclimated to the acceptance by that organization (1968). In the case of the professorate, graduate training provides a platform for students to learn and anticipate the expectations, behaviors, and lifestyle that comprise the working life of a successful faculty member; thus it is regarded as the anticipatory socialization stage of academic careers (Austin, 2002; Golde and Dore, 2000; Tierney and Rhoads, 1994). In graduate school, doctoral students are initially exposed to not only the norms and values of their discipline and the academic profession, but to the skill sets and expectations that they are likely to encounter in their future positions (Austin, 2002; Tierney and Rhoads, 1994). In this crucial process where doctoral students are socialized to the scholar role, faculty's mentoring and encouragement are positively associated with students' successes (Weidman and Stein, 2003). However, Tierney and Rhoads (1994) claimed that many minority and women students face "inadequate anticipatory socialization" as marginalized groups in certain disciplines and departments.

In the process of examining the protégé-mentor relationships between women doctoral students and their faculty members, it is important to frame the study within Tierney and Rhoads's model for faculty socialization because graduate school serves as the anticipatory

socialization stage of the academic career; protégé-mentor relationships in graduate school directly affect doctoral students, and especially women doctoral students' academic career aspirations and outcomes. Protégé-mentor relationships need to be examined within the context of institutional and disciplinary (departmental) cultures. It is important to point out that the present study does not compare the profession of professor with other professions. Further, the study focuses solely on one nation, the United States. Thus, both national and professional cultural influences mentioned in Tierney and Rhoads' model were effectively controlled. Institutional, disciplinary influences and individual cultural influences were the foci of this study, with the individual cultural influences specifically tied to the female gender identity of the doctoral students and the male gender identity of the mentors. Further, to examine the complex cross-gender protégé-mentor relationships, the sample of this study also included some female mentors as a means of drawing cross-gender comparisons.

Tierney and Rhoads' model proves to be crucial to this study for three interrelated reasons. First, the connection between culture and developmental relationships is bidirectional since culture shapes and is shaped by interactions (e.g. mentoring) within an organization (Geertz, 1973). This perspective informs the conceptualization of key notions and data collection of this study. For example, mentoring relationships are operationalized as "protégé-mentor relationships" under the guidance of bidirectional mentoring process proposed by Tierney and Rhoads and Harding's feminist standpoint theory, which reverses the power dynamics normally assigned to the mentor alone. Moreover, ethnographic interviews were conducted with both women doctoral students and faculty mentors to better capture bidirectional interactions in the graduate school socialization process. Second, doctoral training is considered to be the initial stage of the academic career as graduate students are "exposed to the norms of

the professorate" (Tierney and Rhoads, 1994, p. iii). This aspect was used in part to inform the use of codes within the data analysis stage. Third, given that the focus of this study is on women doctoral students' protégé-mentor relationships and how they influence academic career aspirations, it is important to examine how professional, disciplinary, and institutional cultures intersect within this group of women's graduate school socialization processes. Although this study's research site was limited to one large research university, it is important to acknowledge the cultural differences among various physical sciences and engineering disciplines, departments, and programs and that such differences impact women doctoral students' interactions with faculty. Major data analysis codes were developed on the basis of the theory proposed by Tierney and Rhoads, as well as additional literature on cultures in physical sciences and engineering communities.

3.4 Three-Phase Graduate Socialization Model

Gardner's (2007, 2008) three-phase graduate student socialization model is an extension and development of Antony's (2002) model, Weidman, Twale, and Stein's (2001) development socialization models, and Tinto's (1993) student departure model. Gardner's newly proposed (2008) model overcame the weaknesses of these socialization models; such weaknesses include treating graduate experiences as a "monolithic" process and placing emphasis on students' individual differences and their "total developmental transformation experience" (p. 64). The focus of Gardner's three-phase socialization model not only echoes the essence of Tierney and Rhoads' faculty socialization model, which addresses the individual, departmental, disciplinary, and institutional cultures as critical elements of faculty/graduate student socialization processes, but also provides efficient criteria for the sample selection of this dissertation study. According to Gardner (2008), graduate students' socialization incorporates three phases: phase one indicates

the time period from the admission to the program to the beginning of the coursework; phase two covers the doctoral coursework to the examination period; and phase three starts with the completion of the required coursework and culminates with the completion of dissertation research (candidacy). The details of how this socialization model guides the sampling of my study will be elaborated upon in the methodology section.

3.5 Research Methods

This dissertation utilized an ethnographic qualitative approach to explore and examine women doctoral students' protégé-mentor experiences and their relationships with their academic career aspirations in the physical science and engineering fields at a large research university in the Western U.S., designated herein as WRU. This section outlines various details of the research methodology, including but not limited to, research questions, data collection methods, sampling, research site, data analysis, and steps undertaken to ensure the trustworthiness and authenticity of the study.

3.5.1 Research Questions

The study addresses the following research questions and corresponding sub-questions:

1. How do women doctoral students in physical sciences and engineering define and participate in protégé-mentor relationships?
2. How do faculty working with women doctoral students in the physical sciences and engineering define and participate in protégé-mentor relationships?
3. To what degree and in what ways does the gender of the faculty mentor influence the protégé-mentor relationships in the specific case of women doctoral students (protégé) in physical sciences and engineering?

4. How do the protégé-mentor relationships influence deliberations, considerations, and aspirations related to the pursuit of academic careers?
5. Does the gender of the faculty member influence doctoral students' interest in pursuing academic careers?

3.5.2 Glossary of Key Terminologies

Given the complex and rich meanings of some key terminologies used in this dissertation, I conceptualized the following key terms within the context of this study:

Power

This term refers to "a complex strategic situation in a given society social setting" (Foucault, 1980, p. 98). In this study, such "social setting" refers to the physical sciences and engineering doctoral programs, WRU and other environments that women doctoral students are exposed to during their doctoral studies.

Gender

Gender differs from the biological classification sex. It denotes the differences in behavior by sex (Money and Ehrhardt, 1972). The use of women/men (gender) versus female/male (sex) reflects this difference. In feminist theory, gender is a socially constructed concept. Based on Block (1972)'s study of sex roles, feminist scholar MacKinnon (1983) stated "Gender, cross-culturally, was found to be a learned quality, an acquired characteristic, an assigned status, with qualities that vary independent of biology and an ideology that attributes them to nature" (p. 529).

Mentor

A mentor is a senior person who provides advice and necessary help in order for a graduate student to develop and advance professionally. This term is not restricted to the use of only doctoral advisors.

Protégé

This term refers to women doctoral students in physical science and engineering and the fact that they are engaged in experience that requires a more senior person or expert to help them acquire a particular skill set and knowledge base.

Protégé-Mentor Relationships

This is a newly coined term. Instead of using the conventional term "mentoring relationships," this study coined the new term "protégé-mentor relationships" to challenge the power that was commonly assigned to mentors in the widely accepted term "mentoring relationships." Fairclough (1989) argues that power ideologies are embedded in various features of discourse, including certain common definitions in everyday life. This dissertation centers on women doctoral students' lived experiences in their doctoral programs and thus places protégés as the focus of this relationship.

3.5.3 Data Collection

This dissertation study explores and examines the relationship between women doctoral students' mentoring experiences in physical sciences and engineering and their academic career aspirations. Relevant data was collected by interacting with women doctoral students, interviewing this group of students and their mentors, observing their daily interactions and professional activities, and reviewing documents. Given the highly exploratory nature of my study, and consistent with arguments made by Denzin and Lincoln (2000) in which they argue

that a qualitative method is best used for collecting "a variety of empirical materials that describe routine and problematic moments and meanings in individuals' lives" (p. 3), this study employed multi-method qualitative methods, mainly drawn from ethnographic techniques. Informed by feminist standpoint theory (Hartsock, 1983; Smith, 1974; Harding, 1991), this study centered women doctoral students' lived experiences, defining them as crucial toward gaining knowledge and understanding about their protégé-mentor experiences. According to Smith (1987), "the only way we can know a socially constructed world is to know it from within" (107). This study employed methods best suited for understanding the culture surrounding this group of women doctoral students through examining their daily protégé-mentor activities, how they perceive their relationships with mentors, how such relationships influence their graduate school experiences, and how such experiences affect their considerations and aspirations to pursue academic careers (Bogdan and Bilken, 2003).

By applying these guidelines to my study, the primary strategies of data collection were in-depth ethnographic interviews with 25 women doctoral students and 10 faculty members from physical sciences and engineering departments and participant observation at various formal and informal events. All interviews were guided by the interview protocol developed around principles stated in Spradley's (1979) description of the ethnographic interview, which suggests three categories of questions: descriptive, structural, and contrast.

Given the importance of language and culture in ethnographic research, descriptive questions allow the researcher to obtain information through "native" language and culture, which refers to the engineering and physical sciences disciplinary culture and language (p. 90). Structural questions provide an effective tool in understanding the cultural knowledge of the informants. Contrast questions are significant in exploring the meanings and cultural

implications that informants assign to key notions and concepts. An important aspect of graduate school socialization is to socialize into various cultures (Austin, 2002; Gardner, 2008; Tierney and Rhoads, 1994). Accordingly, an ethnographic approach to developing interview questions is essential to examine participants' understanding of the departmental, disciplinary, and institutional cultures' influences on their mentoring and socialization experience in various physical sciences and engineering doctoral programs, particularly with an eye towards the informants' academic career aspirations. In addition to the exploration of the understanding of culture, the ethnographic approach is also helpful in examining and investigating the protégé-mentor relationships experienced by women doctoral students from both mentors' and protégés' points of view in physical sciences and engineering.

In addition to ethnographic interviews, participant observation was conducted through my constant participation in physical science and engineering monthly Ph.D. seminars, research group meetings, some students' dissertation proposal/defense meetings, various Ph.D. student social events, and observation in physical sciences and engineering laboratories. Jorgensen (1987) considers participant observation as the most suitable method for examining the "ordinary, usual, typical, routine, or natural environment of human existence in the world of everyday life" (p. 15). The importance and practicality of utilizing participant observation in this study is threefold. First, the focus of this study is to examine protégé-mentor relationships in graduate school, mainly from the protégé's everyday lived experiences and their interactions with mentors. Second, the theoretical framework of this study, specifically Harding's feminist standpoint theory and Tierney and Rhoads' faculty socialization model, assert the importance of investigating proposed research questions from women's lived experiences and departmental, disciplinary, and institutional cultures. Third, through 3 years of working and spending time

with physical sciences and engineering women doctoral students and some faculty members, I have established an extensive network and rapport with the subjects of this study. I have been participating and observing dozens of formal and informal physical sciences and engineering academic events and social activities. In addition to the advantage that participant observation provides with regard to efficient investigation and redefinition of research questions by exploring subjects' natural working and social environments and cultures, Jorgensen (1987) pointed out that this strategy also helps to avoid the disruptions that occur in some ethnographic methods where the researchers only act as observers and somewhat intrude on subjects' everyday working/living environments.

To further the understandings of women doctoral students' daily interactions with their mentors and their academic/research progresses, I reviewed handouts and notes from research group meetings, TA-professor meetings, dissertation proposal/defense meetings as well as physical science and engineering websites. These documents were crucial in investigating how disciplinary, departmental, and institutional cultures shape the quality and process of protégé-mentor relationships, and in the case of my study, aid in investigating how these relationships influence women doctoral students' consideration, deliberations, and aspirations of pursing academic careers. The documents were reflections of protégé-mentor interactions regarding teaching and research advisement and they depict a large portion of women doctoral students' professional training and development processes as a potential faculty member. Additionally, I reviewed the websites of physical science and engineering departments to assist the understanding of demographic and organizational cultures at various programs and departments. I have been collecting the aforementioned documents from a group of women doctoral students for over two and half years prior to the start of my dissertation. I continued collecting such

documentation and analyzed their content and relevance to this study during the dissertation study. Based on Miles and Hubeman's (1999) suggestion, I organized and recorded the preliminary analysis of the document review, ethnographic interviews, and participant observations on a predesigned journal entry form. For further and systematic data analysis, this form consists of date/time, types of events/documents, a brief description, my comments and reactions, as well as preliminary comments and emergent themes.

Sample

All participants were affiliated with Physical Sciences and Engineering fields at a large research university in the Western United States as doctoral students or faculty members. The sampling strategy for this study followed concepts proposed by Gardner in her (2008) study of doctoral students' development towards independent scholars (academic careers) and Maxwell's (1996) criterion-based selection. As the objective of this study was to explore women doctoral students' mentoring experiences and their relationships to their academic career aspirations, I chose women doctoral students from Phase Three (the period starting with the completion of doctoral coursework culminates with the completion of dissertation research) proposed by Gardner's three-phase graduate student socialization model, where there is a higher frequency of interaction with faculty.

Additionally, Maxwell (1996) suggested that criterion-based selection allows researchers to take into account subject demographics within larger organizational contexts, thus helping the researchers to obtain a more representative participant basis. For example, in the Department of Physics and Astronomy at WRU, one fifth of the students are categorized as international students. Therefore, in my selection of women doctoral students from this department, interviewing at least one fifth of the international doctoral students reflected these demographics.

Snowball sampling techniques were utilized due to the low visibility and representation of women doctoral students in most Physical Sciences and Engineering departments. Snowball sampling is especially suited for research studies that touch upon "sensitive issues, possibly concerning a relatively private matter, and thus requires the knowledge of insiders to locate people for study" (Biernacki and Waldorf, 1981, p. 141). With approximately 300 women doctoral students in physical sciences and engineering programs at WRU, about half of them were qualified for inclusion based on the study's selection criteria. Interviews were conducted among 25 women doctoral students and 10 faculty mentors. Both women doctoral students and faculty mentors were selected based on the principle of snowball sampling. When certain selected faculty mentors happened to be the advisor of participating doctoral students, they were dropped from the sample and a new faculty mentor who was not directly associated with the participating doctoral students was selected. Also, five female and five male faculty members were interviewed to better examine the complexity of cross-gender protégé-mentor relationships as suggested by Kram's mentoring theory.

The interviews were approximately one hour long, digitally recorded, and transcribed verbatim. Subjects, prior to the interview, filled out a short questionnaire aimed at identifying participants' demographic and background information. The following tables reflect demographic information about the participants. In order to protect their confidentiality and anonymity, all information is listed in separate categories:

Students:

	International	**Domestic**
Number of Student Participants	9	16

	Minority	**Caucasian**
Number of Student Participants	11	14

	Physical Sciences	**Engineering**

Number of Student Participants	16	9

Faculty:

	Female	**Male**
Number of Faculty Participant	5	5

	International	**Domestic**
Number of Faculty Participant	3	7

	Minority	**Caucasian**
Number of Faculty Participant	4	6

	Physical Sciences	**Engineering**
Number of Faculty Participant	5	5

Research Sites

This dissertation study was a single-site qualitative study with ethnographic approaches at a large research university in the Western U.S., which is herein referred to as WRU. WRU was selected due to its preeminent standing in physical sciences and engineering programs and its strong commitment to research and doctoral education. Thus, WRU not only provides a good representation of physical sciences and engineering culture, but also reflects the culture of research universities to a larger extent. The variety of physical science and engineering departments allowed exploration of a wide array of departmental cultures that influence women doctoral students' protégé-mentoring relationships. According to WRU's institutional data, physical science and engineering doctoral students account for over 45% of the entire graduate student population of 11,000 students. WRU's physical science and engineering programs also represent a broad variety of chemistry, geology, earth and space sciences, environmental sciences, and engineering programs and departments.

Further, a WRU graduate division report has revealed that, although women constituted almost 43% of WRU doctorate recipients in 2000, the percentage was not equally distributed

across disciplines. For example, women only represented about 10% of engineering Ph.D.s and 25% of physical sciences Ph.D.s. Additionally, women faculty members constitute 10% of engineering and physical science professors. The representation of women in both science and engineering doctoral programs and faculty members at WRU mirrors the national proportion in both categories, respectively.

WRU serves as a reasonable representation of a large research university that consists of diverse disciplinary and departmental backgrounds. Given that this dissertation study was intended to be a vehicle to examine and explore women doctoral students' protégé-mentor relationships and the influence on their academic career considerations, deliberation, and aspirations based on various cultural and organizational implications imposed by physical sciences and engineering disciplines, departments, and research university as cultural entities, ethnographic methods were utilized to best capture these intertwined relationships.

Marshall and Rossman (2010) posited that gaining access and negotiating entry to research sites is always a crucial and delicate task. Two major approaches to negotiate site entry were relied upon in this study. First, I leveraged my previously established contacts with women doctoral students in WRU's physical sciences and engineering departments to recruit more research subjects and conduct the ethnographic study. Second, I had previous working relations with the dean of WRU's engineering school, various women professors from civil and chemical departments, as well as professors from the physics and space sciences departments. These individuals assisted me in gaining access to research sites during the data collection process. Further, I have been continuously participating in a number of physical sciences and engineering students' dissertation proposal defense meetings, lab/research meetings, as well as their social

events for the past two years prior to the start of my dissertation project; these activities were continued for the purpose of this dissertation study.

3.5.4 Data Analysis

Analysis of the ethnographic interview and participant observation data and documents was guided by the constant comparative method, described as "a research design for multi-data sources, which is like analytic induction in the formal analysis begins early in the study and is nearly completed by the end of data collection" (Bogdan and Bilken, 2003, p. 66). This strategy was adopted because it allows data analysis to confirm the existing theory, understand the development of new themes, and further connect the findings with policy- and theoretically-related implications. The data analysis followed the steps for constant comparative method outlined by Glaser (1978): (1) begin data collection, (2) identify major foci by locating key themes, issues and events, (3) collect data that contains many incidents of the major focuses, (4) record emergent themes from ethnographic interviews, participant observation and document reviews in the Journal Entry Form (see Appendix III) while starting to search for new themes and foci, (5) work with the data and emergent themes to identify and discover relationships, and (6) code and write with the major themes and foci in mind. Constant comparative data analysis occurred simultaneously with data collection until all identified themes were explored and the writing began. Deductive coding approaches were employed to explore occurrence themes based on themes guided by the conceptual framework of feminist standpoint theory, graduate student and faculty socialization as a cultural process, and Kram's mentoring theory. Some focus areas of these codes were (1) gendered negotiation, (2) research finance and funding, (3) exposure to academia, national labs, and industry, (4) family life and academic career, (5) gender and mentoring, and (6) power dynamics in gendered socialization process.

Furthermore, data analysis of this dissertation went beyond the themes and categories defined and guided by the theoretical framework. I also employed an inductive approach within the data analysis in order to explore the recurrent themes that emerged from the data. For example, the concepts of "community," "network," and "meshwork" were found to be prevalent themes in the data analysis process. The adoption of an inductive data analysis approach was significant in expanding the theoretical and policy related knowledge of women's experiences in physical sciences and the aspects of understanding that were not explicitly indicated in the major theories guiding this study.

3.5.5 Trustworthiness

Many scholars have raised concerns over the trustworthiness and authenticity of qualitative studies. I followed Lincoln and Guba's (1985) questions on the operationalized definition of trustworthiness to verify the credibility, transferability, dependability, and confirmability criteria of the study. More to the point, Lincoln and Guba (1985) entertained these key questions in their quest for greater trustworthiness by emphasizing the importance for researchers to address "how findings of an inquiry are worth paying attention to, what arguments can be mounted, what criteria invoked, and what questions, asked, that would be persuasive on this issue" (p. 290).

According to Lincoln and Guba (1985), credibility guarantees the production of valid and believable findings by developing a thorough understanding of research sites. Transferability emphasizes issues regarding how applicable the findings are to other kinds of settings. Dependability speaks to the possibilities for other researchers to reach similar conclusions under similar research designs and conditions, while confirmability addresses how multiple sources might authenticate the research findings and data interpretations.

To address trustworthiness criteria, I implemented the following approaches in my research in line with Lincoln and Guba's (1985) recommendations. The credibility and confirmability of the study were strengthened by collecting the data over a prolonged period of time (from September 2011 to October 2012), involving multiple data resources (ethnographic interviews with students and faculty mentors who belong to different stages of professional socialization processes at various physical sciences and engineering departments), and collecting data via various methods (participant observation, ethnographic interviews, informal interviews, and document review). Initially, I planned to employ the technique of member checking by sharing the data analysis and interpretations of the interviews with an advisory panel. This advisory panel was planned to consist of five to eight women doctoral students from the research subject pool to discuss the validity of the interpretation and seek alternative explanations of the data. However, as the data collection process was completed, I realized that women doctoral students in physical sciences and engineering programs form very closely tied communities. Even my general discussions with the subsample of my informants could violate the confidentiality and anonymity of my research participants. I did not think it was ethical to utilize such strategy. Instead, I invited all 25 women students to a second informal individual interview, at which I asked each to comment and interpret certain parts of her original interview transcript. Another reason for my decision to invite these women for a second “interview” was due to my "outsider" status to the physical sciences and engineering doctoral programs. Although I am an "insider" when it comes to graduate students' protégé-mentor relationships, the conversations and discussions achieved from the second round of meetings provided me with a deeper understanding of physical sciences and engineering's disciplinary and departmental cultures. Contrary to the original plan of forming an advisory board, I did not send the findings of my

study to any research participants due to the sensitivity of certain data collected. The input and comments collected from individual women doctoral students on their own transcripts were examined and selected for inclusion in the final manuscript of the study, based on relevance to the research questions. Constant comparative data analysis allowed me to compare the raw data, the interview transcripts, and data interpretation on a regular basis to ensure the accuracy of the data analysis.

To establish sufficient transferability and dependability of my study, I provided a detailed description of the research sites and informants. Given the sensitive nature of this study (women students' lived experiences, protégé-mentor relationships and other graduate school socialization processes involved), I ensured the confidentiality of participants by not providing any identifiable information with regard to individuals or their departmental and institutional affiliations in the findings chapters. In reference to the protection of human participants in this research, IRB reviewed and controlled the research conduction process. All subjects were informed beforehand that their participation was completely voluntary and they could withdraw their participation at their will and at any time. Although the research posed minimal or no risk to participants, all participants received a research information sheet which included: purpose of the study, procedures, potential risks and discomforts, potential benefits of subjects and/or society, payment for participation, confidentiality, participation and withdrawal, identification of investigators, and rights of research subjects. I will extend and expand my current valid research IRB approval form.

Given the participatory and interpretive nature of ethnographic studies, it is important for researchers to specify "biases, values, and personal background[s]" in the process of the data collection (Creswell, 2009, p. 177). My various identities as a Chinese national, a woman, a

doctoral student of higher education, and an outsider from the physical sciences and engineering programs influence and shape the dynamics and relationships established during the interviews and site observations; conversely, the identities of my informants, both faculty mentors and women doctoral students, also played a role in this influence. Consequently, my study was guided with an awareness of the ways my personal values and background, along with the theoretical framework intersect, and how the combination of lenses shaped the data collection, analysis, and interpretation process.

CHAPTER 4: SITUATED KNOWLEDGE: CENTERING THE EXPERIENCE OF A COMMUNITY OF WOMEN PHYSICAL SCIENCE AND ENGINEERING DOCTORAL PROTÉGÉS

"I would say some advice on how to get through the year, like, just little keys to success are extremely important. For example, what are the best tips to finish your course work, or if you're in this field, what were the best classes that you took that you could recommend to other people? Once you are actually working for a lab, who are really positive advisors that would be well suited for your personality? And who has money? And what are good fellowships to apply for if you don't have money and you are worried about funding? Those were all things that I kind of had to figure out and this group of women provided me with [a] tremendous amount of help and support" (Mandy, environmental engineering).

Graduate school socialization can be exciting and intimidating at the same time. It is the exciting beginning of a doctoral student's research career and comes with a higher level of freedom compared to undergraduate studies. Across physical sciences and engineering doctoral programs, a high percentage of students enter graduate school directly upon receiving their bachelor's degree. However, adjusting to, and learning how to navigate and master, a graduate school career can be very challenging. Mandy's perspective cited above precisely summarizes the complicated factors that the graduate school socialization process entails: coursework selection, laboratory choices, funding competition, identity negotiation, and relationship establishment. In a vast majority of physical sciences and engineering programs, there is no written rule indicating explicitly how to navigate these crucial concerns for doctoral students.

Additionally, in physical sciences and engineering, where a majority of the faculty, postdoctoral and staff researchers, and doctoral students are male, women often find themselves deeply confused and even desperate when attempting to find answers to these critical questions. However, many physical sciences and engineering women doctoral students carve out their unique "survival approach" by uniting with other women at different stages of the graduate program to maximize limited resources, survive hazing, and successfully navigate their doctoral program, all while cultivating skills and accumulating necessary scholarly qualifications requisite for a successful career upon receiving their doctoral degrees.

The data from this study reveals a strong nexus between women's graduate school support networks and the decision and desire to pursue an academic career. Some women, who are fortunate to be part of a supportive academic community, utilize the support and resources to survive and thrive in a male dominated environment. Discrimination may not be as explicit as it once was, at least compared to 30 or 40 years ago, yet these women reported their constant struggle with various implicit biases that are embedded in everyday practices, conferences, informal social events, and career prospects. This chapter offers insights about the lives of women doctoral students in physical sciences and engineering via their strategies of uniting a community of women to help each other survive and thrive in a multi-faceted and complex graduate school career. As the primary purpose of this dissertation is to examine the influence of women doctoral students' protégé-mentor relationships on their academic career aspirations, the discussion of this chapter positions women's "survival" and "developmental" strategies in their doctoral programs alongside other influences to portray a more comprehensive picture of this group of women's lives and experiences in graduate school. To accomplish this, the chapter begins by introducing major strategic approaches and networks that these women utilized on a

daily basis for course and lab selection, as well as in terms of pursuing publications and advancing scholarly visibility, and eventually how these strategies, or lack thereof, affected these women's decisions to choose or shy away from academic careers. Additional findings chapters will continue this train of thought, further expanding and elaborating on how multi-faceted cultural factors influence women students' negotiations and experiences in their programs and how these intertwined gender and cultural relations gradually shape and cultivate their career aspirations. The discussion of this chapter is especially crucial as I begin to understand the many aspects of graduate school experiences closely associated with protégé-mentor relations and how they affect women doctoral students' lived experiences from day one of their graduate school career.

4.1 How to Survive and Thrive within Graduate School as a Community

Graduate school is described by many research participants as "a complex mechanism," "a playground without explicit rules," "a place that makes you or breaks you," "the beginning of a research career," and even as a "postdoc machine." The discussion on how to first survive, and hopefully thrive during, doctoral studies triggered the discovery of these women's complex strategies of forming and relying on a community that consists of diverse support mechanisms. The following pages present major themes on the diversity of these strategies that women doctoral students utilize in physical sciences and engineering programs to navigate their Ph.D. career with "community building."

4.1.1 Meshworks Established between Women to Navigate Early Graduate School Career

Women participants emphasized the importance of community as a critical tool to help them get through the initial stage of their doctoral studies. They also acknowledged the fact that

"science is a very lonely field for women," and "expect[ed] doctoral studies to be the same way." Regardless, they found the encouragement and motivation to keep going when faced with the initial challenges of doctoral studies by sharing their experiences with other women doctoral students and supporting each other with their own resources. After being asked how she is currently acquainted with other graduate school attendees, Megan stated:

> We [other women and I] are kind of... our group is rather isolated in that respect. I guess I expected it, just because I'm in science. And it's almost always been like that. So you don't really think anything of it any more... In terms of colleagues, I don't really think I have too many other people besides these two women doctoral students that really support and encourage me.

Megan acknowledged that the two women doctoral students who started their doctoral studies around the same time as her were especially helpful during her first year of graduate school. They not only provided her with a sense of support on a professional level (course work selection, research group selection, interactions with her advisor etc.), but also supported her on a personal level (they faced the same types of challenges and support each other on a emotional level). Jill, a fourth-year physical science student also expressed a similar position and stressed the importance of developing a network of doctoral women to support each other emotionally and conquer the fear of being perceived as "stupid" or "unproductive" by their advisers and male colleagues:

> Most of us share a lot of the similar experiences, even though we wouldn't say that [out] loud normally. So having this kind of weekly potluck get-together really made us not feel alone. And that's a huge thing to understand… for example, I thought I was the only person that suffers through the whole thing but… it might be the case that everybody else

has been through this. Most times, they [other women in the group] have their own experiences and I can adopt their ideas to my own world and improve it a little. That's helpful!

Jill's comment illustrated an important method that women utilize to become socialized to their doctoral programs and cope with various professional and personal challenges- support groups. These groups, varying in size from three to over ten people sometimes, offer a platform for women doctoral students to share their experience, stories, challenges, and offer each other potential solutions to their problems. Another finding from the data was that participants believed graduate school tends to be "idealized" by many women doctoral students prior to starting their programs due to the romanticized version of graduate school portrayed by teaching assistants and professors with whom they interacted at their undergraduate institutions. Sixteen women in this group claimed they thought graduate school would be an "end all, be all" and "life changing" experience. Almost all participants admitted they thought graduate school was going to be filled with guidance from their professors, collegiality and support from their colleagues, and financial support from the institution. However, a few months after entering their doctoral programs, these women suddenly realized that graduate school was not a place that "is filled with clear instructions and directions." Alison shared her story about how she related to a female doctoral student and how they got over their initial frustrations together:

I started talking to Susan after a few weeks. She has the same advisor with me. I would say there are a lot of similarities. There is a lot of frustration, fear. For example, when she's presenting her stuff… I can feel how scared she is. I can identify with her. So that's why I think it's a very similar situation. So the frustration, the fear and the

> helplessness bonded us. We started from a co-worker relationship to a somewhat inseparable friendship.

As Allison's comments reveal, "fear" is a fact of life for some women in the sciences and developing strong ties to other peers can sometimes be critical to success. Five women from space sciences discussed the importance of "female leadership" within women doctoral student groups acknowledging that a few key members of the group provided core values and guidance to the community. With this kind of leadership, they were able to achieve success in advocating for women's benefits. Yet, their community was not able to repeat the productivity after the departure of the community leaders. Cindy described this productive period of time in their group's history, all the while glowing with pride and satisfaction:

> So we had one female graduate student… she was totally kick-ass. She organized meetings… She organized this convention where leaders from this field were invited to discuss being a woman scientist. She campaigned for a women's bathroom in the building because there wasn't a bathroom. So we had that sort of thing till some women graduate student graduated. Then nobody else took it up. Including myself… That was like her baby. We also went out… we went to career fairs and Girl Scout troupe stuff… I guess that's what we did. But after she left the whole thing just kind of fizzled and a lot of us are now lost.

This senior student's story represented a victory in advocating opportunities for women in the physical sciences department. Several other participants mentioned her name and two women professors interviewed used her story to demonstrate the proactive role that women should be taking. Yet, these participants also expressed their worries over the fact that "nobody took on her leadership positions after she left." Nicky, a student in the electrical engineering department

described her bond with other female colleagues through the electrical engineering jargon of "mesh." She explained how a normal electric circuit works by connecting all branches together to create a functional system, while "mesh" refers to "a web of branches forming a closed path in a network so that if any one branch is omitted from the set, the remaining branches of the set do not form a closed path" (Merriam-Bester Dictionary). In other words, Nicky indicated that due to the limited access to traditional physical sciences and engineering programs' necessary "networks" of colleagues and mentors, a large number of women formed informal "branches" or "loops" aside from their efforts to connect with the mainstream nexus in graduate school. These "branches" or "informal nexus" were described as "meshworks" in Escobar's (2008) and Ingold's (2007) works on science, technology, and culture. Gu, Traweek, Holbrook et al. (2011) discovered the significance of meshwork in affecting underrepresented women astronomers' scientific careers in research labs and universities.

As part of an effort to train future academics, and as an approach to mitigate funding shortages and the lack of lectures due to the budget cuts, many physical sciences and engineering departments require doctoral students to work as teaching assistants (TAs) for at least three semesters. Many new students have trouble securing funding in the first couple years of their doctoral programs and turn to this "last straw" to pay bills. Helen was one of the 23 women who taught during her first three years, and she shared some of her "intimidating" TA stories:

> When I first started TAing , I was freaking out everyday. It might not seem to be a big deal to my adviser but it was intimidating to us first timers! How I got over it? I basically started venting with Alice, who entered the program one year ahead of me and she was about to start TAing for another class. Alice has done it before so. She really helped me. So the second year I can TA by myself with 100% confidence.

As graduate school progressed, the group of women not only supported each other to get through coursework, exams, and laboratory selections, but also assisted each other with teaching and research duties. By the third year, almost all research participants mentioned their awareness regarding careers trajectories. Gena, an astronomy doctoral candidate described the "shocking discoveries" made by her group of women doctoral students:

> We had this student orientation a week ago and my friends and I went. All faculty stood up in front of the room, 15 men and 2 women. I mean when you look at that… it's like whoa… looking at that made us think why are there so few women? What are the obstacles that stop women along the way? That experience definitely prompted some discussions between us. We think a lot of women stop trying to get to that point [academic positions]. I think it might be for various reasons. But having these chats between my friends definitely made us think about things like that.

Similarly, all 25 women acknowledged that they were well aware of the fact that physical sciences and engineering were very male-dominated fields, and stated they did not mind interacting with male professors, colleagues, and students as "that's just the way it's always been." However, 20 women who discussed in detail how they actively participated in women's communities in graduate school noted how those activities sparked their questioning of women's underrepresentation. The awareness of the underrepresentation of women faculty is positively associated with women doctoral students' desire to pursue an academic career. Some participants acknowledged that this kind of awareness encouraged them to thrive and explore the "unpredictable academic world."

4.1.2 Interactions with Senior Peers to Advance Scholarly Skills and Expand Network Beyond Department

Graduate school socialization does not stop once students complete their mandatory coursework. In fact, all 25 of the women students in this study acknowledged the increasing demand to reach out to a larger community as their graduate school careers progressed. 20 women doctoral students discussed the tremendous amount of help they received from postdoctoral researchers working with their respective advisers. In certain departments, such as space sciences and space physics, there are tenure-track professional researchers dedicated to writing NASA grant proposals and collaborating with researchers from national labs and the industry, and sometimes Ph.D. students, to carry out effective research for NASA missions. These researchers were described by many participants as "extremely helpful mentors" for professional development processes in graduate school. Many women expressed their preference for interacting with postdoctoral fellows and researchers due to the following reasons: "They just graduated from their doctoral program and are in the same age group with us," "they understand our pain and are more understanding," or "we don't have to be scared of asking stupid questions."

The findings of the present research effort suggest that a high percentage of women perceived themselves as suffering from “imposter syndrome,” which is a psychological term for the phenomenon when certain individuals have trouble internalizing or acknowledging their accomplishments. While this kind of behavior has been reported in a report from NASA's conference on Women in Astronomy and Space Science (2009), there has been little follow-up on this proposed syndrome. While it is entirely possible that male doctoral students suffer from symptoms caused by low self-esteem, this study provides the analysis of women's unique strategies to cope with this kind of situation. In this study, all of the women doctoral students

excelled in a competitive pool of candidates, entered prestigious doctoral programs, published at least three journal articles during their doctoral studies, and are all working diligently towards their doctoral degrees. However, their fear of "not being good enough" or being considered "unqualified and stupid" constantly makes them abstain from many interactions with professors and intellectual exchanges at major conferences. Instead, these students turn to postdoctoral and junior researchers rather than their advisors and colleagues for effective feedback and scholarly assistance. As one woman explained:

> I do believe that it's important to talk to different people in your department. I feel sometimes the senior people in your group can be even more helpful than your advisor… They are in the same group and they've been through all this [doctoral program] and they know what it is like to finish a project and what it is like to finish doctoral education in your field. So sometimes they can give you more specific suggestions that can be more helpful to your research.

This participant elaborated on her strategy of dealing with her constant feelings of "fear" and being "lost" which involved interacting with senior peers in her research group. These "senior peers" could be more advanced doctoral students, postdoctoral researchers, or staff researchers. Some women turn to their postdoctoral peers for guidance in the areas in which their advisers are not specialists. For example, Amy, discussed the reasons why she turned to postdoctoral studies for certain types of feedback:

> My adviser is a good scientist and she has great ideas but she's not a great programmer. She doesn't do all those technical stuff. So if I had a question like that, I would go to a programmer or I would go to a junior research staff or post-doc. They would tell me

> what to do. It's usually turn to post-docs for this kind of things [practical and coding related questions]. More technical stuff.

Amy's research project does not necessarily align with her advisor's research interests. She reported her constant "struggle" of not being able to find the right direction or effective feedback. Eventually, she formed an "advisory panel" where several junior staff researchers and postdoctorals provided her with suggestions that helped further her research. Jacqueline was a fourth-year doctoral candidate who used the words "mentor" and "adviser" interchangeably in interviews. Her adviser was a well-connected, prestigious principle investigator of many large-scale NASA projects. Ironically, Jacqueline noted that she received "very little" or even "no support" from her advisor. While discussing the definition of "mentoring," Jacqueline sighed and said, "I wish my adviser was more hands-on. I feel that I didn't learn much from her. Graduate school has taught me that sometimes peers can provide more help than advisers," using the word "peers" to refer to the postdoctoral researchers in her group. Jacqueline added "Many of them are in the same office with me and they've helped me so much to improve my research skills. I probably would have dropped out by now if they weren't there." Jacqueline smiled with a hint of bitterness on her face. She is not alone when it comes to relying on senior peers for advice and feedback, even in the process of seeking employment. Sue, an astronomy student shared the following:

> I've been applying for many jobs and fellowships in the last six months and my officemates have been doing the same but they are post-docs. I ask them questions on applications. They went through and read my stuff. Their opinions on things, such as salary and living conditions are very helpful. I wouldn't really ask my advisor about that kind of stuff. I think I would ask him about the science and the people who work there to

see if that's a good place to go. But for the outside, for the work-life balance, I would turn to the post-docs.

"Work-life balance" is a concept that refers to proper prioritization between job and life. Job indicates career, promotion, or ambition while "life" indicates family and leisure related activities (Jeanes, Knights, and Martin, 2009). In this study, as advanced women doctoral candidates start to look for jobs or postdoctoral positions—a large majority of them applying for at least five positions at the same time—23 of the women reported that postdoctoral and/or staff researchers provided them with extremely helpful and informative insights on not only their applications, but also other potential career aspects such as learning about living conditions, family friendly policies, work-life balance, and office/research lab politics. These postdoctoral and staff researchers came from different parts of the country/world, most likely had worked with prominent professors in national labs or on research teams, and had done multiple postdoctoral appointments prior to their appointment to WRU. Their insights into the significant details of potential positions proved crucial to doctoral women throughout the employment search process.

In some cases, doctoral women were introduced to their potential employers through networks of these senior peers. Many women doctoral students often meet the researchers and professors who may potentially employ them via introductions from postdoctoral fellows and/or staff researchers. Lindsay, a civil engineering student, shared a story of how one woman in her Ph.D. program found her first job after finishing graduate school:

Being connected with staff researchers is awesome because he probably knows a lot more people in the industry, and I know one girl in our lab was having trouble getting a job. So she went and asked him and he gave her applications to this company, and she got

hired a week later. So he's the kind of the guy who knows people, and that's really convenient.

Lindsay shared that she has been trying to form close relationships with senior peers in hopes that she will be able to find a job upon graduation through their network of engineers. During the first two years of the doctoral program, women students formed their support group and community based on gender and field of study. Yet, as their academic careers progressed, these doctoral women's networks expanded to include both female and male senior peers, such as postdoctoral researchers and staff researchers. The group dynamics also increased in diversification across disciplines, as interaction expanded to the scientific communities that bordered their respective fields. For example, chemical engineers may have collaborated with biologists and biochemists. Funding resources could expand proportionally due to the interdisciplinary collaborations. Some of the interviewed chemical engineering students reported that they ran out of funding on their main research project. They then began to work on an interdisciplinary project in a biomedical research center and were able to secure further funding through a different grant from NIH.

4.1.3 The Influence of Women Peers on Doctoral Women's Career Decision Making Process

Choosing an interesting, reasonable, and balanced career path was reported to be a huge concern of all the domestic research participants, while national security restraints and visa and immigration related issues were more prevalent concerns among international doctoral students. Although the quality of their graduate school experiences varies, 19 women noted the important impact that more advanced women colleagues' career moves had on their own career decision-making processes. These participants suggested "it was not until the more senior women

doctoral students started talking about careers, [that] I realized that we should really be thinking about it too." Cindy, an advanced earth sciences doctoral student, discussed how a career discussion between a group of advanced doctoral women inspired her to start thinking about career related matters:

> There's this small group of women who are going to be graduating this year… and they have been talking about it [job applications]. They never really talked about careers with their advisors in the past. But now they are giving me tips about job application. I guess that is kind of interesting to start thinking about it now because obviously it's good to talk about it when you are applying. It's probably also good to prepare for it before applying to figure out a little more about what you want to do.

Cindy's comment touched upon a somewhat surprising, yet common, phenomenon among student participants- they rarely think about how to prepare for a career until the last year or few months of their doctoral programs. Lack of proper guidance and direction when it comes to career aspirations left many women unprepared in the competitive job market. Six women spent a significant amount of time discussing the troubles in their graduate school careers, caused by, among other things, limited mentoring, insufficient financial resources, changing advisers, and in one case, completely restarting a research project after three years in graduate school. The women also indicated that, no matter how difficult the programs have been or will be, the career outcomes of their more advanced women peers always serve as an "ultimate inspiration and motivation" to "keep going" and complete graduate school. Tina, in her sixth year, reflected on this general trend among women who have not had a smooth graduate school career:

> Every woman I know who's gotten a post-doc has moved to a different city. They've got a house with a yard and they've gotten a dog. And it's just this *huge* upgrade in salary,

> and since they are moving out of this expensive city their money goes even further. So it's like this magic dreamland over the rainbow "one day, I'll get a dog." I don't actually even like dogs but now I want one! It's like this total freedom! "I can afford a dog! I can pay for my own health insurance and help to raise this little creature here!" It's like this ultimate status symbol and everybody keeps sending picture[s] of puppies. Even for people who had really rough graduate career say, they told me that their postdoctoral careers are great. It's those kind of stories that keeps me going.

Tina's view is fairly representative among the participants who did not have a smooth graduate school career. Most of them identified a former woman student who has secured a postdoctoral or researcher position as their role models and inspired them to complete their doctoral programs. However, the average length of time to graduation for this group of women is almost one and one-half years longer than an average doctoral student in the same program. In many cases, women doctoral students base their own academic career decisions on the outcomes of their advanced women peers' job placements. Laura, an engineering doctoral student, had only considered careers in the private sector since the first day of her graduate study. She had second thoughts due to the influence of a more advanced Ph.D. peer:

> I think it [Christine's job placement] has played a big role, really. Because I have seen Christine, one of the grad students who I considered as a mentor, going to a postdoctoral position, and she's been very successful at a big research university and they are paying her well and she really likes it, and I kind of like, want to at least consider it [post doctoral appointment]. So, whereas I had not considered it at all these last four and half years, actually now that I'm getting towards the end, I am considering it and looking at what kind of fellowships are out there for post-docs.

Crystal, a sixth-year Ph.D. candidate was about to start her postdoctoral career. She had only applied for one position and accepted it when she learned that one of her former doctoral colleagues was also working in the same research group. She admitted to me that she felt "bad" only applying for one job. Yet, the research group that she will join has very good credibility in her field and she knows some people who work at the group. So she felt that it was a win-win situation on both the professional and personal levels.

Susan, a third-year physical science doctoral student, spoke of the influence her previous lab mates "going into staff researcher positions" had on the way she thought about pursuing an academic career. She discussed the dilemma that many other international students in space sciences are facing, primarily that "the professor positions in the U.S. are limited" and "international students need sponsorship from the university for working visa and it costs a lot for the institution." On the other hand, "if we decide to go into NASA or other federal labs, we will be on a lower level [due to] national security concerns." Although many international women doctoral students face many barriers when it comes to the process of seeking employment, some are utilizing their international networks to secure funding, expand research resources, and conduct research through transnational collaborations. This issue will be addressed in the following section, which is a discussion of the concept of community for women scientists and engineers that expands beyond departmental, institutional, and national boundaries.

4.2 The Community of Women Across Department, Institutional, and National Boundaries

I was introduced to a doctoral candidate named Jane by a mutual friend in one particular physical science department. Jane was in the midst of writing grant proposals for her potential

postdoctoral position at a major national laboratory. I went to her office for our first meeting, and when I arrived she was concluding a meeting with two other women. The office was small, cold, and had no windows; there was a desk and bookshelf placed in each of the four corners of the room with a round meeting table in the center. She introduced me to her colleagues, Pia, a fourth-year doctoral student, and Ping, a visiting scholar from China. Jane described my research project to both Pia and Ping, who seemed to be very intrigued by the research topic. Pia and Ping both work with the same professor and they started working on a very recent NASA mission a year earlier when Ping arrived at WRU. I scheduled interviews with Ping for a later time.

From the interview, I learned that Ping holds a permanent position in a major research lab in the Academy of Science in China and was sent by her research lab to collaborate with WRU's research team. Pia's adviser recently told her that due to the completion of the NASA mission, Pia's funding for her last two years of graduate school might be "unpredictable." Pia expressed her concerns to Jane and Ping over lunch one day and Ping suggested that they should work on a funding proposal together for an interdisciplinary and transnational collaboration grant provided by the Chinese government; this was the major purpose of the meeting I interrupted. I was very impressed by their passion and enthusiasm to pursue funding in such a novel way. Jane informed me that "the U.S. government is cutting a lot of funding for NASA's missions and many doctoral students are have trouble graduating due to funding constrains. So [they] turn to transnational projects to collaborate with European and Asian scientists." This kind of phenomenon is sometimes referred to as "border crossing" or "boundary crossing," a phrase coined by Traweek (1988) during her research on transnational high energy physics laboratories in Japan, and then

further developed in her research on women and minority astronomers (Traweek, Gu, Guillen, & Holbrook, et al., 2011).

4.2.1 Small Community at One Institution, Big Community at One Conference

Findings of the present study reveal that in any given physical science or engineering department within WRU, the resources for women are limited compared to their male counterparts. Women doctoral students discussed their proactive approaches to pursuing guidance and mentoring outside of their departments or the university. In most cases, these mentors were female junior faculty members who met with the students at professional conferences. Some of the women faculty members served on doctoral students' dissertation committees, assisted them with the process of seeking employment, and provided them with "work-life balance" advice. Women students reported they were "more likely to relate to these young faculty members," and are more willing to share "the full picture of their research and career plan." Lisa, a doctoral student in environmental engineering, had a great working relationship with her adviser who effectively assisted her with the transition to graduate school, provided her with sufficient funding to carry out her research, and gave her plenty of opportunities for—and guidance on—publishing and networking. However, she discussed the "degree of sharing certain information" with different mentors when we discussed issues related to building supportive networks:

> I think one of the reasons why I like to talk to her about my career choices is because she can give me a little bit of the outside perspective. Also, she's just a little more casual than my advisor. Our research group in particular and our larger research group in my department, we have a lot of older faculty members, and I'm not sure it's because of their

> age or it's just personalities… There's not a lot of outside work interactions. It's strict. There is work life and there's home life. It's very separate. I don't know about some departments, some people I've met are much more integrated. I feel like those people are a little more approachable.

Lisa is not alone in her experience when compared with other women interviewed for this study. Many research participants who had experienced various degrees of "alienation" in their "lonely graduate school career[s]" stressed the importance of conferences in identifying mentors who can provide them with professional and personal advice. Linda, a Ph.D. student in earth sciences, expressed her views on the importance of attending professional conferences in her field:

> I think doing science could be a very lonely journey. I think that's what these conferences are there for. We talked about this, the importance of conferences, too, of networking, and that lets you unconsciously search out potential mentors. Even if you're not thinking along those lines, you're still thinking this person is ahead of me by this much and they are friendly to me. I feel like I can talk to them and go to them for support at any time.

Linda portrayed "conferences" as arenas for many doctoral students to seek additional mentors and effective feedback. Given that many women reported dysfunctional relationships with their mentors in their doctoral programs, attending conferences appeared to be a very rational and necessary coping strategy. 85 percent of the participants discussed their experiences attending various conferences and woman-oriented sessions. All participants agreed that it was a very good experience talking to other women and connecting with people in the same field. Kelly, a physics student, laughed about the fact that she "never knew that there were so many women working in physics" and that it helped her "feel the sense of belonging … like going home!"

Krista, a fourth-year engineering doctoral student, discussed her pleasant experience attending a Women's Environmental Council meeting:

> It's just a whole bunch of women who are really friendly towards the cause and they're just, they don't really talk about their being women, they just kind of just say, OK, this is a group that is just composed of people who don't have as much representation in the field. So then I think it's just, it's just good in the sense that everyone can get together and be like, OK, we're still people, we still have rights, so we can kind of fight for it.

It was widely believed among interviewed women that attending these conference activities geared toward women had an important impact on them. They realized that these events were not about "complaining about discriminatory behaviors" or "hating their male colleagues." They were more focused on providing "a sense of community" and a "supportive network" where women at different levels of their careers could "get together, share what is going on in their lives, share resources, and sometimes collaborate on research projects." This kind of practice is not only prevalent in engineering, but is also common in the physical sciences, as reflected by an astronomy doctoral candidate:

> I usually attend the meetings organized by the American Astronomical Society Division of Planetary Science. It's the same group of women who belong to other fields. There is a lunar and planetary conference that's not technically through the same organization but the same group of women would come together and made sure there is a room or things are available so that women can have more access. They have a lunch or dinner at these all the time and people bring issues. For example, women at smaller colleges have issues accessing journals. You can't access journals because you are a smaller institution… get

> on this mailing list with everyone… and we'll email you the articles you need. So to a certain extent, we have much more networking than the guys have.

This comment reflected the width of the network built amongst women physical scientists. Not only are women doctoral students benefiting from these types of network, but also women faculty who have less access to professional resources. Unfortunately, about 80 percent of the women in the present study reported that their departments had no particular program that provided a platform for women to support each other. Nicky discussed how she was very excited to be invited to a "women in astronomy" departmental event during her first year at WRU. However, she went on to note, "all we did was get together and take a picture and that was the last time I heard from the organization." Disappointed by the lack of such mechanisms within their departments and the institution, many participants found more encouragement and advice from the women they met at professional conferences. A doctoral student in civil engineering described her experience attending a conference's social event and her subsequent encounter with a woman professor in the field as an "eye opening milestone." It was the second time Mary attended the annual meeting of the American Society of Civil Engineers. There, she met a woman assistant professor from a different university who shared some fairly disturbing experiences of trying to "break into the old boys' club" and the challenges that she faced in advancing as a serious scholar and developing a solid reputation in her field. Mary reflected on the conversations with this assistant professor and on the significance of having such interactions at professional conferences:

> It's definitely good to have outspoken people like her who will say that to the people in our generation because she was sitting around… basically with the next generation of faculty in our field and for her to just come out and say that [it's a very challenging field

> to break into]…I was glad… It's validating to hear something like this from a woman professor. Now, I'm at least prepared to be facing all these situations.

Mary stayed in touch with this female professor following the conference and she has provided Mary with much effective feedback on how to prepare to pursue an academic career as a woman. Conferences are an inseparable part of scientific careers. Graduate students learn about the value and importance of participating in conferences from the very beginning of their doctoral studies. However, the real benefits of meeting more people and exchanging scholarly ideas do not normally register with students until they "incidentally benefit" from the network that they "unintentionally" built through conference meetings. Some of the participants received generous help with career decisions from women professors they met at conferences. Others got involved with various women's sessions at different annual conferences where they encountered positive assistance. Almost all women in the present study admitted that they did not realize the importance of attending conferences at the beginning of their programs. Now, as they look back upon their graduate career to date, they realize that the gradual network and involvement in various professional conferences has benefited them to a great extent. A fourth-year engineering doctoral candidate, Sasha, reflected on her past conference-going experiences and how she gradually became more involved in her organization. The network she established through the conference is helping her with her present career move due to its nexus of industry and academia:

> There is this conference I started to attend two years ago, American Institute of Chemical Engineers. So it's like this main conference for the chemical engineering society... I'm attending this workshop organized by this women initiatives committee, so that's not necessarily just for academic positions... but that's like a combined group of women...

> both in industry and academia... in chemical engineering. So I'm going to go this year to network with my potential employers. I applied for a travel grant from them and I got it. I'm actually looking forward to meeting them.

Different from conferences in many other fields, engineering conferences are usually attended by both academics and people from the industry. As such, they serve as a great platform for graduate students to learn from and network with professionals from the industry or professors from other institutions. Whether or not a student chooses to work in academia, employers usually require prospective job candidates to have at least three recommendation letters. In most student participants' cases, these letters came from professors with whom they worked throughout their graduate studies. An interesting finding of the present study is the trend that a large majority of women students normally only work with one professor on numerous projects throughout their entire graduate career; this professor is usually the student's adviser. This limits the opportunity for students to obtain an array of letters of reference. Women who had limited connections outside of their home institution experienced challenges in finding suitable references. A fifth-year Ph.D. candidate shared her thoughts:

> I ended up having this mentor who's from Cornell. We met at a conference during my second year and she has been a really big influence over the course of my Ph.D. and I wasn't really expecting that, but it was a very good thing and she's been very helpful promoting my career, and she was one of the people who I listed in my job application. It wasn't really something that I was looking for, but it just I think it turned out to be the best thing that happened in my Ph.D. program. She's more like a friend than a mentor and she is definitely a good complement to my adviser.

As I was editing the findings chapters, I learned that this woman has secured her first postdoctoral position and the research group she will be joining is lead by a professor who used to be in the same doctoral program with the female professor from Cornell. The community of women could be small within a particular department at WRU and the quality of interactions and mentoring could vary between students and their professors. Interviewed women reported that there were no particular programs in their departments that are geared towards doctoral women's needs, nor do they provide resources for students to grow professionally and promote their careers at a more advanced level. Women participants have discovered the benefits of attending conferences to reach out to a broader community of women scientists. Through the interactions with other women doctoral students, researchers, and professors, these doctoral students found the necessary support to keep them motivated to complete graduate school. Additionally, these newfound mentors helped facilitate the graduate school to work-life transition that women doctoral students eventually face.

4.2.2 The Benefits of Long-term Collegiality Built among Women Scientists and Engineers

The student participants also discussed that "community building" and networking does not start in graduate school. The communities and support networks of woman scientists and engineers are extensions of their undergraduate institutions where they were first socialized into their fields of study. This network includes (a) undergraduate friends, some of whom pursue graduate education, (b) women faculty members with whom the student worked or who have largely encouraged the student to stay in science and engineering, and (c) undergraduate women from institutions whom the student might have met through summer internships or through other circumstances. Certainly, graduate school provides women doctoral students with a platform to

establish and expand their individual networks beyond departmental and institutional boundaries. Some of these nexuses are built on the collegiality established between more advanced women doctoral students, some are based on inter-campus collaborations, and others are built through interacting with women faculty members at conferences. At a time when these women face perplexing career choices, must complete doctoral dissertations, and will conclude their research projects, they must utilize the resources they have accumulated to ease their transitions.

A fifth-year doctoral candidate described her experiences with a women professor at her undergraduate institution. During her senior year in college, she seriously considered changing her major because she did not think she could finish her degree in physical science. She felt that she could never make a career in hard sciences and went to the professor's office and started crying. Although this woman professor did not know her too well, she took the role of mentor and encouraged her to join the professor's lab. Working more closely with this student, the women professor helped the student apply for graduate school and to the date of this dissertation, still provides her with career and personal advice. Now, this doctoral student is moving to a major east-coast city for her very first postdoctoral appointment in a few months. She reflected on this experience:

> I think she has been a tremendous influence on shaping my thought of going to graduate school. She still occasionally calls me or e-mails me to encourage me to keep going and give me advice. We are in different fields now but her career advices are extremely helpful.

In the case of this participant, the role of her mentor contributed to the major career changes. She was not confident enough to continue her undergraduate study in physical sciences. Yet, with the continuous guidance and encouragement from this woman mentor, she is now actively

pursing a career in academia. In a nearly dismal job market for physical science Ph.D.s due to budget cuts imposed on various space programs funded by the federal government, having industry connections is extremely beneficial. A fifth-year space science doctoral candidate acknowledged the significance of her college friend's recommendation in her experience of seeking employment. One of her friends, who started her postdoctoral position at the University of Texas, has suggested that there is a research group who might be interested in the type of research that this interviewee does. As a result, she applied for a postdoctoral fellowship with the university and was accepted.

Jane, a soon-to-be doctor in a physical sciences department, worked for NASA during an undergraduate summer internship in her sophomore year. Jane met a group of young scientists passionate about space physics research, some of who went on to graduate school scattered amongst various institutions in the U.S. They have kept in touch and started holding annual get-togethers at their professional meetings. Some of the greatest benefits, according to Jane, are the "non-research related" discussions, which tackle important questions, such as family-friendly policies, work environments of various institutions, and collaborators' personalities:

> In some cases, the world is catching up, and in some cases it's behind. You know, you hear about, 'this institution is very family-friendly, and this institution is not.' But you only hear that from someone which is already there. It is not like they advertise on their website, "We are not family-friendly. Don't come to us if you want to have kids." We always talk about, "oh, science; it's so different." But like any other job, most people, they go to work, they come back, and they do something else. You know? There's no reason why science has to be different.

Jane's statement echoed many other student interviewees' views, which valued the significance of the scientific communities they established throughout their student years. A chemical engineering doctoral candidate expressed her interest in going into industry early in graduate school. She discussed the most crucial aspect of securing a job in the industry and how she will utilize her connections from her undergraduate years to boost her competiveness:

> Conferences are really important if you want to go to academia because those professors are there and you want them to know your name before applying for those positions. For industry, the more contacts you know the better. So I will try to reconnect with a lot of my college classmates who went into industry and who are working [at managerial level] for some of the companies that I will try to get into, try to get some good contacts there.

This chemical engineering student acknowledged the fact that having a doctoral degree will benefit her competitiveness when it comes to jobs in the industry. However, she also told me that friends from her undergraduate institution have an upper hand over her now given their four to five years experience working first-hand in the industry while she devoted so much time to her "research papers and laboratory tests." While graduate school is referred to by many women doctoral students as a "lonely" experience, it also provided myriad opportunities for doctoral students to meet a number of scholars and broaden their existing networks through collaboration with inter-disciplinary teams. Women reported that this kind of experience positively affected their career paths prior to graduation. Miranda, a Ph.D. candidate in engineering, was looking for funding during her second year as her NSF fellowship was running out. She began doing some testing work for a material science research group at a different university. Over time, Miranda developed a strong rapport with one member of the research team. Although they have never met, they have published two papers together and are planning to present the results from

their latest research together at an upcoming conference. Miranda's material scientist cohort is currently job hunting and has shared many tips and experiences with Miranda. This type of interaction prompted Miranda to start thinking about her career path earlier than most of the women students interviewed for the present study who did not have this kind of experience.

Women students in this study also reported that although networking with potential employers and getting one's name established in professional circles might be great ways to boost a doctoral candidate's competitiveness, deciding on a job can be a two-way decision making process. While doctoral candidates are trying everything in their power to show potential employers how qualified they are, they tend to forget that there are "soft criteria" that every Ph.D. candidate should know before accepting a job that they ultimately do not really enjoy. This kind of circumstance was clearly identified by a fifth-year doctoral candidate in engineering, Sally, who discussed her strategies on how to utilize her network of scholars to advise her in her decision making process:

> I applied for this job at [Z University] but I wasn't sure about the group whom I would be working with. So I talked to a few researchers that I met at the conference and asked them about the group I would be joining and what I could be doing there and is it a good fit for me. I also asked them about the person that I will be working for. Is she a very horrible person who just seems nice at conferences? If it's a good career move? Is this university respected? And also talking to them about what is their life like outside of work. Do they have work-life balance? Do they enjoy their work? Are they happy about the decisions that they made? What other options did they have? How did they find their current positions?

As indicated by Sally's numerous questions, findings of the present study revealed that career decision-making criteria were the unspoken familial concerns. As most of the doctoral students in physical sciences and engineering directly entered graduate school upon completion of their undergraduate studies, all doctoral women interviewed were between 27 and 30 years of age when they started a family while also pursuing a career. Taking on postdoctoral positions or entering academia does not necessarily make balancing career and family life easier. While most doctoral women reported that they were too "embarrassed" to turn to their adviser about such issues, not wanting to be considered "unserious about their scholarly work" nor "a true scientist," women turned to junior woman faculty members in their network/community for mentoring advice. Leah, a doctoral candidate in civil engineering, discussed the question of "when to have your first child" with a woman mentor that she met at a conference during her first year in graduate school:

> She said if I could wait a little bit, I should wait a little while before having a kid, especially not during the first couple of years after I become an assistant professor because it's going to be helpful for me to stay motivated to do research and finish everything during the first few years to get tenure. She said when she had kids, they are her most important thing, and it seemed that she didn't care about research anymore. It's good to hear that from a woman faculty member who has been there and done that.

Leah was pleasantly surprised when she had this conversation with the women professor. She shared that she was very accustomed to the type of male-dominated environment in engineering and she almost forgot that she could "still ask for advice from women mentors!" Mentoring in doctoral programs goes beyond training students in research; it is also reflected through providing them with different perspectives, interpretations, directions, and results of their

research projects. Having a perspective different from that of their advisors appeared to be extremely helpful to the women in the present study:

> Having this woman mentor [outside her institution] is important to me, first because it's a faculty example to follow and I know I'm not going to be here forever, so to have connections with people at other institutions is beneficial. We also talk a lot about work and I feel that she has a very different perspective on our work than my advisor does. Everyone has their individual biases. So it's really nice to talk to somebody in that level of details about my work and get a different perspective and that kind of stuff. I think she's made me a better scientist because she teaches things very differently and doesn't always agree on what we're [my adviser and I] doing. But being able to respond to her questions and her arguments is kind of making me and my work stronger.

This doctoral student's view reflected almost all women in this dissertation study's concern of "being molded into their adviser's line of research and research style" and not being able to "stand out and have their own areas of research focus." These women also acknowledged that having a professor—most times a woman professor—outside of their institution who could give them a different perspective on their research was very "beneficial" and "eye-opening." Note that that the participant women doctoral students' "external mentors" were mostly women. When I discussed this question with a group of women physical scientists and engineers over lunch after data collection was completed, they suggested three crucial reasons behind this phenomenon:

1. Women professors are easier to relate to while at conferences and especially, the special sessions geared towards women provide a lot of opportunity for them to meet and network with women professors.

2. They feel more comfortable discussing “soft criteria” such as “family-friendly policies,” “work place politics,” and “particular career approaches” with female faculty.
3. Women students connecting with a male professor on a personal basis beyond conference interaction might invite "unnecessary” and “unwanted” gossip and “awkward situations.”

Many women students reported disturbing stories of conferences serving as “hook-up places for highly educated scientists and engineers,” a point that I return to in the next chapter.

4.2.3 A Global Network of Women: How do they Advance their Careers beyond National Boundaries?

Based on the latest National Science Foundation statistics (2011), since 2000, the proportion of international graduate students in science and engineering has consistently stayed at 30% among all enrolled graduate students in the U.S. This rate is higher in the physical sciences and engineering: approximately 35% of these students are international. In some sub-fields of engineering, international students are reported to constitute over 45% of the entire doctoral student population. Additionally, the NSF 2011 report revealed, “temporary visa holders were much more likely than U.S. citizens and permanent residents to be men (65.7% vs. 52.5% in 2009)” (p. 4). With this statistical trend forming the backdrop, findings of the present study revealed transnational networks built among women from the same nationality. They utilized such networks to help each other negotiate, thrive, and collaborate in new cultural and academic environments.

Ling was a doctoral student from China. She was younger than most of the women in her program and she graduated from one of the top universities in China. I met her through a domestic doctoral candidate who was about to finish her Ph.D. in the same department as Ling. My plan was to schedule an interview with Ling after being introduced by Jane. We still

arranged to meet over coffee at an off-campus coffee shop without any research related conversations. I got to the coffee shop 15 minutes early, so I found a corner seat and settled in. Ten minutes later, a baby faced woman with short hair and a black backpack walked into the coffee shop. She looked around and saw me waving at her. Ling walked to my table and started introducing herself in Mandarin, which I immediately realized might be part of the reason why she was not comfortable doing the interview: language issues. I chatted with Ling in Mandarin about international doctoral studies at WRU. "My adviser is very nice and smart," Ling said in Mandarin, "he's pretty much the only professor that I've been interacting with during the past three and half years." When asked about her career objectives, Ling laughed and said she never thought about anything that related to her future career. "I just wanted to be a good scientist and finish my Ph.D.," Ling mumbled shyly. I was somewhat taken aback by her comment given that she was one year away from graduation.

I asked her about talking to her adviser regarding job searching and career aspirations. Ling laughed and said, "No! I only talk about science to my adviser, nothing else!" This trend was fairly common among international women doctoral students who are very advanced in their doctoral study, but do not take the initiative to discuss career goals with their mentors. However, Ling indicated that three universities in China specialize in space physics, so most of the students she interacted with in her WRU program were from one of the three universities. These women formed a strong bond, which included weekly dinners together, and helped Ling acquaint herself to her new country, city, and doctoral program:

> We exchange ideas about how to deal with our advisers. Some of my friends' advisers are not always available to their students. They seldom see their advisors. Some advisors are very busy with their own research and companies, so they don't really care

about what their students are doing. That's frustrating. We gradually learned to share our resources, give each other feedback on our research, and suggest to each other how to apply for certain grants.

Transnational collaborations are also an important component of international women doctoral students' networks. Nina was a doctoral student who recently was involved in a transnational collaboration between her undergraduate university in India and WRU. When asked how she got involved in such a large-scale collaborative project, Nina responded:

> It was very random at the beginning. A senior classmate of mine got her doctorate a few years ago and went back to India to become a professor at our undergraduate institution. She saw a very recent paper that my adviser and I published together. So she got in touch with me about the potential grant that we could work on together, so I connected her with my adviser, and the next thing you know, it turned into a multi-million transnational collaboration!

A similar trend was also observed among other foreign-born scientists and engineers, especially among the large group of Chinese space physicists who received their education in China and then moved to the U.S. to pursue their doctorates and careers. As Ling indicated before, many Chinese space physicists, men and women, are acquainted prior to their doctoral study or scientific career in the U.S., given the small community that specializes in space physics in China. Among these scientists, the women act as the organizers for frequent social events at which they learn more about each other's work progress and expand their networks to include advisers and colleagues from the U.S. A doctoral student from Beijing asserted:

> China has Project 985 and many grants to support Chinese scientists to collaborate with their American colleagues, and my lab needs more money and we have many talents and

potential projects that fit with the parameter of these grants, so my adviser encouraged an American post-doc and I to work on a grant proposal together to submit to the Chinese Academy of Science. Of course, we are also working with my undergraduate adviser in Beijing. He has a big lab and tons of manpower there!

While collaboration was widely observed between Chinese and American scientists, one obvious difference exists in their research processes: the requirement, and even awareness, of the previously mentioned "soft criteria (e.g. work-life balance, family friendly policy, other researchers' styles, and internal politics)." For instance, many soon-to-be graduated Chinese women physical scientists and engineers were less familiar with the concepts of a "family-friendly policy," or "salary and spousal employment negotiation," and were less concerned about the institution's geographic location and institutional climate. To many of these women, "conducting effective and significant research" is the top priority, followed closely by "visa sponsorship" concerns. Yet, overlooking the "soft criteria" could limit the long-term professional growth potential of these scientists and make them more prone to dealing with extra financial burdens and discriminatory treatment in the workplace.

4.3 Summary

In focusing on women doctoral students' daily lives in the physical sciences and engineering, findings revealed a prevalent concept: communities of students assist underrepresented women in surviving, navigating, and eventually succeeding in graduate school programs. While the concept of community is not strictly defined by departmental or institutional boundaries, it extends both horizontally and vertically beyond these women's graduate careers. At the beginning of graduate school, women doctoral students connect across research teams and laboratories to identify and implement appropriate approaches to choosing

the right classes, selecting the right research projects, orienting themselves to their advisers' "styles," and securing funding.

As the initial two years pass by, women doctoral students increasingly reach out to senior members of their groups, such as more advanced doctoral students, postdoctoral researchers, and/or junior staff researchers, for feedback and advice on research proposal writing, technical aspects of their research, and improving their conference presentation skills. This form of interaction largely influences women doctoral students' professional growth as scientists and engineers given that many of them prefer to "interact with their senior peers" rather than "asking the same questions of their advisers." The primary reasons these women are reluctant to interact more with their advisers are threefold:

1. Some advisers are not always available to their students when needed, due to their roles in multiple research projects and industry.
2. Women are more likely to suffer from imposter phenomenon and low self-esteem about their research skills, and thus have fewer interactions and networking opportunities with their potential employers and colleagues.
3. Women are more concerned about asking their advisers "the right type of questions."

Therefore, many women choose to consult their postdoctoral peers or staff researchers about certain technical problems before turning to their advisers due to concerns regarding how they might be perceived. In most cases, these women manage to solve their problems with the help of senior peers so that they "never turn to their advisers" for research advice unless "something goes seriously wrong."

When it comes to career aspirations, women doctoral physical scientists and engineers are also largely influenced by more advanced women doctoral students, women graduates, and

former staff researchers from their research team or doctoral program. The graduates and scientific research staff members who have shared resources, research projects, and possibly advisers with these doctoral students are mostly in the early stages of their careers in different regions of the country, necessitating the use of email, Skype, Facebook, and other social media to stay connected, aside from annual events at professional conferences. Hearing stories about senior members' current statuses and experiences at different institutions, laboratories, or jobs largely affects these students' career aspirations concerning academia. Women colleagues' effective advice not only touches upon research related matters, but also addresses the institution's climate, its family friendly policy, and resources to support women academics. Such feedback was reported to be "extremely helpful" by women doctoral students in science and engineering.

The more interactions that doctoral women have with their senior peers, the earlier they start to consider various career related questions and strategically implement approaches to prepare themselves for the challenging and confusing job market. Women doctoral candidates who are less than one year away from graduating not only reach out to their undergraduate women classmates and junior women faculty members from other institutions, but also their international colleagues.

Communities of women united by nationality have become a prevalent tangential theme in the present study and a similar trend was described discovered by Traweek, Gu, Guillen, and Holbrook et al. (2011) in their research on women and minority astronomers' networks and their influences on building glocal (local-global) knowledge infrastructures. Many transnational collaborative opportunities have been established between foreign-born women doctoral students and their current doctoral advisers, colleagues, and home institutions. These projects are more

likely to have a larger budget and longer time-frame, and involve a greater number of scientists with international backgrounds.

While the findings in this chapter were focused on women doctoral students' strategies to their socialization process to doctoral programs, almost all participating students acknowledged the significance of the relationships with their doctoral advisers. Although some had trouble creating collaborative and long-lasting relationships, they all agreed that doctoral advisers were the critical person in their programs given her/his power in deciding the timeline for their doctoral studies. Additionally, doctoral socialization experiences and how such experiences eventually influenced their career aspirations extended far beyond the realm of "community" discussed in this chapter.

Largely influenced by the guidance of feminist standpoint theory, this study revealed the concept of "community" which was not originally part of the study design. Although Kram's theory touched upon the peer mentoring concept, what was unique in this study were the communities of women that formed based on their disciplinary and minority status. The meshworks and networks established among women physical science and engineering professors, researchers, and students have provided a large portion of mentoring support for all women interviewed. This topic of social network/meshwork and its relationships to the advancement of women's careers in physical sciences and engineering is worth exploring in future studies.

Chapters 6.0 and 7.0 are intended to decode and illustrate, from both women doctoral students and their faculty advisers' perspectives, women doctoral students' complex socialization matrix and how it affects various aspects of these women's scholarly, personal, and professional lives. Particularly, Chapter 6.0 is intended to focus on the formal and informal aspects of

doctoral studies socialization under the influence of cross-gender mentoring. Implicit gender bias, hidden sexual harassment, and negative advising relationships are revealed and how they affect women's experience in their programs and their coping strategies. Chapter 7.0 will follow the development of women doctoral students' career aspirations and how their graduate school experiences influence their decision making processes.

CHAPTER 5: THE INFLUENCES OF PROTÉGÉ-MENTOR RELATIONSHIPS: GENDERED GRADUATE SCHOOL SOCIALIZATION UNDER COMPLEX CULTURAL INFLUENCES

"In the beginning, the real question is: 'Should you be in grad school?' The first year [is] all about 'Is this really where you want to be?' I'm always asking [first year students] how their classes [are] going, are they happy. Just taking a temperature of whether or not they're enjoying where they are. Second year, it's really, 'Have you found the research group that you really want to be in?' 'Do you have the right advisor/advisee relationship?' Third year [is about] trying to figure out what students are really good at, figure out where their strengths are and whether or not they are really enjoying the TA experience, which might tell you that teaching colleges would be a really interesting opportunity. Should they be going to workshops about teaching methods—which there aren't that many [of] in the sciences, but there are a few opportunities. Then, what about careers? I guess at that point, in terms of thinking about career mentoring, have you set up the right collaborations for them for their thesis? So who might they be in contact with that will be a good connection for them afterwards? Then we [advisors] need to figure out from your array of collaborators outside of the university, where might the grad student have good connections because that's a useful way for them to get a letter of recommendation that's not at this university, which is that third letter that's so hard to get. And then exposure to a different university or different observatories and then of course at the end it's just really explicit conversations." (Professor Smith, Western Research University)

Professor Smith's comments effectively summarize the socialization process that occurs in doctoral programs in the physical sciences and engineering fields. It was acknowledged by student and faculty participants that the knowledge and skills that graduate school imparts on physical scientists and engineers go far beyond the areas of research, teaching, and publishing. The types of training and mentoring activities vary at different stages of their graduate career and the locations where these activities occur are not limited to research labs, classrooms, and offices. The data from this study reflected that the production of scientific knowledge does not only occur between advisors and their advisees. This study reveals that one key factor for women doctoral students' success in graduate school is for them to initiate aspects of the socialization process and proactively seek out research, teaching, and/or career advice, instead of passively receiving it. Those who successfully navigate graduate school receive effective mentoring from their advisers in the areas of collaboration and networking, fulfilling career goals and objectives, and selecting graduate laboratory and research teams. The seemingly less fortunate students, those who severely lack sufficient advice and guidance from their doctoral advisors, seek graduate school and career advice elsewhere. Possible "outside mentors" include peer members, staff researchers, colleagues from other universities, and possibly parents. As Szelényi found in her (2007) study of graduate students in science and engineering:

> Graduate students thus come to navigate and interpret their experiences in graduate school amid a variety of cultural influences stemming from a range of internal and external sources (p. 125).

These internal and external sources revolve around four major cultural forces theorized by Tierney and Rhoads (1994): disciplinary, departmental, institutional, and national cultures.

Graduate school socialization is also largely influenced by these factors, especially in the early stages of one's program. Yet, when gender intersects these cultural forces, the complexity multiplies, most notably in the formal interactions between women doctoral students and faculty during traditional graduate school activities, such as teaching, researching, applying for research grants, producing publications, and networking with other scholars. This chapter discusses gendered negotiation in these frequent, formal and informal interactions from the perspectives of both women doctoral students and faculty members. Results showed major implicit challenges that women doctoral students face during both the formal and informal socialization processes. The central focus of this chapter is on these cultural influences, with particular emphasis on educational and gender implications of cross-gender mentoring and the career/psychosocial influences described by Kram (1985). Specifically, the following sections demonstrate two spheres of graduate school socialization, from the perspectives of both faculty and students, based on both the theoretical perspectives suggested by the cultural academic socialization model and the complexities of formal and informal gendered mentoring with specific emphasis on the degree of proximity between mentoring relationships and career/psychosocial influences.

5.1 What does Mentoring mean to Protégés and Mentors?

The Matrix Embedded in both Formal and

Informal Graduate School Socialization

Using Van Maanen's model as a foundation, Tierney and Rhoads (1994) described formal socialization experiences as "the recruit [being] separated from other regular members of the organization while participating in a series of specifically designed activities" (p. 27). Results revealed six categories of major formal socialization experiences for physical sciences and engineering women doctoral students, revolving around the areas of research and teaching

training, publishing, funding, conference interactions, networking, and career trajectories. These categories are derived from every day graduate school apprentice experiences at different stages of doctoral studies and play a crucial role in the training and socializing of doctoral students into their professional roles as physical science or engineering scholars. The findings illuminate the priorities across these formal interactions in physical sciences and engineering graduate programs: teaching graduate students to conduct effective research, publish significant results, and be efficient teachers. While these priorities could be very similar to those of other doctoral programs, given that physical sciences and engineering programs heavily rely on outside resources for funding, the ability to research and deliver practical and useful outcomes seems especially crucial. Consequently, many doctoral student participants prioritized learning the arts of/secrets to applying for and securing funding from NSF, NIH, and NASA from their advisors. However, the findings from this study revealed a large gap between these important scholarly skills and some advisors' reluctance to provide such training and resources. Due to insufficient training, many women doctoral students have to "'work for free before getting funding from their departments" or pay their own tuition.

Informal mentoring experiences could largely influence doctoral women's overall graduate school experience, attrition rates, and career outcomes. As Tierney and Rhoads (1994) defined it, "informal socialization relates to more laissez-faire experiences where the norms of the organization are learned through trial and error" (p. 27). The data collected in this dissertation research demonstrated the important effect that these informal interactions have on women doctoral students in physical sciences and engineering programs. These informal socialization experiences discussed by women students mainly included discussions with regard to work-life balance and other non-research related topics. In almost all cases, informal

socialization only occurred between women doctoral students and a female member of the research group who was likely to be a junior faculty at a different institution.

5.1.1 Formal and Informal Socialization

A central role of doctoral education is to socialize students into the "cognitive and affective dimensions of social roles related to the practice of learned occupations" (Weidman and Stein, 2003, p. 642). Subjects of this study were socialized into the world of physical scientists and engineers. Regardless of a student's career aspirations, the skills and knowledge needed to conduct research and perform teaching duties remain crucial to the doctoral training process. However, guidance from advisors can be ambiguous and even confusing for new women graduate students, as discerned by Cindy:

> I started the program two and half years ago and I still don't have my own project. He [Cindy's advisor] doesn't tell you directly and just really kind of suggests: "There's this topic and then there's this topic and that topic. Go work on this." I feel like other students they go do the same thing in the beginning: your advisor tells you kind of like what to do step by step and then you eventually get a project.

Cindy's view reflected a common pattern that a majority of student interviewees discussed. Many of the doctoral women reported experiencing a "lack of clear guidance" from their advisors. Consequently, these women doctoral students tended to "freak out" when left alone. Newly admitted Ph.D. candidates normally need to finish at least one and a half years of doctoral coursework before they are eligible to be teaching assistants. Research participants discussed that the duty of teaching is voluntary in some physical sciences and engineering departments; however, in others, such as astronomy, with a high demand for undergraduate teaching and a low ratio of lecturers and visiting professors due to budget restraints, doctoral students are required to

teach for at least three years. Although teaching is a necessary and integral part of the academic career and doctoral training, women students interviewed believed that a majority of the physical sciences and engineering departments studied do not have the sufficient infrastructure to train doctoral students in teaching methodology and classroom pedagogy. In this culture, becoming a research assistant at a laboratory or on a research team is much preferred to teaching. Many women expressed the concern that "teaching takes up too much research time" and that it "can delay [their] dissertation project[s]." Therefore, a large majority of students consider teaching duties "the dirty job in graduate school," or "the last straw" when they have no other source of funding. Sue's comment reflected this tendency:

> They [the department] typically give you about ninety students, so it's three sections of thirty, and I taught an oceanography introductory class and an astronomy class and, in general, it wasn't bad. I enjoyed the material. But I wanted to graduate really soon. So if I'm spending all this time trying to teach and putting good lectures together—which I did do because I'm not going to do a lousy job—then getting teaching duties was just kind of frustrating.

Sue's concerns were also shared by another five student participants, who stated their passion for teaching, but could not afford to "lose more time in preparing teaching materials" instead of spending more time to complete their dissertation research. When asked how she performed her teaching assistant duties, Lisa stated there was no training geared towards "how to teach undergraduates" or "how to have an effective lecture" prior to her teaching experience three years earlier. Lisa looked back on her two and half years of teaching experience and stated:

> There was no training other than this language-training course for TAs who are international students. Initially when I was a TA, I just got up there, did discussions, and

> talked to the students. And then sometimes the students were just coming to me and told me that they were confused about something. So I explain[ed the material] to them. It was very dry and it wasn't a great experience.

Lisa further discussed how many students in her department were very interested in teaching undergraduate students. However, there was very little direction or guidance regarding teaching methodology and pedagogy. Thus, some students chose to avoid teaching as a way to cope with the situation. Almost all students interviewed reported that they were more likely to be approached by professors to teach a course when their male counterparts turned down a teaching assignment due to various reasons.

While teaching undergraduate courses did not appear to be the priority for physical science and engineering professors as pointed out by majority of the interviewees, publications are the foremost criteria by which a large of number of professors assess their students. Many professors clarify their expectations by quantifying the publishing criteria of their research groups while others make special rules wherein a doctoral student "will not be funded if she has not published her results as a paper." Sasha reflected her experience on her chemical engineering research team:

> Definitely a major focus is publishing papers in our lab. That's always the goal: to get enough data to put a paper together... so a lot of the times, in our conversation, he [Sasha's advisor] will talk in terms of that. He will be like, "Once you get it done, this will be a solid publication." So that's definitely a focus. And he has this special rule on me where I cannot attend a conference without publishing the results. So I haven't been to that many conferences.

Sasha further elaborated that her advisor has no "differential treatment based on gender" when it comes to sending students to conferences. However, she discussed how women students are more likely to be involved in teaching, organizing research meetings, and other administrative duties, which made them less likely to publish. Thus, they are less likely to be offered the opportunity to attend conferences. Several physical sciences student participants discussed the differences in publication requirements based on their career goals in the department: university positions require students to have at least three first-authored papers, whereas industry prefers doctoral graduates to have more hands-on experience. Lisa discussed the process by which her advisor helped her to publish papers and how she negotiated authorship for their publications:

> If you do the master's thesis, your thesis also has to serve as a published paper. And then for the doctorate, you have to at least have two first-authored papers. The first author thing is hard because you get called into different projects and you kind of serve a role there, but it's not necessarily yours. So I need to make it clear and negotiate at the beginning about who was going to be the first author. Again for me, I don't mind because I want to go into academia. But if you want to go into industry, it's not necessarily as important to publish as just to be involved a lot.

Lisa's comment sparked two major issues touched upon by nearly all student interviewees. First, negotiation for authorship is a key factor in a protégé-mentor relationship, especially when a student is approaching her/his end of doctoral studies. Yet, women students discussed their difficulties in discussing and negotiating for first authorship during the interviews. Secondly, student participants also discussed a phenomenon in which faculty members try to make everyone publish as much as possible regardless of their future career aspirations. Some participants suggested that students who only want to go into industry upon graduation should be

trained and prepared differently than the students who want to pursue academic careers. For example, training students to transfer research theories and results to industrial applications should be prioritized for students who are determined to go into industry.

A majority of this study's participants reported a common theme: women doctoral students are more likely than their male counterparts to take their advisors' comments and feedback personally. Additionally, women reported that they believe women are more likely to question their own ability to conduct research and author significant publications. Many women described in detail the intense process by which their advisors help them prepare to publish their research results. Angela, a space science doctoral student, shared:

> We have a few publications that we've worked on together. He's very particular, so we ended up doing thirty versions before we submit and then we got revisions and then we're doing thirty more because it has to be perfect for him. We went sentence by sentence and tried to make it as good as it could possibly be. He's very anal when it comes to publishing any work that has his name on it.

Angela's experience was not singular. Other women interviewed in this study reported similar cases. Faculty advisors are likely to be the sole source of help to women doctoral students during the publication process, especially during the first few years of graduate school. Two major stages of the publication process were identified in this study: the first draft, followed by a lengthy revision. First, after the completion of a research project, advisors suggest related references for a literature review and the students produce the first draft alone. Once the first draft is completed, faculty advisors step in and revise and correct the manuscript with the student over a prolonged period of time. Lindsay described the process when she tried to publish one of her manuscripts in a top tier civil engineering journal:

> When you are writing journal articles, my advisor is very helpful. The first thing is, normally he gives me an outline to put together figures and to decide what parts of my results that I want to include in this paper and how to kind of discuss that. And then he leaves me alone until I have a draft. The first time, he would normally just look it over with me at our one on one meeting and again go through the figures. But in the end, he's very picky about the revision stage. He would ask: 'Is it in the format you want? Did you get the data you wanted? Did we present everything?' Just when I think it is ready to be published, he'll actually sit down and he'll go through it with his red pen and he's literally read everything and even check[ing] your grammar. So anything that gets published with his name on it, he won't let it through at least he's completely satisfied.

Lindsay discussed in detail the approaches that her advisor adopted to mentor her in the process of publishing papers. She admitted that although this kind of approach appeared to be "frustrating" or "scary" from time to time, she largely benefited from it. She is in the third year of her doctoral program and has already published four top tier journal articles. She also reflected on how this positive publication outcome has encouraged her to pursue an academic position upon graduation.

Professors participating in this study revealed two significant reasons for their expectation that students "publish as much as possible" during their doctoral studies: the dismal outlook for the job market and ambiguous expectations for academic position recruiting criteria, and the notion that publications can serve as effective communication channels for doctoral students to network with their potential employers at conferences and other scholarly events. Most of the professors' rationales associated with "encouraging students to publish" were directly

linked to their concerns about their doctoral students' career outlooks. Professor Sarah Smith from the one physical sciences department discussed her concerns:

> I want the doctoral students to be productive members of my group at this point. I want them to do well, I want them to write papers, and the job market is so tough that I want them to do as well as they can. But I'm not sure with the current set of students; I'm not sure how it's going to turn out for them. But for now I want them to try to be productive and mature as scientists and see where that takes them and for now, at least with the ones that are graduating, I want them to at least stay on and do a post-doc because I feel they can do that. But ultimately it's just so hard to get a job in astronomy these days, so I don't know how it's going to work out for them. I hope it does. But for now I want them to be productive. I want them to write papers and learn how to become better scientists.

Professor Smith's perception was representative among faculty participants in this study. Many of them discussed the challenges that the dismal job market poses to the new Ph.D. recipients and how the best they could do is to help these students get as many publications as possible to boost their competitiveness. Some faculty participants also discussed the positive effect that publications have on a student's conference attending experience.

Professor Bob Brown discussed his view on the significance of publication in students' conference attending experiences. According to Dr. Brown, "doctoral students have to first produce some research and new results, which they can present. You get more out of the conference when you are presenting something because then you see people ask you questions and you in return ask others questions." This statement largely represents one major concern that most professors have when it comes to students' productivity regarding publication in physical

sciences departments, which is related to whether or not a student can publish before attend a conference.

The fact that many physical sciences and engineering professors consider publications as a key tool for students to network at conferences is reflected in a very common requirement of their doctoral students: publish to present. Krista expressed her frustration over her advisors' "high expectations about conference going," which caused her to only "attend one conference" during her four years of study in the engineering program:

> He had a weird rule with me where I couldn't go to conferences unless I had a paper published and I was presenting that paper. That was unique to me, which was kind of frustrating. I think he eventually forgot, and then I got to go to one conference.

Krista compared her own experience with some peers who were able to attend more conferences. She perceived that she did not get to go to as many conferences as other students did, which put her at disadvantage in terms of networking, expanding her scholarly horizon, and seeking out additional mentors. It is widely believed by the interviewees that participation in professional conferences is an integral part of graduate school life and benefits doctoral students' professional growth, research, and scholarly skills. Further, it has a major positive influence on women doctoral students, boosting their confidence and academic career aspirations. Given the small representation of women faculty at one particular institution in the physical sciences and engineering, attending conferences appeared to be particularly beneficial in terms of encouraging women to pursue academic careers, as reflected by a civil engineering student:

> When I entered the Ph.D. program, I was thinking that I could go forward into academic life. Otherwise, I wouldn't have started. But during the first two years graduate school did not influence me at all; it didn't affect it in a good way or bad way because I just took

> classes and it was pretty much just like going to school. Then when I started going to conferences and I started to write papers and do research, I started to be more into the academic life. Like I said, last year, I was really motivated when I went to conferences and met all these encouraging women professors from different universities. I kind of got on the right track. I guess that was really part of graduate school. So I think that affected it in a good way last year.

This advanced student expressed her frustration over her first two years in graduate school, when she was without much needed mentoring to encourage her pursuit of academic career goals. However, the experience of attending conferences changed her situation. She kept in contact with two women professors whom she met at the conference and one of them recently expressed interests in hiring this student as a postdoctoral researcher upon her graduation. Faculty interviewees in this study also echoed this student's interpretation of her conference-going experience. A large majority of the professors interviewed pointed to the crucial aspect of "networking opportunities" that conferences provide to students. One professor of earth sciences conceptualized the notion of "networking" in the field of physical sciences as "talking and meeting with other scholars about the work you do and how that is going to get you a research job." A professor of physics expressed a similar point: "Drinking cocktails with other scientists doesn't count as networking. You really need to get your work out there and let other[s] know about it. That's real networking." Professor Jane Miller of engineering explained her approaches to helping her doctoral students prepare for professional conferences:

> When they [doctoral students] are going to a conference, the first thing we [the professors] will do is make sure their presentation is well-prepared.. So I'll usually have my students show me a draft of their slides beforehand and then we have weekly group

> meetings. In terms of networking, that's a harder one to teach students and one of the best ways you can teach them that is just by sending them to conferences earlier—earlier than they need to know how to do it—so that they learn by watching other students. If they go with me, then I can also introduce them. There are pros and cons to actually going to the same conferences as your students. The pro is that you have the opportunity to introduce your students to help them network, to do the introductions. The con is that there's an over-shadow affect. As they get older, especially if they're giving a talk that they're the experts in the room as opposed to you, they become the authoritative figure in their work if you're not in the room. So toward the end it's really helpful for them if you don't attend the conference.

Professor Miller's view reflected the common strategies professor participants use to teach their students about the importance of networking, especially at conference settings. A professor from physical sciences asserted the significance of sending students to a conference:

> I don't talk to them very much about what they want to do after graduation because, actually, they're figuring [that] out for themselves by going to conference. Because the whole conference and collaboration thing is a giant exercise in networking. It's not just exposure to real research experience, it's also networking. It's very effective because networking for me is always working together.

This professor then acknowledged that students who had more opportunities to present their research at conferences tended to be more proactive when it came to discussing their career trajectories with their faculty member and getting prepared for future academic careers. Both faculty and women doctoral students acknowledged that given that WRU has very strong science and engineering graduate programs, most doctoral students remain productive and conduct

quality research. When it comes time to search for a job, most students are at a similar starting line with a similar resume: publications, rigorous research, methodological knowledge, and skills to design and conduct large-scale research projects. Therefore, the deciding factor for "who gets the limited faculty and postdoctoral positions" depends largely on "who you know." Networking was a very prevalent theme in discussions of mentoring experiences in doctoral programs. Unsurprisingly, many of these networking experiences occurred during conferences and collaborations through mentors' introductions. Julie shared her experience with "the benefits of networking" in space sciences and discussed how her advisor's network of colleagues and scholars helped with her advisor's career progression and research expansion. She stated, "I think that [observing her advisor's network] just made me realize that I should be proactive in terms of talking to people about my research and about their research, figuring out if there are links between the two."

Lisa, an environmental engineering doctoral student, mirrored Julie's perspective. She shared a story about a female professor in her department who was very active in introducing her doctoral students to colleagues at different universities. This professor usually introduces her students to collaborators and colleagues in the field at professional conferences. Lisa noted that it was a very small research community in the subfield of her discipline. Being introduced by this professor to colleagues was very beneficial to the doctoral students looking for a job in the near future.

Because research areas in physical sciences and engineering doctoral programs are highly specialized, many doctoral students' research areas drift away from their advisors' main line of research. Results revealed that networking functions in mentoring relationships appear to be less effective for this group of students. Ling, a fourth-year physical scientist, discerned:

> It's important that your research aligns with what your advisor is doing. For me, my advisor is working on [a highly specialized area]. She does not work on my research project. So it's less likely for her to introduce me to her colleagues. If your advisor works on the same project with you, then they can be really supportive to you and promote your work. They can advertise your work and introduce you to people. In that case, you are much more likely to stay in the same field and become an academic.

Ling has less than one year before graduation. She decided not to apply for a postdoctoral position, which is typically necessary for doctoral students in the sciences and engineering who wish to enter academia. Ling did not discuss her career goals with her advisor and said she just wanted to enter the aerospace industry where she can have a nine-to-five job and be free from the enormous amount of pressure that she experienced in graduate school.

The data collected for this study categorized formal graduate school socialization processes in physical sciences and engineering into four interrelated areas: (1) teaching/research skill building; (2) productivity in publishing; (3) attending conferences and (4) career related networking skills. In physical sciences and engineering programs, some women doctoral students believed they were negatively affected and marginalized by male-dominated departmental or disciplinary cultures in the areas listed. Many student participants discussed that they need to be "extremely proactive," perhaps even "aggressive" in their tasks to be perceived as equal counterparts. Women reported having a harder time in negotiating first authorship when they worked with their advisors or colleagues. Student participants in this study felt they were more likely than their male counterparts to silently endure "abusive behaviors" in their daily graduate school interactions- not physical harm, but offensive, discouraging, and even hostile verbal and non-verbal behaviors that created extra barriers to women surviving their programs

and becoming productive scientists. I regard these stories as "implicit graduate school socialization experiences" and will further discuss such instances in the next section.

5.1.2 Informal Socialization

Informal socialization is easily overlooked by many physical scientists and engineers, but appears to be a likely influence on women doctoral students' graduate school experiences and career aspirations. Tierney and Rhoads (1994) argue that informal socialization occurs simultaneously with formal socialization in terms of the careers of faculty members. Many symbolic norms and values within an organization, which were not made explicit to the new faculty members upon their arrival, are interpreted and learned by these new members from their daily informal socialization experiences with their peers and senior faculty members. Results revealed that the informal socialization process experienced by women doctoral students was largely influenced by physical sciences and engineering culture wherein "things tend to be quantified" and "people expect calculations, equations, and numbers to solve all the problems." Many women reported difficulty talking to their advisors about work-life balance and other related career concerns due to their worries of being considered "not serious about their research" or "not a real scientist." Assuming "academic careers are extremely family unfriendly," many women doctoral students shy away from academic careers without any career related discussions with their advisors. Others, unaware of specific institutions' or departments' climates and cultures, end up in academic positions that do not fit with their research interests and/or personality and eventually become, as one woman noted, "miserable and unproductive" scholars.

Women doctoral students are especially concerned with work-life balance and the workplace culture and politics of academic careers, specific knowledge that can only be obtained

by informal socialization processes in which students open up about their concerns and exchange ideas with mentors freely. More often than not, these mentors are also female, and are more likely to be affiliated with a different institution. Students' and faculty's perspectives and experiences demonstrated that women students who have periodic discussions with their mentors about work-life balance, family friendly policies, and work place cultures of other institutions are more likely than student participants who have not had such experiences to graduate in—and under—the average time span of doctoral study in their particular departments.

Sue, a fifth-year engineering doctoral candidate, recently secured her first post-doctoral research position with a prestigious research team. She discussed her positive informal interactions with her advisor and the women professors in her department:

> Outside of research, we also have [a] great personal relationship. I definitely have [a] beyond-advising relationship with him. We have two [women] in our department. I will comfortably approach them and just catch up [with them] outside of the lab. Last week, we hosted a professor here and we all went to lunch afterwards at the faculty club. I was walking back with the two women so we chatted: 'How's your boyfriend? How's everything going?' I asked them about how their kids were doing. That small talk doesn't usually happen between my advisor and me.

Sue kept a very good relationship with both her advisors and women faculty members in her department. She has been very motivated in pursuing an academic position upon her graduation. She has produced more publications than other peers and is in the process of putting together her postdoctoral applications. Similar discussions also occurred between women doctoral students and their "outside" female mentors. One woman reflected on her discussion about work-life balance with a women professor she met at a conference:

> [I asked,] 'How do you balance kids and your career?' She said she is doing fine and she just told me to maybe take it easy for the first couple of years of the academic life if I want to have kids because it's going to be really difficult if I have both kids and that first couple of years at the same time. Everyone knows that this is going to be difficult, but if you manage to make it work they really give you more credit. So I was really impressed. It was amazing. I think I can do it too.

This interviewee had academic career aspirations in mind from the beginning of her doctoral studies. Yet, many work-life balance-related concerns made her have second thoughts since she advanced to candidacy and started planning for her careers. She acknowledged that the advice from this woman professor at a conference had encouraged her to keep pursuing her dream of becoming a professor. A clear pattern from the data shows that women faculty interviewed are more likely to be approached by women doctoral students in their departments who are not necessarily their advisees. Engineering Professor Linda Moore compared male and female doctoral students' concerns in her graduate program:

> I think one of the concerns that my female students [have] expressed a few times is work-life balance. This one student, she sees how pressed I am all of the time and remarked a number of times how she's concerned about how she's going to balance everything when she's [a] professor. I [as a professor] have to make sure that [my students] are all making progress and [monitor] my post-doc and teaching and funding and services to the community. I have to make sure that they're all making progress and my post-doc and teaching and funding and services to the community. So it's a lot that's going on all the time that you're responsible for. I think when male students talk to me about their concerns. They are more likely to be about coming up with their own research program.

Professor Moore's comment reflected some major questions that doctoral students have when it comes to concerns that stop them from pursuing academic careers. All five women professors stated that only women students have expressed work-life balance concerns to them and that these concerns seemed to be a significant factor that stops women doctoral students from pursuing an academic position. All doctoral women participating in this research had been in their graduate programs for at least 3 years. When asked what they wished they would have known when they began graduate school, almost all 25 women stated that taking the initiative to learn and communicate with advisors was extremely crucial. Particularly, many women doctoral students addressed the importance of taking the initiative to discuss career and personal concerns (including discussion of future family life) with faculty mentors. Most times, they received very effective feedback from their advisors to solve the problems and move in positive directions.

For example, Tina is about to complete her last year in one physical sciences doctoral program, after which she will move to Europe for her first postdoctoral position. However, she was unsure if this move will make her more marketable as a researcher for future positions; she turned to her advisor who is very well known. Her advisor shared some important research that Tina's soon-to-be research group had been contributing and educated her on this particular group's internal politics. As Tina completes her doctoral program and moves on to a new stage of her research career, she feels well prepared, not only for her future faculty positions, but also for knowing the values and norms of the new organization of which she may become an integral part. Dana, a fifth year astronomy doctoral student, elaborated in detail on why this kind of "insider information" could be helpful to doctoral women in their future careers:

> I think he's [Dana's advisor] just a great source of advice. I think the career advice and the insider information, especially when you get to grad school and what you study is so

> specific... It's a really small job field as well. So I think having that insider advice, having somebody so well connected to talk to you about your options and who's good to work with. That kind of advice is just invaluable

Dana maintained that her advisor's insider information has helped her to narrow down the pool of postdoctoral positions that she is going to apply and helped her choose the most strategic option to advance her career. Many women doctoral students discussed the importance of receiving advice beyond "research related" questions.

Julie, an advanced space sciences doctoral candidate, has been applying for postdoctoral positions. She is intent on joining one of the NASA research centers as a researcher for both professional and personal reasons. She has been in contact with one of the scientists with whom she could be working, and her advisor has helped her with "how to handle certain type of email questions," and "how to respond to certain kind[s] of request[s]." Julie's advisor provided her with a sufficient amount of background information about the place where she hopes to work in the future its workplace politics, and even her prospective coworkers' personalities. These kinds of non-research related conversations are highly valued by many women doctoral students and are considered to be equally, if not more, "helpful" and "beneficial" in their employment search process than other types of information.

5.2 Behind the Scene, Yet Critical

A significant pool of literature addressed some of the major barriers that women are facing in the physical sciences and engineering. These challenges mainly include having difficulty balancing work and family, being alienated by the male dominated culture, and lacking mentoring opportunities and informal networks (Hall, 2007; Preston, 1994; Rosser and Taylor 2009). These challenges could be traced back to many decades ago when physical sciences and

engineering fields were predominately men. Many scholars believe that the "hostile macho culture" and its negative influence has disappeared as the number of women in science and engineering program—and the workforce—surged over the past two decades. Professor Young received her Ph.D. in the 1970s and was hired for her first faculty position with WRU in the early 1980s. She reflected on the drastic change in gender climate in the male dominated field of engineering, but that the field still lags behind other physical science disciplines. She argued, "Female disadvantage still exists today, but it depends on the field and the progression of the female faculty in the department." Other women faculty interviewed also share this view, as one women professor stated, “the more examples there are that male colleagues see of women who have kids and [are] exactly like the[ir] male colleagues, then they're not as easily persuaded by someone who might put something down or, you know, say something discouraging. But it still happens.”

Many women faculty discussed that “hostile culture” takes a more implicit form currently. When it comes to workplace interactions, advancement opportunities, and research collaboration negotiations, women interviewed discussed their experiences of implicit gender bias and harassment. Women participants perceived the physical sciences and engineering infrastructures as "research outcome driven" and there is no mechanism for women to report these implicit barriers that interfere with their scientific productivity and success in academic careers. Professor Young compared today's engineering culture to her graduate school experience and shared:

> A department’s culture is really important. It's more important when you're a faculty member than when you're a student. Now it's not common for male faculty to put down female students who are to say something that might be offensive or awkward. When I

> was going to graduate school that was much more common; [and there were] many fewer female students. There were zero women faculty in all of engineering when I went to school there, and I was among the first group of woman to get a degree in mechanical engineering there. That wasn't that long ago. So when you're the first, and when you really stand out, and it's a completely male dominated environment—my graduate school's climate and culture were very much ingrained in the faculty—the jokes [are] the sorts of things that are just commonly accepted.

Professor Young acknowledged that today's engineering culture is still male-dominated. However, the "hostile environment" no longer exhibits itself in an explicit form.

The remainder of this chapter focuses on issues related to implicit gender bias, hidden sexual harassment, ineffective negotiation, and negative advising relationships caused by a larger male dominated disciplinary culture. I will elaborate on how these implicit, yet widespread phenomena, negatively affect women's retention and achievement in their physical sciences and engineering programs. As a qualitative researcher who employed an ethnographic research approach, I have spent a great deal of time with the women physical scientists and engineers I studied. It is my responsibility to protect their confidentiality and anonymity. After such a long period of interaction, some of them regarded me as their "close friend" or even "therapist" given the nature of my research topic. Various hidden gender bias and sexual harassment cases were shared during our weekend outings and phone conversations, with some of them even turning to me for advice. I was perplexed: too scared to offer any help, and confused over whether to include this data in my dissertation. After more conversations, research, and observations, I decided that what is happening to these women scientists and engineers needs to be told, discussed, and reflected. In the remainder of this chapter, I utilized data collected from

interviews with women doctoral students, women professors, and ethnographic encounters during the dissertation research to unveil some frequently occurring, yet overlooked and understudied aspects of women doctoral students' graduate school experiences and how they have influenced their views on academic careers and their respective disciplines in general.

5.2.1 Implicit Gender Bias

Interviewed students shared multiple stories where their female peers dropped out from physical sciences and engineering doctoral programs. Sasha discussed this issue during our interview and expressed concerns for women's outlook in chemical engineering, "One [who left] this year I heard of was a girl, one last year was a girl, and when I first got here, I had heard about a girl in our department who did [drop out]. But I've never heard of guys doing that. I actually heard of a girl leav[ing] after four years with a master's degree because she was just so fed up and she was done!" Other participants also shared Sasha's observation. Many interviewees in physical sciences also reported that they saw some women dropping out from their doctoral programs after many years in the program. Linda, a doctoral candidate in earth sciences, reflected on a recent incident—one of her close friends dropped from the program after 3 years—sharing a fear that a lot of student participants are facing:

> It [doctoral program] takes a lot out of you so I can't imagine starting over. But some people do [drop out], more in the beginning, like after their first year. Maybe they feel like this is just not going to work and why struggle? Which I think is okay. I mean, after your first… maybe after your second year, if something happens and it's just so unbearable, but after that, it's like, you leave with a master's degree [for] all these years' work. It's scary. I don't know what I would do.

The phenomenon described by Linda among physical sciences women doctoral students was prevalent. The interviewed students and faculty both reported a higher dropout rate for women due to funding, family, and mentoring relationship related barriers. Jill, a physics student, has been experiencing clinical depression due to the high pressure in her doctoral program and negative interactions with her advisor. She discussed reasons why women are more likely to drop out from their physics doctoral programs from her first-hand experience, "graduate school basically deteriorated my confidence. As time goes by, I just realized that I'm becoming dumber and dumber. It's a very sad realization for me. But I think that's what graduate school does to a lot of people. It actually tells them whether or not [they are] bright enough to finish graduate school. So sometimes I feel like maybe I'm not made for this. Maybe I've chosen a wrong career path to begin with." Jill's comment was also discussed in previous sections, where interviewed women students reported themselves to have low self-esteem. Jill's story captured one serious problem that many women participants reported to suffer— mental health issues.

Student participants regarded the lack of formal supporting mechanisms in physical sciences and engineering programs to be a major reason why some intelligent and qualified women scientists who have invested years of their professional and personal lives to graduate school decide to drop out. Nina, a fourth year engineering student, compared female and males students' confidence levels and asserted, "[male students] are definitely more confident. They can easily attack my advisor if she said something wrong. They are very confident. Even though they don't know what they are talking about, they pretend to be confident. That's something that I'm definitely missing. They can basically stand up for themselves." Nina shared that she was very intimidated during her first 2 years in the doctoral program. She said that she was scared to go to group meetings, was challenged by her male colleagues, and never felt

adequately prepared to pose challenging questions to her advisor. As time went by, she realized that "male students don't always know what they were talking about." So Nina gradually built up confidence and started challenging her male peers and advisor on the ideas that she wasn't sure about. "It actually got me a lot more credibility and respect," Nina commented.

The majority of the women interviewees discussed that a common form that implicit gender bias and stereotyping takes is sexist jokes and comments made by more senior male colleagues and professors. These incidents not only occur during these doctoral women's daily interactions, but also during professional collaborations and conference presentations. Dana shared one of her encounters at a prestigious astronomy conference:

> I had a poster and it was right next to one of the very well respected people's posted in our field. We did like a little round table where everybody talked for like thirty seconds about their posters, so I talked about mine. I think it went pretty well, [but] then the guy next to me, instead of talking about his poster, he talked about how mine was all wrong—which wasn't actually true, because he just wasn't listening to a word I said—and completely missed the whole point [of my poster] and misinterpreted my graphs, and [the experience] was terrible.

Other student interviewees also reported similar encounters in their doctoral studies. Almost all women doctoral students interviewed expressed different degrees of frustration toward having to deal with situations of implicit gender bias on top of their research, teaching, networking, and job searching efforts.

Casey was about to graduate from her doctoral program in a physical science program and discussed multiple instances of "not being taken seriously" in the male dominated field. She addressed biased issues that occur not only at conferences, but also her daily work environment.

In one such instance, she heard some "old male geologists talking about how all the changes [more women in the field] are destroying the field." She was very stunned by this "off-hand and sexist" comment. Although these men were not her professors, biases across the physical science and engineering programs are sometimes voiced openly:

> We do get some very off-hand comments sometimes from professors. And I've heard stories and I've had things said to me. Like, once somebody said to me that he thought it was better for me to assume that women were worse in science because then you can start to fix the problem. I was like, 'Really? I can't believe you are saying that to me!' Despite of all the research, teaching, and networking stuff, we still have to deal with this, the very subtle stuff.

Casey admitted that she did not know what to do the first time she heard this kind of comment, and that she was stunned that such "old school thought." Yet, she learned how to defend and negotiate for herself in similar situations. In my later visits to the women participants, we had further discussions about patterns of implicit gender bias. "Pattern" here indicates the characteristics of the people whose comments or behaviors are more likely to exhibit gender bias. Surprisingly, most women participants reported that gender biases were not only held by the older generation of professors and scholars, but that some "professors in their 40s also show [similar] behavior." Many research participants expressed frustration over this phenomenon and tried to seek answers. Their problem solving processes and conclusions are documented and analyzed in the following text on negotiating with their advisors, mentors, and colleagues.

5.2.2 Standing up for Yourself and Negotiating when Facing Challenges

WRU is a very prestigious institution of cutting-edge research in physical sciences and engineering. Its abundant funding opportunities, advanced equipment, competitive salary offerings, and desirous geographic location have attracted many renowned professors and researchers. Similarly, only students who possess strong academic merits, advanced research skills, and remarkable records of undergraduate research and coursework receive the privilege to enter doctoral programs at WRU. However, for most of the interviewed students, their understanding of graduate school was limited to knowledge of their advisors' outstanding research.

Data revealed that daily graduate school interactions and socialization consists of much more than collecting and calculating data, building models, drafting plots, and publishing results. Many student participants tended to "idealize" the type of experience they receive in graduate school prior to the beginning of their doctoral studies and imagine doctoral programs as a place where they receive all levels of mentoring. However, most of them gradually realize that they will need to take the initiative to create a mentoring environment and to negotiate research, publication, and teaching responsibilities for themselves. This study unveiled many dysfunctional advisor-advisee relationships and how women doctoral protégés eventually realize that "graduate school is what they make out of it" and that "having a famous advisor does not mean you will get proper mentoring." One common struggle that women doctoral students face is being ignored by their advisors, creating a lack of proper guidance in graduate school. When I had discussions with these women about the challenges they faced interacting with their

advisors, they were more likely to employ mild or ironic language to describe the serious barriers presented by the lack of and/or negative mentoring. For example, many doctoral women used the phrase "hands-off" to indicate a "lack of mentoring interactions." Sally looked back on her four and half years of graduate life and stated:

> My advisor is very hands-off and I think that style was definitely not good for me for the first couple of years. Eventually, I just figured out myself what I should be doing, so I did it. Some other women dropped out. She [her advisor] is almost not approachable because of other engagements. Our interaction was, basically, [that] I went to her if I absolutely needed something. It's more like I have to take the initiative to ask, 'Should I take this class or not?' or 'Should I be taking my qualifying exams sometime soon?' She didn't really guide me through my academic progress. I figured everything out on my own.

Sally told me that at the beginning of her doctoral studies, she thought having a female advisor would give her advantage, but it turned out to be irrelevant. Based on the data collected in this study, the gender of the advisor does not necessarily play a role when it comes to lack of mentoring. The advisors who were reported to "ignore" students' professional development needs, choosing instead to "focus on their own research" or "pay attention to their own companies," were both male and male. Student participants believed that faculty ranks appeared to be a stronger factor in this case: full professors, especially those nationally and internationally renowned professors, are less likely to spend time mentoring their doctoral students and are less likely to implement networks and other necessary qualifications to get their students prepared for the competitive job market. Discussions with student participants revealed that lack of efficient mentoring extends beyond daily research practices. Several women doctoral students expressed

concerns over incidents at professional conferences where they hoped to be introduced to prestigious scholars by their advisors, yet the advisors would just "leave the students behind" and "hang out with their friends." As Sue put it, "if having a famous advisor means there is no mentoring and networking opportunities, then I should have started working with an assistant professor, who at least knows I exist."

On a more significant note, four women doctoral students interviewed shared their experiences related to being verbally abused by their male professors. Several of them attribute this phenomenon to the perceived fact that "they were less likely to be treated equally compared to their male counterparts by their advisors." Jill, a physics student, shared her reactions to her advisor's abuse:

> It [advisor yelling at me] definitely did not help [with my progress]. It made it so much worse. He makes me feel stupid everyday. I really [take] that personally. I question myself everyday. This is my fourth year here and I still don't think I'm qualified to be in this program. I don't think I can even get close to an academic position. Well, I don't know how I'm going to graduate if it continues like this.

Other women in physical sciences discussed the language their male advisors use sometimes sends mixed messages, which intended to be encouraging, but seemed to be so harsh that many women participants were likely to internalize them. A woman physics student's story mirrored this phenomenon:

> I'm clinically depressed and am under treatment now. I can see myself giving up actually, like just dropping out of grad school. So I guess mentoring means a lot to me, even though his behavior is very contradictory. He tries to be encouraging, but he phrases [encouragement] in a very intense way. You might get a little offended at the

> beginning, but if you think in a deeper way, you realize that the motives behind what he's saying are good. For example, he can be very meticulous about little things that aren't important, so you would get frustrated when you see that. But after a while, you think about it and you realize that what he's saying is for your own good. So I put up with it, but I know I can't do that forever.

This interviewee in physics told me that she never communicated with her advisor about her problems. She told me that her advisor is not an empathetic person and sharing her problems with him only made her look weak. While a lack of mentoring can be resolved by reaching out to senior graduate students and postdoctoral researchers for advice in certain situations, certain women doctoral students expressed extreme frustration and anxiety when their advisors "do not care enough to keep their [students'] deadlines in mind" for letters of recommendation for job applications or publication submissions. A woman in space sciences shared her "anxiety filled" job application process due to her advisor's indifferent attitude:

> He likes to use the phrase 'It's not my problem.' It is my most hated phrase in the whole universe after all these years working with him. For example, I have a post-doc position that is waiting for me to graduate. So I told him that I need to get all this stuff done and it would be great if [he] could read my thesis at least before the defense, and give me feedback. And he's like, 'That's not my problem.'

This research participant ended up having to bring on board a co-chair who could help her push the progress forward and get her dissertation approved on time for her to start her postdoctoral position at a reasonable time.

Some women in this study shared their concerns over the working style that their male advisors expected them to adopt. Sixty percent of the women reported that their male advisors

"expect them to work the same way that their male students do," meaning “no vacations and weekends." Sally, an engineering doctoral student, stated, "My advisor is very demanding and a little bit on the intimidating side, so I’m always under stress. But it also encourages me to sort of keep working, just to keep him happy. Everyday, he just walks into the lab and he expects me to be in the lab working all the time!" Sally started going into the office on the weekends to catch up the work that she did not get to finish during the week. She told me that she felt really lonely and overworked. Sally started to consider going into industry upon her graduation so she could take a break from her “seven days a week” work style.

Many conversations with student participants revealed an interesting “golden child” phenomenon, which indicates favoritism towards certain male students by a senior women faculty member. Some student participants revealed their concerns of “not getting enough attention and resources from their advisors.” This finding challenges the existing literature, which indicates that women mentors are more suitable for women protégés when it comes to the professional development process. It further illuminated the complex situations created by cross gender mentoring. Mary was starting her third year in an engineering program when I interviewed her. She explained that her advisor has a student whom she has been working with since the student's undergraduate studies. This student is considered the "golden child" in the group and has a very close relationship with the professor. Mary and many of her fellow doctoral students believe that their advisor spends "twice as much time" advising and mentoring her favorite student and leaves other students to wonder what they could do to get more. Ling's reflection on this issue largely represented the view held by many women interviewed, "I think it comes down to being [the] favorite student. We have this one male student and he’s ahead of us. My advisor really, really likes him, so they would hang out all the time. I think it’s because they

are working on the same project all the time. Whenever there is an opportunity to collaborate with outside researchers, she always picks him." As previously discussed, Ling has been working with a female advisor, yet rarely had the opportunity to collaborate with her advisor, let alone being introduced to collaborate with researchers from outside of her institution. She has been working on her own project without much guidance and help from her faculty advisor. Leah, a civil engineering doctoral student, elaborated on this phenomenon with more detail by touching upon the potential reasons why this type of favoritism exists and how it reproduces itself:

> We had this guy named Greg, who graduated last year. She [Leah's advisor] knew him since undergrad and he stayed as a master's student and she had a really close personal relationship with him where he would come over and help babysit her kids. The kids loved him, and she adored him. Also, he was one of the only people in the lab when she first came here. She knows a lot of people in the industry and was able to get him a job. He was definitely the golden child.

Leah shared her frustration with regard to competing for the "golden child" position after Greg's departure. She considered that being in this position could give a student many mentoring and networking advantages, but Leah believed that women in her research group "rarely get those positions."

Several participating students reported the difficulties and barriers caused by dysfunctional mentoring relationship with their faculty advisors. Some students ended up dropping out of their programs while others ended up navigating the system by themselves. Some interviewees who are now close to graduation discussed and summarized their strategies to negotiate with their faculty advisors and peers to "gain the rights that should belong to them to begin with."

After witnessing how nervous some of the women students were at her weekly research group meetings and witnessing research results produced by women students being "stolen" or "rephrased and reclaimed" by their male counter parts, Nicky, a fifth year doctoral candidate, decided to stand up for herself. She stressed the importance of women students having sufficient confidence to speak up for themselves: “We need to realize how smart we really are and should not be bothered by some male colleagues' off-hand comments." Nicky shared that she feels many women in her laboratories are not confident enough to share their results with their research groups. So they take the results to share with their male colleagues before presenting it to the entire research group. "The next thing you know," said Nicky with a higher pitch voice due to anger, "they [the male students] take your results and integrate [them into] their own research and produce a new publication. We have no place to complain about it.” Other students and female faculty members also discussed Nicky’s type of incident.

Given the collaborative nature of many physical sciences and engineering research projects, many researchers work on a single project and have access to the data. Many student participants believed that when the project's Principle Investigator, in most cases, the advisor, does not make explicit rules for authorship, women doctoral students, particularly the junior ones, are less likely to be in the position to negotiate and thus the least likely to produce first-authored publications. Nina, a civil engineering doctoral woman, was working for 6 months to compile a database of testing results and statistics from her three and a half years of research. Nearing completion of the project, she went to her advisor to discuss publishing the data. However, Nina's advisor told her that this new product (the database) should be shared by all of his doctoral students, particularly a new male member of the research team who wanted use of Nina's database to publish his paper. Nina was very upset when her advisor told her to give this

male student access to her database and to work collaboratively with him. She wanted to talk to her advisor but was concerned she would be perceived as “selfish” and “overly protective." "I just wanted him to know that these are my results and my baby. I don't want other people to touch it," Nina said with frustration. "I just need to really stay encouraged and go and tell my advisor that I don't feel comfortable sharing my work before copyright[ing] it."

As an engineering student, Nina's close friend Krista has felt the same pain, yet she pointed out the significance of having "effective communication" with an advisor regardless of "how mean and ridiculous he seems to be:"

> I think it’s important because, first of all, our advisor is the person who lets us graduate, so it’s definitely good to have a good communication with him and at times. Sometimes I just really don’t like my advisor. He’ll just write things to me and I’m like, "Why did you write that?" That’s just mean. And then sometimes I just have to get over it because, of course, he’s my advisor and in the end he wants what’s best for me. So if he wants to hold me back, he might have his reasons. Maybe he doesn’t think my dissertation or a paper is good enough. And even if he’s really mean about it, he will in the end give us some advice and say, "Okay, this is how you progress."

Krista perceived her advisor’s feedback and advice positively, but she admitted that it was not easy to see it that way in the beginning. Another area that women doctoral students need to negotiate in has also evolved from stereotypical gender role. Tina pointed out that some women doctoral students or even post-docs should turn down many gender specific secretarial jobs: "they [some women post-docs and graduate students] put themselves in a position where their professors can treat them like secretaries. They really should speak up for themselves, only assist the professors when it comes to research, not, ‘Give me a coffee’ or ‘Run this errand’. Tina

reinforced her point by further stating that women students should take the initiative to turn down this kind of request and put themselves on the "equal ground" with their male counterparts and their advisors.

Women student participants who did not receive sufficient amounts of mentoring have summarized the "essential rules that every woman who has hands-off advisors should know in graduate school." They can be summarized into the following major areas: (1) when your advisor ignores you, do not be discouraged, take the initiative yourself to learn more in graduate school; (2) the best resources are senior peers in your group and post-docs next door who are there to answer your questions;(3) research is about what you do and what you learn from other peers in your group; (4) your advisor might be famous, but chances are their names won't help you much if you do not take the initiatives. Several student interviewees discussed the fact that their departments' cultures supports the notion of the "independent researcher," which indicates that doctoral students need to take charge of their own research and expect to produce results by themselves. As Jane summarized, "I think in our department, it's generally true that the culture is more like 'you should be the one that's in charge of your own research' and 'you should be the one [to] do all these on your own instead of depending on someone to do it for you or even guide you.'" Jane shared her strategies to cope with the situation where she received very little feedback and advice from her faculty advisor. She became more proactive and started approaching senior peers and a couple of women professors that she met through conferences. She acknowledged that she has been receiving more useful feedback from the network of people that she established the relationships with by herself than the advisor that she was "assigned to."

5.2.3 Switching Advisors

Not everyone finds the perfect advisor to work with in graduate school, and when the relationship does not work, women participants believed that they were less likely to be in a position to negotiate about switching advisors than their male counterparts. Several student participants discussed difficulties caused by dysfunctional advising relationships and having trouble bringing up their intention to change advisors to one whose research interests and personality might be better matched. Professor Hill, who once held a significant administrative position in the department, elaborated on this issue in greater detail, discussing the nature and implications of such phenomenon in physical sciences and engineering:

> I talk to them [women doctoral students] when they're visiting about this issue, that not every student can work with every advisor and not every advisor can work with every student because everybody's styles are different. So more important than the topic is you've got to find the right topic, but if that advising relationship doesn't work or doesn't function well, you don't have fun and you won't be motivated and it's not going to work. Students shouldn't feel obliged to continue; there's no offense [changing advisors]. There's absolutely no offense, and especially if [the relationship] is short.

Regardless of the suggestions given by Professor Hill, a reality discussed by majority of the women in this study is that women have few places that they can turn to about their dysfunctional advising relationships. Some of them chose to stay silent, but others found ways to negotiate with their advisors and departments.

Funding issues and research interests have forced Gena to stay with her advisor despite his "hostile and abrasive" behavior over the past few years, "my advisor does have very male tendencies, which has been very challenging to work with. He's just abrasive and rude and that

type of thing. I did think about it [switching advisors], but there's really no one else in the department who does what I do, and the other person who I was interested in didn't have any money." Gena has been coping with a dysfunctional protégé-mentor relationship for almost four years. She has been actively approaching other faculty in the department for various research and personal questions. While Gena is not the only person interviewed who shared this kind of experience, other interviewees elaborated additional reasons that stop them from changing advisors. These factors are mainly due to their fear of being perceived as "not being loyal" to their current advisor and also "wasting their two or three years of doctoral studies" to start over with a new advisor. Tina, an interviewee from physical sciences, regarded switching advisors to be "the best decision she's ever made in her entire graduate school career." She reflected on working with her former advisor as "the darkest period of time in her graduate school memory." Tina reflected, "a few other people [started] working with him but lasted maybe three months because he's rather rude and abrasive; he is not a very sympathetic person. So if you have a problem, he's going to scream at you. Either you fight back and that pisses him off, or you just sit back and take it. Oh my God, it was terrible." Tina eventually accumulated enough courage and decided that she would refuse to put up with her advisor's behavior any longer. Although she had to start over on her dissertation project, she turned out to be much more efficient and less scared. Many doctoral students this study believe the myth that "if you change to a different advisor, it will take you longer to graduate." Angela, who is getting close to graduating form her program, challenged such hegemonic belief and argued that changing to a different advisor whose research interests and personality are easier to work with can "in fact benefit your research skills and career outlook:"

> The first [advisor], I didn't get along with personally and I just couldn't work with. I also wasn't interested in the research. And so after the first year, I switched to my second advisor, who I liked a good deal and who's very supportive, who's also very willing to talk about which conferences I should go to. He was very supportive of my research and was also very supportive for the teaching. But I didn't actually work with that person. I worked with two other people. They had the extra funding and their research is more appealing to me. One is also the very supportive and very nice and the third was not very supportive and I had a very hard time with and then the funding ran out in that project and I ended up switching to my other advisor, who's currently more formal than the other two were.

Angela then asserted that many women doctoral students are unaware that it is not mandatory to stay with the same advisor throughout their program. Based on Angela's first hand experience, to maximize the research, funding, and networking resources, constantly searching for the best advisor to work with turns out to be an effective approach. It is this kind of constant negotiation and collaboration that helps women doctoral students get through their graduate program successfully and eventually land their ideal research or teaching positions.

5.2.4 Hidden Sexual Harassment

Several interviewed students discussed sexual harassment issues occurring in their offices and labs, on research teams, and at conferences. These implicit forms of sexual harassment pose challenges for women doctoral students to various degrees. These common forms could be summarized as: (1) verbal sexual harassment by peers or between advisor and advisees; (2) peer sexual harassment and advisor's protective behaviors; (3) sexual harassment from collaborating scholars who are prospective employers of the students. Compared to the first two categories of

sexual harassment behaviors, the third type of sexual harassment identified by interviewees directly sheds negative light on women doctoral students' career decision making process and perplexes them in terms of merit-based academic career selection process. These behaviors also hinder them from establishing professional networks. Due to the high sensitivity of this matter, I share some ethnographic data without detailed description with regard to the individuals' departmental affiliation or specific field of study to guarantee research participants' confidentiality.

I gave the pseudonym "Amelia" to this research participant. Amelia is a straight-A student and she has received many awards based on her cutting-edge research ever since she joined WRU. She reported an incident that has been bothering her for a long time:

> A professor who has been collaborating with my research team from Y university. He's much older than me. This professor was following me everywhere when I went to this conference last week. He asked me out to dinner, coffee, and drinks at the conference, but I turned him down. Then he offered me this opportunity to give a talk at his university on the topics of my latest research. You know, that could get me a good job in his department! I didn't know what to do. After we returned from the conference, he drove to WRU to see me today and we had coffee together. Over the coffee, he grabbed my hand and asked me to go out with him! I'm very confused right now. What do you think I should do?

I was stunned by such a question that put many responsibilities on this researcher. Throughout the years of interacting with women scientists and engineers, this is not the first time that I heard of story of this nature. This type of sexual harassment behavior and its potentially damaging nature could cause much personal and professional damage to women doctoral students.

Although I debated writing on this topic throughout the authoring of my dissertation, the high frequency of these incidents eventually prompted me to report and discuss this form of sexual harassment. By discussing this issue, I want to open discussions in three different areas: (1) what does this type of sexual harassment mean to women doctoral students and how they should deal with it, (2) the ethnographic researcher's positionality, (3) the researchers' professional ethnics in case of sensitive issues or even criminal behaviors.

It is easy for departments and institutions to overlook this form of sexual harassment due to the fact that the more senior male professors, scholars, and/or researchers who initiate this kind of behavior do not belong to the same institution as the student. However, that should not change the nature of this phenomenon given that it involves hierarchical relationships and power dynamics. According to The Code of Federal Regulations (2000), this type of sexual harassment termed *quid prop quo*, is defined as "unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature when submission to such conduct is made either explicitly or implicitly a term of condition of an individual's employment" (p. 186). In Amilia's case, this professor does not work at the same institution, he was in a higher position than Amilia, and promised providing potential employment opportunities to her if she agreed to go out with him. Amilia became very confused because she is uncomfortable with this situation, yet had a great working relationship with this professor and had the false hope that he would "find her a job" upon graduation. Amilia eventually declined and is now greatly suffering from the consequences: she is no longer included in the collaborative research project where the professor is the co-principle investigator and her peers have spread hurtful gossip. She did not know to whom she could turn in this matter. It created a major barrier for her to continue her

program, despite being only 1 year away from graduation. Amelia has considered quitting her program and leaving academia forever.

I also want to address the issues of researchers' ethics especially in ethnographic settings where researchers are exposed to research participants' everyday lives. Interactions on regular basis with women doctoral students' assisted my understanding of the culture and interactions among this group of women and with their mentors, yet it also blurred the line of researcher-researched. Over time, researchers are regarded by the community they study to be the "therapist" of the community and thus hear many stories that would not otherwise be divulged. However, sensitive issues such as those in this study usually put ethnographic researcher in a dilemma where she/he does not how to approach this issue.

5.3 Summary

This chapter was a discussion of the crucial role that both formal and informal socialization play in women doctoral students' mentoring experiences. The women students and faculty participating in this study identified six major formal socialization stages that faculty involve their students in at different times of graduate school: (1) teaching/researching skills; (2) publications; (3) funding; (4) conferences; (5) networking opportunities; (6) career outlooks and aspirations. The data showed that the more students are exposed to the above concepts, the more likely they are to begin planning for their careers and more likely to be better prepared for the competitive job market upon graduation. Women participants believed that they are less likely to benefit from advisors who are more prestigious in their field—denied networking and publishing opportunities—while they benefit from their advisors' research direction and abundant resources in funding. Women doctoral students participating in this research reported that they had many concerns balancing an academic career and domestic life, yet they choose not

to discuss these concerns with their male advisors, turning instead to women faculty in their department or outside of their institution. Male faculty members interviewed did not speak of work-life balance at all, while women faculty spent a good deal of time discussing multiple cases where they were approached regarding concerns related to work-life balance by doctoral women students' whom they've "only taught one class" or "had no previous interactions with."

Centering women's experiences in graduate school, negative influences caused by implicit gender bias, new forms of sexual harassment, and weak mentoring greatly impact women doctoral students' graduate school progress, career outlooks, personal and professional development; how they negotiate with their advisors, peers, and colleagues on issues of intellectual property, overbearing authority, and personal confidence. Influenced by disciplinary, departmental, and institutional cultures, this chapter unraveled the complexity of graduate school socialization process and how women negotiate their positions in their process. Intersecting with the concept of "community" that women scientists and engineers formed through their graduate school and professional career, the following chapter will discuss how their graduate school mentoring and socialization experiences influence this community of women doctoral students' career decision making processes and how they choose to pursue their “dream careers” in physical sciences and engineering.

Theories from Kram’s (1985) and Tierney and Rhoads (1994) on the importance of formal and informal socialization process were reconfirmed in this study. They took forms of teaching/research skills, publications, funding, career outlooks, Although the importance of informal mentoring seemed to outweigh formal mentoring in some circumstances. The complexity of cross gender mentoring mentioned in Kram’s theory was furthered by the findings of this study in the sense that male and power privileges persist in and beyond organizational

boundaries. Given that the design and data analysis of study was partly guided by feminist standpoint theory, many negative aspects of protégé-mentor relationships were revealed. They do not necessarily indicate that women doctoral students are in very miserable positions. However, the unveil of some disturbing mentoring incidents should bring out attention to further research in this area.

CHAPTER 6: THE DEVELOPMENT OF WOMEN DOCTORAL STUDENTS' ACADEMIC CAREER ASPIRATIONS IN THE MATRIX OF DOCTORAL EDUCATION

"I'm usually the one that asks (about students' career trajectories). When a student is starting their Ph.D, I ask them why they're going for a Ph.D and what their goal is. Many students say I'd like to work in engineering companies and others say they're interested in academia. So that kind of shapes what they do and how they are prepared to a limited degree. If a student is really interested in academia, I insist that they do TA shifts at least a couple of quarters if not more. I have really superb graduate students and the ones I've had in recent years have been absolutely superb and very few of them have been interested in going into academia. I had this one female Ph.D student who had a vague interest in it for a while. She had three job offers when she graduates. Two were for prestigious postdoctoral positions. And one was at a research and development sort of what they call an FFRDC (Federally Funded Research Development Center) that provides technical advice for the government and it was a very good match for her background. So she accepted that position. She could go in to academia probably, but she would have do it soon and apply soon because at the place where she's working it's not likely she can be publishing any research papers. I think she's extremely happy there and she's earning a lot of money and it's not exceptionally stressful or high-pressure the way an academic position usually is. So I think she's going to stay there and then teach once in a while for us or some other place. (A women professor in engineering, Western Research University)

American academics are characterized as a group of professionals who are at the service of others, possess extensive knowledge and technical skills, and obey a code of ethics (Millett, 1962). Some major characteristics of the academic profession include scholarly devotion, required doctoral training, hierarchy of rank, and academic freedom (Millett, 1962). Scholars consider graduate school to be the initial stage of an academic career (Austin, 2002; Austin and Wulff, 2004; Fox 2001; Tierney and Rhoads, 1994). Clark (1987) drew attention to the disciplinary and institutional complexities within academic professions. Graduate studies vary drastically among disciplines due to different primary goals of training students to be independent scholars and researchers. This study focused on women doctoral students' aspirations to pursue academic careers in physical sciences and engineering through an examination of protégé-mentor relationships in their doctoral programs. The above professor's comment reflects the strong disciplinary influences on academic careers in engineering. Gender also plays a significant role in the process for women to socialize into academic careers. Long and Fox (1995) suggested five dimensions exist regarding women's career attainment in academic scientific communities: the organizational environment, location of the institution, professional rank, research productivity, and recognition by peers.

A shrinking number of tenure-track positions and small representation of women among tenure-tracked positions have affected new doctorate recipients' career trajectories. Jobs are no longer abundant in the form of full-time tenure track positions. In 2004, according to the U.S. Department of Education, 36% of U.S. Science and Engineering faculty were employed part time. This trend is even higher among women faculty: 44% of women science and engineering faculty are employed part-time.

Based on discussions in the previous two chapters, this chapter is focused on six major themes arising from the results of the study that shape the development of women doctoral students' aspirations in pursing academic careers. They are (1) interactions and communications with advisors, (2) career observations and speculations, (3) postdoctoral positions, (4) academic, industry and national laboratory comparisons, (5) work-life balance, and (6) finance and funding. These interrelated categories are well grounded in the discussions of the previous two chapters where both formal and informal socialization processes are identified and discussed as well as challenges and relevant strategies that women doctoral students' face in their protégé-mentor activities in respective doctoral programs.

6.1 Interactions and Communications with Advisors

Although all women doctoral students participating in this study had various degrees of interaction with their advisors, the communication of career trajectories between protégés and mentors were mostly ambiguous. Both students and professors shared their reservations and reasons why they did not normally bring up the topic related to career aspirations and job hunting. A fourth-year women student shared her concerns:

> Even if I told him that I would like to enter a research institution and become a professor there, I really have no idea what he's going to do to help me move forward. He hasn't had that many graduate students before and I'm his first student after he moved to WRU. I've been kind of putting up for fillers for post-doc myself. I'm sure he will probably help me but he doesn't see that I'm at that point yet.

This student had doubts about her advisor's ability to help her with her career decision-making process. Thus, instead of discussing career related topics with her advisor, she started working on

submitting postdoctoral applications on her own. This student acknowledged that such situation puts her at a disadvantage when it comes to the quality of her applications.

A common pattern was discovered in the process of interacting with women doctoral students: they do not see the necessity to talk about potential careers given that they perceive their "only responsibility in graduate school is to do good research and be productive." As Christa, a fourth-year doctoral student asserted, "My advisor never asked me what I'm going to do in the future. Maybe I will spend more time considering that question during the next year. For the first several years, I just concentrate on my classes and research. My advisor probably thinks it's too early now to consider that." In this case, Christa was left to speculate about her advisor's rationale for not addressing her future, but a frank and open conversation may have benefitted her own career development.

Christa's was not alone in her concerns; many other women participating in this study also interpreted the fact that their advisors did not bring up their career trajectories, as "they don't think we're ready for that talk yet." Others set a timeline based on their progress in their doctoral programs and are "waiting for the best time to talk to their advisors." As one fourth-year doctoral student explained:

> I will probably talk to my advisor about my career plan after my proposal is passed. I always wanted to talk to him about my career choices but I just couldn't. He's very new in this field. So I don't know the standard. He always tells us to do it quickly but we just can't! It's better when we already got some good results and then talk to him about our jobs. But now I'm not confident enough to talk to him.

This student was clearly willing to discuss her career related questions with her advisor. However, she was unsure of her own "readiness" to bring up this topic. In fact, many women

interviewed had such a concern. They wished their advisors all had some kind of "criteria" that they could achieve before they bring up the topic of a career. For example, another interviewee said her advisor told her and other students that they needed to publish at least three tier-one journal articles before they could even think about getting a faculty job. So she has been working towards that goal and is planning on bringing up the "career talk" with her advisor as soon as she achieves the goal. One student in physical sciences particularly pointed out that she perceived her doctoral advisor as only part of her graduate school life and she should depend on herself when it came to future career choices:

> I think it's less difficult now for me to talk to her. It was impossible for me to even imagine having this conversation with her two years ago. But I think it [career aspirations] really comes down to the question- what do I want to do with my life? I mean I have committed to my Ph.D. life and I have been always trying my best to make my advisor happy. But what I really want to do next is really up to me. I need something that makes me happy. My advisor never brought up this topic before and I don't think she cares.

This interviewee's advisor was a renowned scholar in the particular field and had a very strong network of scholars collaborating with her. However, this student did not get many opportunities during her doctoral studies to work with her advisor or receive much feedback from her. She said that her advisor was always "too busy with her multi-million research projects" and "never [has] time for a little doctoral student like me."

While doctoral women students shared the reasons why they demur on bringing up the discussions of career options, faculty members have concerns of their own. An astronomy

professor shared her insights about mentoring doctoral students and the tendency for faculty to steer doctoral students toward academic careers:

> One challenge is that academics are always accused of only recommending academia and portraying that as the only definition of success. I think that is a challenge. That is a big pit we all fall into repeatedly. This recent student said that she wasn't sure [about going into academia] and instead of saying that that was okay, I guess I sort of questioned why she was making that choice. So I guess for me this is a challenge because I saw her as somebody who is very talented and I didn't understand why she was not going this route because I think she has the potential. So I wanted to pose the question to show her that she was capable, but at the same time I was feeling conflicted. I was doing this thing that we're all accused of, that that's the only route to success. And yet I wanted to make sure she wasn't falling off the track because she felt she couldn't do it or she felt like this life [academic life] was too crazy.

This professor in astronomy then explained that this is why she normally does not bring up the topic of career options with her students

A few faculty members emphasized the importance for students to be proactive and take the initiative to consider and discuss their career trajectories with faculty advisors. One male professor discerned his timeline and system when it came to providing career related guidance to his doctoral students:

> The median time for graduation in my subject is six years. First two years are classes and then it's like a wasted year and then they get into research later. Typically it's like that. But they all know it's extraordinarily difficult to get a job in this subject especially in this time when there is no money. So they bring up the discussions of career choices early.

> Typically a year before they leave because you typically need to apply for a job before you get out. So I'm guessing they probably think about it for a year before they talk to me. Then they talk to me about possible places they can go and I just tell them whatever I know. For example, this is a good place or a bad place in general. Usually they tend to be too conservative. If you go to a yuppie school, like Harvard, MIT or Cal Tech, the attitude is different. But if you go to a public school like [WRU], there is a little bit of a tendency to cut yourself down and not apply for the more prestigious schools. So I tell them to be confident and apply for everything because those guys in MIT are no better than you and that's really true. When they have kind of a psychological breakthrough, they went ahead and apply and some of them get those high level places too.

This professor's comment posed two interesting points. First, he automatically assumed that his doctoral students' normally "waste" one year after they pass their qualifying exam. Second, he considered bringing up the topic of career as one year prior to graduation as "early." He then elaborated that he does not like to talk about job prospects with his students because if they are true scientists, they should be passionate about doing science instead of finding a well-paid job. Additionally, this physical sciences advisor shared his style of mentoring students during the last year in graduate school. He encourages students to break their conservative mode and apply for as many prestigious positions as possible. Student participants who receive this kind of positive and encouraging feedback from their faculty advisors are more likely to pursue careers in academia. However, some of them discovered the importance of bringing up the "career talk" with their advisors early on in their doctoral studies:

> When I got back from this summer's internship in the industry, I was a little nervous to tell her that I didn't want to apply for post-doc positions. I didn't want to disappoint her

> and I don't want her to think that I'm not good enough for faculty positions. I'm just not sure if I want to get into it right away. But when I actually brought this up, she seemed really open. She said, "yeah, who knows? You might get a job there [at the company where I worked over the summer]." Ironically, I applied for a post-doc position and got in! Now I'm going to do that during the fall. I could have never done that without knowing how much faith she has in me.

This student described her inner debate before bringing up the possibility of going into industry with her advisor. She thought her advisor would have hated the idea and reacted strongly against it. In contrast, her advisor was very encouraging towards her possible career decisions. This kind of supportive reaction somewhat inspired this student to keep all career options open. She finally decided to pursue a career in academia and will start her first postdoctoral appointment soon. Almost half of the women interviewed acknowledged the importance of the networking opportunity that their advisors' reputations brought them. A fourth-year engineering student shared her story about discussing career trajectories with her advisor, which was prompted by a request that her advisor received from a colleague. This professor received an invitation to lead a research center at one university on the east coast. He turned down the offer yet recommended this woman student to researchers who had started working at the new research center. This student's advisor started helping her create a CV to apply for this potential job. This interviewee stated, "At that point, I realized that he [her advisor] is the one I should be talking to because he's well connected. I'm his protégé and I'm getting his recommendation. I think it's very important because I do want to go to the academic route." As it turns out, this research participant is going as a summer research fellow this year to start engaging more in the establishment of the new research center. She now has a very positive academic career outlook.

Some students reflected on their conference attending experiences with their advisors, and that conversations have led to very crucial discussions of their career path and how they should approach the next steps of pursing an academic career. A fourth-year engineering student shared that she always knew she should have the conversation about career with her advisor. However, she never found a chance for such a conversation. This participant went to a conference where a professor from a different university asked questions about her presentation. When she got back to WRU, the interviewee asked her advisor about this professor. Her advisor said, "He is a good person to get a post-doc with if you want to get into that direction." As a result, this student is now in the process of applying for that postdoctoral position. This experience made her realize that her "advisor just doesn't want to actively push me in one way or another but he definitely wants me to bring up the conversation."

A woman doctoral student in astronomy shared how a particular conference served as the platform for her advisor to introduce her to other scholars in the field and give her further guidance about who could potentially offer her a permanent position:

> Even though we are a small group, there are still a small amount of jobs out there as well. I'm also doing instrumentation, which actually widens my job aspect compared to most graduates here. This one conference that I went to with my advisor was important. There was just two of us from [WRU] and told him about wanting to give a talk so people will remember my name. He told me that it was a great idea and it could help me to get a job in the future. He introduced me to a lot of colleagues who are from different institutions and several of them expressed interests in working with me.

This participant started working on a collaborative research project with several professors who she was introduced to by her advisor. One of the professors had expressed interest in continuing

to work with her upon graduation. From professors' perspectives, socializing students into academic careers requires students to take the initiative to communicate with them about whether or not they are interested in pursuing a career in academia. A professor from engineering expressed his view on this topic:

> It depends on the student. Some are very focused on an academic career and I'd say they either come in with that as their goal or they come in not knowing what their goal is. I think relatively a smaller number know that they have a different career goal from academia but as they move along they may decide that academia is not for them. They're most interested in an industrial type position or government labs.

This comment was made by a senior professor in engineering. His observation was also reflected by many student participants who shared their confusion when it came to career goals at the beginning of their doctoral programs. When asked about their different mentoring approaches to cater to students' various career aspirations, several professors addressed the importance of postdoctoral positions and publications for students who either want to enter academia or industry. A professor from physics reflected her mentoring and communication styles with her doctoral students:

> A lot of it has to do with working on their writing, but I also try to talk to them about how they're feeling and, recently two of my students are getting close to graduation this year. So I have been talking with them quite a bit about what their plans are. Basically what they need to think about moving on to the next step for careers. Very conventional trajectories would be doing a postdoctoral position but one of my students isn't 100% positive. She is applying for post-doc but he's also considering doing a more outreach

job. So we've talked about taking that path successfully or how she might continue that path successfully. Either way, doing a post-doc is important.

This professor's view was also shared by several other professors in physical sciences. A very common practice for doctoral students who are about to graduate is to pursue a postdoctoral position given the limited job postings. While postdoctoral positions may assist new graduates to better their research skills and complete more publications, in some cases, they serve as a "buffer" or "temporary shelter" for students who have trouble finding a job after graduate school. One major benefit of pursuing a postdoctoral researcher position prior to seeking a permanent position in the U.S. is boosting the quality and quantity of one's publication and grant writing. One professor's comment was representative among all professors interviewed, " I encourage them [post-docs] to publish. I usually engage my students and post-docs who want to go to academia in grant activities. I also spend a lot of time discussing what it is like to be a professor with those who are interested."

He further discussed the importance of learning how to create research proposals for those who are interested in academic careers. As many institutions start to put more weight on grant seeking activities, he suggested all students who have goals to become a professor should start learning these skills early in their graduate school training. Students mostly perceived their faculty advisors' career expectations for them as the traditional academic route. Thus, several women discussed their concerns regarding "effectively communicating" with their advisors regarding their non-academic career aspirations. One student mentioned her intention to teach at a four-year college where she can have more interactions with undergraduate students. However, her advisor reacted strongly after she discussed such an idea with him. He told this student, "You were better prepared than that [teaching at a four year college]." This student

stopped communicating with her advisor after that encounter and started applying for postdoctoral positions on her own. This pattern was also revealed during interviews with several other women doctoral students who had career aspirations to teach at a community college or a four-year college. They did not receive much feedback on their decisions from their male advisors and they perceived such "lack of directions" as due to their advisor's "bias towards research universities."

The majority of women interviewed had been in their doctoral programs for longer than three years. However, very few of them discussed their career trajectories with their advisors due to their concerns about their considerations of non-academic career trajectories. Faculty advisors discussed their concerns of "being blamed for pushing everyone into academia" when they ask their students about their career goals. Thus, they were less likely to initiate the conversation regarding career trajectories unless their students brought up the topic

6.2 Career Observations and Speculations

The previous section discussed the communications and interactions between students and faculty advisors. Many women doctoral students form their own speculations based on observing other peers' career outcomes and their advisors' research, grant applications, and teaching activities. Many of the students interviewed expressed their concerns pertaining to "long work hours," "ability to secure external funding," "the pressure to support research labs and graduate students" and lack of "passion and dedication about research." These major reasons were identified by interviewees who had academic career aspirations at the beginning as to why they changed their minds about pursing an academic career. A women student in engineering discerned:

> Motivation is the most important quality of being a professor, especially if you want to be somebody's advisor. You have to be motivated yourself to motivate other people. If I'm not interested in what I'm doing, how can I do that? Also, professors in this department all have crazy life styles. My advisor is normally in the lab from 7 a.m. to 11 p.m. He's putting a lot of energy into this and for some reason his energy does not go down for all these time. I'm exhausted after 5! I feel that I'm kind of weak in that sense.

This participant's observation echoed a major concern of the majority of the interviewees regarding the demanding life style that academic positions require. A similar point was made by a fifth-year physical sciences student about to leave WRU for her very first postdoctoral position. She reflected the changes that occurred during her doctoral study and concluded:

> I think I'm probably less inclined toward academia than I was when I came in, just because it seems like a kind of like a rat race. Everybody is just fighting over these very few positions and once you get into that position it doesn't necessarily become easier. And I'm not saying it's going to be easier if you become a researcher at a national lab. But I think it's very safe to stay in academia because that's what we've been doing for the past decade and it's all that we know. I'm not ruling it out for the future but right now unless I have to I'm probably less inclined to go into academia.

This interviewee had an interesting observation about the purpose of doctoral education. She pointed out the shortcomings of doctoral education: "It narrows down my areas to such a large extent and I don't feel comfortable doing anything else but my own research project." She also expressed her concerns over her "inadequate training" in a broader scheme of research and felt it will hinder her ability to look for a job outside of academia.

Several doctoral women discussed the "isolating" nature of academic jobs, and their graduate school experience somewhat confirmed such assumptions. Many of them were very concerned about their ability to generate original ideas for research proposals, which is closely tied into grant applications and the achievement of tenure:

> The reason why I'm less interested in staying in space physics is that I feel like it's easy to work on something but it's difficult to come up with original ideas. And that is not something that I feel like I've gained strength in graduate school. Academic life is sometimes too isolating and graduate school was kind of like that too. We just sit in front of our computers and analyze data all day long. We don't talk to people and we don't meet new people. It's not what I want for the rest of my life. I wanted to do something that involves more interaction with people.

Besides the discussion of concerns regarding the generation of original ideas, this participant also addressed her concerns regarding the "isolating" nature of daily academic life. Among the women students who were one year or less away from completing their doctoral programs in this study, a majority of them entered their graduate programs with academic career trajectories. Yet, about 80% of them changed their mind two to three years into their programs. Some of them decided to go into national labs or industry, while others decided to leave their discipline and pursue a completely different career path. The latter choice was not uncommon among interviewed physics doctoral students, as stated by one student participant:

> When I entered the program, I basically only wanted to go into academia. As time went by, I realized that there's some type of personality that I'm missing for that kind of position. I might have to find a job in finance. That's actually the destiny of a lot of physics students. They find jobs in finance because basically it's just data analysis. We

> have very good math and physics background due to our training in coding and programming. Finance firms love people with physics background.

This point was brought up many times by student interviewees in this study. They discussed the high frequency for doctoral recipients in their fields to leave the field of finance, and many of them are women. They all agreed that the "finance industry" path is the least preferred among physics doctoral students. However, the competitive pay and less demanding work style of the finance industry attract many women graduates.

One space physics woman discussed her observations among her colleagues who have graduated recently and the way her advisor commented on the career outcomes of these peers: "my advisor had a few students before me and most of them didn't end up doing research in space physics. Some of them went into finance and that's completely different from what we are trained for in the field. She definitely doesn't like that. I know that because she pointed out to us how off-track those students are at our research meetings." This student's comment reminded us of the communication dilemma between women students and their advisors when it comes to career trajectories.

Some faculty do perceive academia as the only appropriate career path for doctoral students after the long period of doctoral training. Yet, some advisors try not to bring up the discussion of career due to their concerns of being stereotyped as a professor who "only wants to see their students to be in academia." Amanda from chemical engineering commented on this matter and her view is fairly representative among women doctoral students in this study:

> So I think advisors generally prefer when their students go into academia because their reputation seems to be based on how many students they have placed in top tier universities. I have definitely heard some ironic comments that he made about his

> students who went into the industry. So I think that was the subtle warning that he was giving to all of us. But we actually never had a conversation [about career] yet. I'm not planning on going to academia but I'm kind of scared to tell him that.

Amanda based her assumptions about her advisor's attitudes towards career goals on her observations of comments he made about former students' career outcomes. In some cases, participants discussed how they delay their career discussions due to their assumption about what kind of career path their advisors preferred.

It is important to note that protégé-mentor relationships are bidirectional. Women doctoral students are not the only ones doing observations and making assumptions about their future career path based on their advisors and peers' career choices and outcomes. Professors also make substantive observations and subconsciously base their mentoring styles on the ways their doctoral students interact and communicate with them. As one professor posited:

> Some students flip back and forth, but you can see that this student will go into academia and this one not because they're more active with research, publishing their work, and so forth. Some are satisfied with one or two papers, others write five papers, and somebody you don't even ask them they come back after weekend, "Oh, I wrote this." So those are the kind of people that will go into academia. I spend a lot of time helping them to publish and improve their writing skills because they normally take the initiation.

This professor's comments clearly put students who have not decided to go into academia at a disadvantage when it comes to training and publishing opportunities.

A second professor (from engineering) specifically discussed the importance of women students' socialization in academic careers early on, even prior to entering graduate school:

> I think it has to do with the education early on. Female students should be more aware of the fact that it's not that tough to go into academia. A lot of them enter graduate school with preconceived notion that it is a lot easier to go to industry. So only a small fraction of our female students want to go into academia. And those who are in academia are doing pretty well. We have several women professors in the department and they are all doing pretty well. One of them even has children!

This engineering professor's view is somewhat representative among male physical sciences and engineering professors. Four out of five professors interviewed stressed the importance of "educating" women students about what an academic career is during their undergraduate studies. They almost all cited examples from their female colleagues to demonstrate that being a women professor is "not difficult at all." However, female professors participating in this study interpreted their working lives in a rather different manner; none of them mentioned how easy it is to manage their academic careers and family lives. Interestingly, they were more likely to focus on the possibility of pursuing academic careers for their women doctoral students. One particular woman professor was very honest and explained that an academic career for women is not easy. She shared her experience in dealing with efforts to obtain tenure coupled with childcare duties. She ended up getting tenure a few years later than her male counterparts who entered WRU around the same year that she did. She explained:

> It is definitely not an easy thing to do. But I did it. I know it's not for everyone. That's why I don't push my women students to go into academia. I would sit down and talk to them about how they feel about their graduate program and then ask them what they really want to do. For the ones who are passionate about going into academia, I'm honest

with them about all the difficulties that they need to overcome. Then I'll provide them with publication and network strategies on how to land a post-doc position.

Three women professors interviewed shared similar strategies to mentor women doctoral students who are considering academic careers. However, male faculty showed less understanding toward women students' concerns regarding work-life balance. Several male professors in the physical sciences stated that scientific careers need to be pursued with passion and scientists should be able to sacrifice many things for their passion. This point can be sufficiently reflected by a space science professor's viewpoint:

> I think when people start to talk about careers for me the game is already over because science is not a career. One shouldn't think of it as a career. To me, career is a business school or something like. I don't care about that. A career is a way of life and how to live your life. So I'm not really interested and I never talk about careers to students because to me that's a huge red flag. Sometimes people come to ask me, can I have a good career in astronomy or planetary science and I know that person shouldn't be in science. They should be in a firm at Wall Street.

This professor's perception was not unique among the male professors interviewed. Many had strong feelings about the physical sciences and made some critical comments about the social sciences, even offering negative remarks about my own work being a "humanities thesis," and questioning my study's validity and design. The gender and power dynamics that occurred in my interactions with physical sciences and engineering professors will be discussed in a later section and is reflected upon in my concluding chapter.

Another male professor from the physical sciences asserted his view about the difference between "career" and "job" by comparing academic positions with medical and legal professions.

He also commented about childcare responsibilities and how they should not be an "extra burden" for female academics:

> The good news for careers in sciences is people are of the higher educational levels and are less interested in having children, which is fabulous for the rest of society. Academics are very creative; if you're an academic it really reflects some inner desire. People, in a family sense, can go into law and medicine because it is a profession. It's not a passion really. You need passion to be an academic. But you rarely meet a passionate lawyer. If you were concerned about pay you wouldn't be in academia at all.

In this professor's mind, doctoral students who were "serious about science" needed to pursue a career in academia and should be cognizant and reactive to this fact from the very beginning of their doctoral programs.

On the students' side, many productive and scholarly oriented student interviewees shared their views about pursuing an academic career after graduate school. They expressed interests and passion in the research they were doing; however, not all of them had made a firm decision about becoming an academic from the beginning of their doctoral studies. A women student from engineering shared that she never thought that doing a Ph.D. meant that she had to become a professor. She regarded getting a Ph.D. as the necessary step to becoming a researcher rather than a professor. She did not start her doctoral program thinking, “This is what I need to do in order to become a professor." She also acknowledged the difficulties of finding a job that many of her peers faced and said she was not going to be picky once she completes her Ph.D.

A fifth-year student who just completed a summer internship with a company commented on her career trajectory and how graduate school had positively influenced her decision making process: "I can’t say that they are very specific yet. I haven’t ruled out a possibility of pursuing a

career in academia. I know it's not that easy either. I'm also interested in working here in a company. I've had similar type of plan when I entered graduate school. The only thing that changed is that I'm more optimistic now. I see many of the past students of my advisor are professors in different universities and it just gives me more hope." This student's observations of peers' career outcomes who used to work in the same graduate program with her has provided her more confidence in pursing an academic position upon graduation.

6.3 Postdoctoral Positions

Taking multiple postdoctoral positions in the fields of physical sciences is considered to be a "standard practice" before a Ph.D. lands her/his permanent job. Almost all professors and doctoral students in physical sciences have discussed the necessity to have one or more postdoctoral positions. A professor from astronomy shared, "I have never seen students not have a post-doc. So post-docs are almost a given in the field. Most people will go through two post-docs. Some may get away with doing one. It depends on where they're aiming for. I think two is the average. Some will have one, some will have three." This professor's statement mirrors the current state of career paths for physical sciences Ph.D. recipients. Reported by both student and faculty participants, almost all Ph.D. recipients were doing postdoctoral positions in the "early" stages of their careers. However, women students in this study believed they are less likely to be mobile when it comes to selecting postdoctoral position compared to their male counterparts. This limitation largely hinders their ability to obtain postdoctoral positions with prestigious institutions and programs. It forms a vicious cycle where when someone fails to work on a "quality project" during their first postdoctoral positions, they usually need a second, third, or even fourth postdoctoral position to boost their competitiveness for applying for a faculty position. The women in my study reported their perception that they were more likely to be

victims of such a cycle. A fifth-year student also expressed the "common understanding" within the physical sciences community regarding postdoctoral positions. Many participants regarded postdoctoral positions as an integral part of doctoral studies. Even if they end up going into industry or a national laboratory, postdoctoral positions are necessary and extremely beneficial when it comes to the competitive job market:

> I think almost everybody does [a post-doc]. Only the few people just decide to drop off science entirely or they go into community college teaching don't do it. But for the most part, everybody goes to a post-doc. It's incredibly hard to get a position without a post-doc. I have not heard of that being done during the past five years. The post-doc is also necessary if you want a research position. So at least one post-doc is mandatory if you want to stay in science research. Some people do two and some people do three but by the time you get to three you are seen as the "damaged goods." The employers would question "why don't you have a permanent job by now?"

This student also discussed the timing for doing a postdoctoral assignment and how strategic they need to be to have a smooth transition from doctoral studies to a postdoctoral position and eventually to a permanent job. A professor in space sciences explained why doing a postdoctoral assignment is absolutely necessary when it comes to a career in physical sciences and what the major challenges are that this group of highly educated scholars face:

> In my subject people expect to be post-docs. If we're talking about grad students, they all expect to be post-doc. Very few people go into the trouble of getting a Ph.D. and then go off into something else. I've seen that but it's rare. So they all want to be post-docs. They want to stay in the academic stream. But the problem is how do you get out of being a

post-doc? There just aren't enough academic jobs for the people. And there never were. But it's worse recently than ever it was due to funding issues.

The professor's point reflects a common trend regarding strategies to prepare their doctoral students for a shrinking and competitive academic job market. Almost all physical sciences faculty participants acknowledged the bleak job market for physical sciences Ph.D. recipients. They argued that they try to prepare their students in two major ways: try to help them publish as much as possible, and try to help students establish a sufficient network of scholars who can potentially increase students' possibilities to obtain employment opportunities. The majority of women mentioned their advisors' flexibility in terms of assisting their graduating doctoral students with the transition to their first postdoctoral positions. An engineering doctoral student stated:

> Very few do [stay at WRU for post-doc]. I know people who graduate and they have a post-doc with another institution starting three months after the graduation. So they will technically be a post-doc with their advisors for three months. They'll get paid double but they will be still wrapping things up with their advisors. It's nice that sometimes advisors give them that kind of leeway. I think the advisors appreciate it too because they can get this person who already knows what's going on and they're still paying them as much as a grad student.

This interviewee regarded such phenomenon as "a win-win situation" for both faculty and the graduating doctoral student. This period of time is categorized as the "separation" period by Kram's mentoring theory, meaning that it is triggered by significant structural or organizational change and/or psychological changes within both mentor and mentee. Several professors interviewed summarized three common factors that trigger the start of the "separation" phase at

the time close to students' doctoral graduation: (1) writing postdoctoral proposals; (2) creating their own research projects; and (3) learning to be an independent scholar and secure their own funding. As one professor explained:

> It gets very challenging towards the end, especially when they're developing their post-doc applications. They have to write these proposals and this is the one proposal I won't help them much with because it has to be their work. It's going to be judged as their work. I will talk to them but I won't rewrite it or edit it. So we have conversations about the ideas, the directions, and that's usually where the "independent scholar conversation" comes up. I usually advise my students if they're going on the academic track is, "you want to be an expert in your proposal, but it has to be a little different so either you take your science and you play a different technique or you take your technique and do a different science." It's like stepping-stones to your independence. I actually find the most talented students often the most challenging ones because they're the ones you want to keep collaborating with. But you're pushing them away and yet you want to keep collaborating.

This professor's concern with regard to bringing up the "discussion regarding independence" was not isolated. It was more likely to be observed within women faculty interviewed. Patterns were also seen among some women student participants who used postdoctoral assignments as a buffer between their "tedious doctoral studies" and their first job. Some interview participants revealed that they did not know what the plan was after graduating, but they all knew that doing a postdoctoral with a prestigious group was "the right thing to do." Some attributed their lack of career planning to the fact that they "went to graduate school because they didn't know what to

do." Others consider a postdoctoral position as a strategic move to boost their competitiveness in the academic position searching process. Nina, a fourth-year student, stated:

> What I want to do is be post-doc for a few years and then I want to start finding teaching and research positions like assistant professorships. The goal eventually would be full professorship somewhere. So I get to do research somewhere and mentor graduate students. That was my goal when I started graduate school. It hasn't changed so much. My research has changed a little bit. When I started graduate school I thought I would study objects in the outer solar system. Now I'm studying the objects in the inner solar system. So there's a difference there. But in terms of the career that I wanted to have and the career that I think I'm going to have during the next few years, it didn't change much.

Nina had started planning for her postdoctoral position applications. She had been giving many research presentations at conferences and trying to build an audience base. She added, "I have been keeping in touch with the professors I met at conferences. I will check in with them as soon as I'm getting close to completing my dissertation for postdoctoral opportunities." While postdoctoral appointments are nearly "mandatory" for all doctoral students in physical sciences programs, this pattern does not seem to be prevalent in engineering doctoral programs. Many physical sciences students who choose to pursue academic careers are able to secure a tenure position upon their graduation while less than 30% of the engineering students interviewed mentioned such an option as part of the pursuit of academic careers. Doctoral students in certain engineering specializations reported a higher likelihood to be engaged in industry and interdisciplinary work. These engineering divisions consisted of, but were not limited to, chemical engineering and environmental engineering.

6.4 Academic, Industry, and National Laboratory Comparisons and Rationales

Many women participating in the interviews offered insights into comparisons between a career in academia, industry, and government research laboratories. Some of the most compelling reasons for interviewed students to choose academic careers related to the high level of autonomy, academic freedom, and the stability associated with salary and welfare. For the research participants who decided to work towards an academic career upon graduation, they reported an attraction to the interaction and mentoring experience with undergraduate students. Almost all women interviewed had fulfilled teaching duties for one year or more during their graduate studies and they acknowledged that this teaching experience provided them with a clearer perspective regarding whether or not they would pursue a career in academia. A student in planetary sciences shared her view about why academia was more appealing as a career option:

> I really like teaching and I really like the not having a boss business but still have health insurance. I know, as a professor, I still have to deal with committees and other stuff. But if I had gone into aerospace companies and I had to report to managers all the time! I'd much rather be independent and I'm much happier that way. I really like to have health insurance and a stable income. So professors just seem to be a nice condition of that whereas research scientists you just always have to be worried about where your funding comes from. It's not stable and you don't get to teach. Those are major disadvantages.

This student compared the pros and cons between working in the industry, in academia as a professor, or as a research scientist. A high degree of academic freedom appears to be a major reason that attracted her to academia. Compared to being a research scientist, teaching became a

major factor that made her lean towards the decision of becoming a professor. An engineering student who had experience working in the industry prior to attending graduate school, considered the aspect of interacting with students to be particularly appealing. She commented, "I love interacting with students and conducting research to contribute to the field of civil engineering. I found it very rewarding to mentor students and pass my knowledge to them. Universities keep people more up to date with our profession and the research while the industry just requires us to do the same thing everyday for many years." This engineering student was the most junior doctoral student among all women interviewed, however she had the most experience working in industry. Her view on "mentoring students" represented the reasons of many other student participants who want to pursue a career in academia. It is noteworthy that there was a slight difference when it came to physical sciences and engineering doctoral students' career alternatives to the academic path. Women interviewed in this study discussed their concerns and even fear of entering academia. Yet, for physical sciences women students, the major career alternative was concentrated in postdoctoral and researcher positions in governmental laboratories and research institutes, such as NASA research centers or other national labs. Engineering women in this study were more inclined to join industry when they decided to forego an academic career. In the meantime, some women in engineering also discussed their reservations about entering industry due to their observation of professors' involvement in the industry during their doctoral studies. Eight students emphasized the stress associated with grant writing and supporting graduate students that might stop them from entering academia. Tina, a fourth-year student, shared her concerns about academic careers, "I'm particularly worried about those times of the year when a professor needs to write grants. Professors have deadlines and so many people depending on them. It seems that all students need

you to be there all the time. They need money, funding, advice, resources and it goes on and on. At least in the industry you're not worried about money. That really takes pressure off from you." Tina focused on the financial aspect of being a professor and expressed her concerns over the "difficulty to obtain funding." She further stated that although she really enjoys the teaching and researching sides of an academic career, having to constantly apply for research funding and supporting research laboratories and graduate students made her hesitant about pursing such a career.

Maria from environmental engineering spoke about the application of her research results being more likely to occur in industry than in academia. She further discussed her concern that although her research results could be published in the academic world, she was not sure how many people would read the journal articles. Thus, she was worried that her hard work would not "pay off" in the sense of being applied and manufactured as products.

This view was widely held by many engineering students in this study. Another woman doctoral student discerned a fairly common practice among engineering faculty members who demonstrate a high level of involvement in industry and entrepreneurial activities:

> The men in our department have their PEs [licenses for professional engineers] and have worked in the industry before. One of the professors has his own company and he is pretty much going to quit sometime and just focus on that. But I don't really see that with the women professors. That's interesting. Also, talking with other people about how hard it is to get the PE gives me some perspective. I keep asking myself: "do I really want to do that? Is it important to actually do it in I want to stay in academia?" Industry really likes it if you have PE. They like it if you have it in Civil more than just Environmental. A lot of the faculty in the department do have PE. Faculty who have their own business,

who are entrepreneurs, are more likely to have an open mind in terms of our career choices.

As indicated in the comment above, a majority of the student participants mentioned the opportunity for male faculty to become entrepreneurs. This observation triggered some discussions among student interviewees on the idea that male doctoral students could possibly have both academic and industry careers, while women were less likely to experience dual-careers in their futures.

Several professors in physical sciences programs summarized the employment trend in their fields. They posited that in physical sciences, students' possibilities to go into industry are slightly smaller compared to students in engineering. For example, an astronomy professor pointed out that 45% of her department's graduates went into academia, and another 45% went to work for governmental laborites, such as NASA, Jet Propulsion Laboratory, or the National Optical Astronomical Observatory. Approximately 10% of all doctoral students go into industry upon graduation. In astronomy, the concept of "industry" is limited to aerospace corporations that build telescopes or instruments for telescopes. Sometimes these companies are sponsored by government funding to conduct research for national defense purposes.

Another professor in physical sciences stated that national laboratories' research styles are very similar as the ones in academia. Thus, he asserted that he does not adjust his ways of mentoring for students who have different career trajectories. He claimed that the students just need to "slightly adjust the way they do research" to fit in with the style of the new research team that she/he will be joining.

A doctoral woman who specializes in planetary sciences reflected on a common perception that was reported by many other student interviewees in physical sciences

departments:

> It's true that you have to go to an institution that wants your kind of researcher. So maybe one university does more research based on instrument work but I have zero instrumentation training. So they won't select me regardless of how qualified I am as a scientist. So it's kind of like a vicious cycle and it narrows down the candidates whereas NASA is much more broad. For example, you will still be assigned to a team that has somewhat of a research specialization but you will be working on different missions with so many scientists who not only have specialization but also a broader perspective on research in general.

This student participant realized the advantage that a career in a national laboratory had over academia early in her doctoral studies. So she worked as a NASA research fellow over several summers to establish a good working relationship with various NASA research centers around the country. The discussions about career alternatives besides the traditional academic route focused on the comparisons regarding advantages and shortcomings between academic careers and counterparts in industry and national laboratories. As indicated above, the engineering women students interviewed who turned down academia as their first career choice reported more interest in entering industry. On the other hand, women physical sciences students in this study were more likely to join the workforce by entering national laboratories upon graduation. The following section is a presentation of some representative data from both women students' and professors' views regarding the "Number One" barrier that hinders all participating women doctoral students from pursuing academic careers.

6.5 Work-Life Balance

In a prior findings chapter, the data revealed one of the major benefits that the interaction with senior peers and the establishment of networks with junior woman professors bring to women student participants was the receipt of effective advice on work-life balance in academic careers. This theme emerged again in the discussion regarding women's development of career aspirations. However, this time, work-life balance evolved from "an idea or assumption" in these women's minds into a "reality" they need to face as they accumulate more experience in graduate school and become close to graduating from their doctoral programs. Before moving to a discussion of the relevant data, it is necessary to reiterate the definition of "work-life balance" in this research project. "Work-life balance" is a concept that refers to proper prioritization between job and life. Job indicates career, promotion, or ambition, while "life" indicates family and leisure related activities (Jeanes, Knights, and Martin, 2009). In the case of this study, "work" refers to women students' perceptions and concerns regarding academic careers and "life" indicates their desires about starting a family, having a "stable" life, having children, and having a less stressful lifestyle.

Almost all women interviewed in this study discussed significant "changes" in their private lives during their doctoral studies. These changes mainly consisted of meeting significant others, getting married, breaking up from long-term relationships, or interning in their industry. A sixth-year student shared her career moves and how they were based on her relationship status:

> Before I started the graduate school, I would have said the science is the Number One. I think it pretty much still is except that I have a boyfriend now and I tried to get

> fellowship in the same city. He's a working professional. I actually just got one postdoc offer last Thursday. So I will be working for this research center that is close to his work. That's only one of the reasons for me to get a post-doc at there rather than somewhere else. But if the work isn't interesting or new or original, then I don't know if it's worth doing even though I can get some papers out. They won't be good papers. In that case, I don't think it's worth it. I definitely think science is important but I can't leave my personal life behind.

This interviewee also expressed concerns regarding the outlook for her to pursue academic positions. Her postdoctoral researcher appointment was one year. She mentioned that she would need to look for a faculty position six months before her postdoctoral work ends, which does not give her much time to further her research and publish. She acknowledged that her top concern when it came to a permanent job was to be in the same city with her significant other. However, the few universities that recruit faculty in her research area are not in "desired locations."

Another woman who recently became engaged spoke about the difficulty for dual science couples to secure jobs in the same region, let alone the same institution. She reflected on her colleagues' experiences and speculated "one person in the dual science couple needs to go into industry or completely change her/his field." She expressed her career choice dilemma in one of the interviews, "If I do enter academia, I'd probably need to do many postdocs. And I'm really tired of not being settled. My fiancée and I want to buy a house but we can't do it until we actually know we're going to be living at some place for longer than a couple of years. So I'd really like to settle down and go to wherever he ends up going. I realize that if I chose to go into academic career, then that would be at least another five years of instability. And that's not something that I care to do." This research participant revealed her willingness to "give up

science entirely" and pursue other career paths given that her significant other is a much stronger candidate than her to pursue an academic career.

Another common perspective shared by several women students is the change of their interpretation of "choosing an academic career." Many discussed how an "academic career was the only way to do real science and research" before they entered their doctoral programs, yet as four or five years passed by, many of them realized that science was not the "only important thing" in their lives. Catherine, elaborated her thought transformation on this topic:

> My mind has changed in the sense that I think I had a lot stronger sense of academic career aspirations when I first came in. I was very focused and I wanted to make space *the thing* in my life. My first year kind of reflected that. I was in the office all the time. I had two papers out and I think I know what I was doing. But then I got a little burnt out and started searching for more meaningful things outside of academia and career. I met my husband in graduate school and we recently got married. I found a lot of friendships and fulfillment outside of work. And then still kind of balancing the two together. So as far as my career aspirations, I think it has become less of the focus. I realized that I wasn't finding fulfillment in what I was doing. Sitting in the office all day in front of the computer is just not that meaningful.

The reasons Catherine changed her priorities between her science career and her personal life were not surprising. She started to "enjoy her life" rather than "sit in front of her computer all day long." She further discussed that graduate school offered her a "preview of academic careers' isolated nature" and how she does not want that to be part of her life. Further, the "greedy nature" of both an academic career and childcare responsibilities are closely associated with the desire of "settling down" and "starting a family." All women interviewed discussed in

various degrees their worries about having a child while working towards tenure if they decide to go into academia. One engineering women's view reflected this common concern among all student participants in this study, “even if I married a man who wants to be a stay at home dad, I still don’t see how I can have kids. I’d like to have a personal life, have kids one day, and go on vacation for a week sometimes. I think a smaller institution will be a little bit more accommodating of that because they are not pressuring you to publish. But we don't have any woman faculty who have kids in the department! That really worries me. There must be a reason behind that.”

Although work-life balance related concerns turned out to be one of the top reasons why interviewed women doctoral students decided to avoid academic careers, female and male faculty perceived this kind of phenomenon rather differently. Women faculty reported that they were more likely to be approached by female doctoral students in their departments regarding their work-life balance concerns. Male faculty participants, on the other hand, failed to mention any incidents where they engaged female students in conversation about concerns of having a family and how it could affect their academic careers. One particular physical sciences male professor phrased his perception in a somewhat "male centric" way and could somewhat represent a fairly common view among male faculty on the issue of "family or career:"

> One of the most promising students I ever had, she quit and got married! I can say that's a 100% family distraction and that seems to affect women much more than men. I was kind of disappointed but that story had a happy ending. She eventually came back after quitting and finished her degree. But she could have then probably been a leading member of the field if she didn't quit. Maybe she could still be something impressive but clearly is not going to be the leader. She could have been a professor at a top tier

university without too much difficulty. But she did not. She had a life choice and we hardly see a life choice like that with men.

Without too much interpretation, this professor's comment clearly delivered the message that "he was disappointed" in the fact that one of his most promising women doctoral students quit her doctoral studies and got married. He made a very interesting assumption that "she could have become one of the leading scholars in her field," but now "it is hardly possible." Women faculty in physical sciences and engineering, while acknowledging that "having a family and children" was not an easy thing to do in academia, provided advice and served as role models for women students. One physical sciences women professor noted:

> If they're married and have a child, it [being an woman academic] becomes very difficult. So some women delay the whole process and then they are competing with men in their field. It's natural how they always feel maybe they are behind. But we have female faculty in the school who are doing as well as male. So women can totally do it and it's just a lot more difficult than men.

Another women professor discussed how she used her own example to advise women doctoral students who approached her for questions about starting a family and having children. Additionally, she pointed out the "implicit bias" imposed by male counterparts in the organization:

> I started my faculty position right out of graduate school and got tenure in my early thirties. The same year when I was expecting tenure, I got pregnant. The first kid was born approximately the time I got tenure. So I was able to swing it. There is another woman professor in my department actually had her first child before she got tenure by about a year but by that time you will accomplish what you're going to accomplish. The

only thing working against you really is bias in the department and that's not insignificant.

The implicit bias toward women doctoral students was discussed in the previous chapter regarding the topic of "negative mentoring" among women students and their male peers and professors. Women's authorities were reported to be more likely to be challenged by their male peers, and such a phenomenon was also revealed by almost all women faculty interviewed.

6.6 Finance and Funding

Szelényi's study (2007) on biological and physical sciences doctoral students and faculty revealed that a major part of faculty identities in these fields is based on the ability to provide monetary resources for their doctoral students and research laboratories. It is noteworthy that this study, which focused on physical sciences and engineering female doctoral students and faculty, furthered the 2007 study in three major dimensions:

1. Biological sciences fields were not included in the realm of this study; thus, the notion of laboratories did not appear to be a major theme in the collected data.

2. Szelényi's study included only chemical engineering students and faculty. This study confirmed Tierney and Rhoads (1994) theory about the cultural differences within a given disciplines, such as engineering. For example, the chemical engineering division experiences a higher rate of collaboration with biological sciences departments and is more likely to follow similar lab-based research practices as some biological fields. However, aerospace engineering is more closely related to the field of astronomy and physical sciences and focuses more on instrumentation, data coding, and analysis.

3. Data from this study also revealed that women perceived themselves to be more likely than their male counterparts to question their own ability to secure external funding if they become faculty members. A student in physical sciences shared her fear:

> I see that professors have to get their own funding. I feel that I don't have what my advisor has. They have a love for what they do and to get funding you have to be creative. It's not enough to be just knowledgeable. You have to think outside of the box and I just don't have that skill set. So I cannot imagine me being a good professor in the future. Being a good professor is not just about teaching anymore. I feel like the part of getting funding is the most important element and that scares me.

This participant's view on research funding revealed an increasing characteristic for research universities, namely, the ability for faculty to secure funding from the government and private sector. However, the training for these types of skills and knowledge was reported as missing from many students' doctoral programs. While the lack of training in grant application activities might affect both women and men, this study focused on the unique strategies that women use to cope with this kind of situation. Judy, a fifth-year student, compared funding situations in the industry to academia and stated that industry has more abundant financial resources for a researcher/scientist to fully utilize their skills to apply scientific knowledge to products. Additionally, Judy explained her reservations about the stress that she would face in terms of securing constant funding to maintain her labs and support doctoral students. She admitted that pressure from support graduate students alone could make her avoid academic positions.

Several women interviewed expressed interest in academic careers that only entailed teaching responsibilities. A civil engineering student's comment explained the reasons why she does not want to become a professor at a research university, "I don't like the idea of funding

graduate students and always having to write grants and trying to have a family. I have seen my advisor try to raise kids while doing all that and it was very tough on her. Having a family is very important to me. So, I just think it would be less demanding to be a professor at a research university like this." Several other participants also regarded community colleges and teaching institutions as more beneficial when it came to balancing work and personal life. The national statistics show that women are more likely to be employed part-time than in full time tenure positions in the science and engineering workforce (NSF, Science and Engineering Indicators, 2012). This student's perception and its consequences could be a contributing factor to this phenomenon.

Several male professors discussed their observations throughout the years regarding the top two reasons that stop women doctoral students from pursuing academic careers, as one professor summarized:

> It [career aspirations] evolves during the students' doctoral studies. And very often I see female students do not want to go into academia. Why they don't want to go into academia? First several years of academia, you have to put in very hard work and raise money to support students. That's a tough part in some sense. Also, most woman want to raise a family but having a family delays their tenure process. So they opt to go to industry. I've been teaching here for many years and most of my Ph.D. women students ended up going to the industry.

This male faculty's perception was not alone among all male faculty interviewed. Many of them discussed their awareness of women's concerns regarding the pressures stemming from the funding aspect of the academic profession. Yet, none of the male faculty discussed potential approaches to address this major concern that stops women from pursuing academic careers.

The majority of men attributed women's decisions to shy away from academia to their "distractions" from starting a family and having children. This viewpoint contrasts women faculty's explanations where they were more likely to acknowledge students' concerns and then address them with their own examples and experience. Students interviewed who had such interactions with women faculty were less likely to be concerned about the work-life balance aspect of academic life.

6.7 Summary

Faculty and women doctoral students participating in this study reported fairly different views on students' career trajectories. Women students shared their difficulties in communicating with their advisors regarding their questions about pursuing academic careers. Many of them decided to avoid academia before even having a career-related discussion with their advisors. Faculty participants were not at ease with this kind of phenomenon. They reported to avoid bringing up the topic of career unless students initiated such conversations. Many professor participants discussed their concerns of being stereotyped as only wanting to push their doctoral students into academia. Importantly, only women professors who had been in their positions for less than ten years had such concerns. They were more likely to be pursued by women doctoral students in their departments and asked work-life balance related questions. Contrarily, interviewed male professors were least likely to speak to their students about the various facets of academic careers. Their women students perceived them as "working machines who are in the office all the time." Several student interviewees shared their speculations regarding how some male professors must have a stay-at-home wife who takes care of the house and children. The data revealed a communication gap between faculty and women doctoral students. Over half of the women interviewed had never held a career related conversation with

their advisors. The ones who had such conversations only reported having it during their last year of doctoral studies. Almost all students interviewed agreed they wished they could have had such conversations earlier with their advisors to be better prepared for the competitive job market. Yet, such a practice was reported to be extremely rare by both student and faculty participants.

Disciplinary differences were revealed when it came to common career moves upon the completion of doctoral programs for students in physical sciences and engineering. Participating women physical sciences students discussed the necessity of obtaining postdoctoral positions before graduation. They reported that it was fairly common for physical science doctoral graduates to do two or even three postdoctoral assignments before landing their permanent jobs as scientific researchers or an assistant professors. The quality and reputation of the research teams that they are teamed with during postdoctoral work are extremely crucial. The ones who failed to work with renowned research groups in their fields ended up being in a "limbo" stage where they keep doing more and more postdoctoral assignments, but could not find a permanent job. In contrast, student interviewees from engineering departments hardly discussed the practice of being a postdoctoral researcher. They did mention their interactions with the ones that they were working with currently. However, many women discussed their options to secure an industry career, which would not require them to have any postdoctoral working experience. Some women shared their observations about how some of their previous peers who had graduated were able to obtain an assistant professor position right after graduate school.

Compared to women student participants in engineering, participants in physical sciences were discovered to be less likely to have industry options. For the ones who decided not to pursue academic careers, the majority joined various governmental laboratories. Some of them

became scientific researchers and were somewhat independent from a laboratory and more likely to rely on a NASA mission or other short-term funding source.

Not surprisingly, one of the main reasons for women doctoral students in this study to avoid an academic career path was attributed to their concerns on work-life balance. All but one participant discussed their desire to start a family, have a stable income, and raise children. Yet, they all perceived academic careers to be the least friendly towards this kind of practice. They compared the options of going into industry, governmental research laboratories, or academia, and concluded that governmental labs and industry were more likely to provide them with five day a week jobs and plenty of free time to spend with their significant others and children. Importantly, female and male faculty in the study held completely different views towards this issue. Women professors shared their strategies to mentor women doctoral students who approached them regarding these conflicts. These women faculty were more likely to validate these concerns and acknowledge the necessity to worry about such issues. Then they used their own anecdotes and experiences to explain to these students how they could still achieve as much as male faculty members. The validation process was well accepted by the students interviewed and they admitted that women professor's approach provided them with more confidence in pursuing academic careers.

Several women faculty stated the problem of "implicit bias" in their departments, which was created by male faculty members when women were facing childcare responsibilities. Yet, they decided to not reveal this phenomenon to their female students. All women faculty in this study acknowledged that the climate for women in physical sciences and engineering has been improving for the past two decades and they expect more positive changes in the fields towards women in the future. On the opposite side, male professors interviewed did not discuss their

strategies to mentor women doctoral students to prepare them for academic careers. Several male professors regarded "having a family and children" to be a "100% distraction" for women doctoral students and they could not achieve as much as they should have once they started a family.

Another significant reason for women to withdraw from the options of academic careers was the pressure to secure external funding. Over 80% of the women in this study discussed their concerns regarding one prevalent aspect of an academic career: the need to secure external funding to support doctoral students, maintain their laboratories, research equipment, or other resources. Closely associated with the ability to secure funding, many students also discussed their concerns that their limited knowledge in the field may hinder them from generating original ideas, which is extremely crucial in the process of funding applications.

Kram (1985) stated that "mentor relationships vary across organizational settings in terms of the range of the functions provided, the length of time a relationship endures, and the level of intimacy and commitment achieved" (p. 197). One major finding of this chapter on the career path differences not only confirmed Kram's theory, but also reflected Tierney and Rhoads' socialization model which touches upon the disciplinary differences between socialization processes. While the findings of this study confirmed the role modeling function in Kram's theory, the acceptance/confirmation, counseling, as well as friendship functions of the theory were challenged to certain extent. I argue that these functions do not necessarily occur within the same organization and between one mentor and her/his protégés. Her assumption of fulfilling all mentoring functions was also challenged by the findings of this study. Career functions and psychosocial functions do not occur simultaneous for all mentors and protégés. Certain protégé-

mentor relationships do not display both career and psychosocial functions, and some of them emphasize one function more than the other.

CHAPTER 7: CONCLUSION

The findings from this study fill in the gaps from previous literature in the following three ways. First, they contribute to studies of "community" and "social networks" among women physical scientists and engineers. These notions appeared to be very critical in career development for this group of women in my dissertation study. This underscores the need for further examination and studies that focus on the relationship between social networks and women physical scientists and engineers career progressions. Second, the findings revealed gaps in formalized mentoring efforts geared toward women in many physical sciences and engineering doctoral programs and identified potential policy related implications that could assist various physical sciences and engineering programs in the area of career mentoring for women students. Third, the findings of this study identified major areas in which women doctoral students perceived themselves to need the most mentoring and attention, such as postdoctoral positions, communications with advisors, peer career influences, and work-life balance. Each one of these areas could lead to a new research project that further explores the reasons and strategies to help doctoral women cope with their doctoral program socialization and their career decision-making processes.

7.1 Summary

This study was designed to explore women doctoral students' protégé-mentor relationships in physical sciences and engineering programs and how such relationships influence this group of women's academic career aspirations. Graduate school serves as the most important institution at which future academics are trained and prepared (Austin, 2002; Tierney and Rhoads, 1994). As the views and experiences of the women doctoral students and faculty

interviewed for this study illustrated, doctoral students' professional development under the influence of multi-faceted mentoring relationships in graduate school largely affected their decisions and readiness to pursue academic careers. My findings reveal that students are key to the process of preparing for a career and need to take initiatives to communicate with their advisors and other mentors regarding their career aspirations. Faculty may subsequently address their mentoring styles, methods, and strategies and train doctoral students to prepare them for their future careers. Some professors may also include students in their professional networks to create career opportunities for them, while taking a more active role in assisting doctoral students with their career development.

In summarizing my findings I return to my key research questions first presented in Chapter 1:

RQ1: How do women doctoral students in physical sciences and engineering define and participate in protégé-mentor relationships?

Tierney and Rhoads (1994) described formal socialization experiences in terms of the recruit being "separated from other regular members of the organization while participating in a series of specifically designed activities" (p. 27). Results revealed six categories of major formal socialization experiences for physical sciences and engineering women doctoral students revolving around the areas of research and teaching training, publishing, funding, conference interactions, networking, and career trajectories. These categories are derived from everyday graduate school apprentice experiences at different stages of doctoral studies and play a crucial role in training and socializing doctoral students for their professional roles as physical science or engineering scholars. The findings illuminated the priorities across these formal interactions in physical sciences and engineering graduate programs: (a) teaching graduate students to

conduct effective research, (b) publishing significant results, and (c) becoming productive teachers. While these priorities are likely to be very similar to those of other doctoral programs, it is important to note that physical sciences and engineering programs rely heavily on outside resources for funding to enable research and deliver practical and useful outcomes, which seems to be especially crucial. Consequently, many doctoral students prioritize learning from their advisors the art of applying for and securing funding from NSF, NIH, and NASA. Yet, the findings from this study revealed a fairly large gap between these important scholarly skills and some advisors' proclivity to provide such training and access to resources. Given what some of my student interview subjects perceived as insufficient training, many women doctoral students see themselves having to "'work for free before getting funding from their departments" or pay their own tuition.

Informal socialization occurs simultaneously with formal socialization in doctoral programs (Tierney and Rhoads, 1994). The informal socialization process is significant because through informal daily interactions with their peers and faculty members, new members of the academic community learn many implicit organizational values, norms, and attitudes—the essence of organizational culture. The findings of this study revealed that women doctoral students' needs in the area of more informal forms of socialization were not usually satisfied and tended to be overlooked by many advisors in the physical sciences and engineering programs under study. Some women professors pointed out that physical sciences and engineering cultures are more likely to value quantitative factors such as the number of publications, the number of grants, and the implementation of research results than paying much attention to the various aspects of informal socialization. For example, many students reported difficulty talking

to their advisors about work-life balance and other related career concerns due to their worries of not being considered as a "true scientist."

Regarding the assumption that “academic careers are extremely family unfriendly,” as one woman put it, many women doctoral students decide to avoid academic careers without any career related discussions with their advisors. Women doctoral students are especially concerned with work-life balance and the workplace culture and politics of academic careers, specific knowledge of which can only be obtained by an informal socialization process in which students communicate their concerns and exchange ideas with mentors freely. More often than not, when women doctoral students in my study found such support, their mentors were also female and likely affiliated with a different institution than the one attended by the student. Student and faculty perspectives and experiences demonstrated that women students who have periodic discussions with their mentors about work-life balance, family friendly policies, and work place cultures of other institutions seem to have a higher probability of pursuing an academic career and are more likely to graduate in or under the average time span of doctoral study in their particular departments.

The community that women scientists and engineers established to support each other at both a personal and professional level extended beyond their departments. Also, the findings of this study revealed a gap in resources made available for women compared to their male counterparts in physical sciences and engineering, at least based on the perceptions of women in this study. Although my study did not seek to confirm or reject such perceptions by actually calibrating the resources made available to male and female doctoral students in the physical sciences and engineering departments, the perception itself can be quite limiting to one’s academic and career aspirations. Here, I am reminded of the classic sociological theorem offered

by William I. Thomas and Dorothy Thomas (and I paraphrase here): situations defined as real, are real in their consequences (Thomas and Thomas 1928, p. 572). The definition of the situation could serve as a significant tool to understand how people in an organization identify and reinforce certain social norms when they agree on certain types of behaviors or help to locate challenges of certain social norms when people in social interactions disagree on certain behaviors or norms (Thomas, 1923, 2002). Rhoads and Gu (2011) utilized a definition-of-the-situation approach in their study of women academics in China to analyze the contradictory ways in which woman faculty members and their male counterparts at a Chinese research university described the challenges faced by women.

Women doctoral students also discussed their proactive approaches for pursuing guidance and mentoring outside of their departments or their home university. In most cases, these mentors were female junior faculty members who met with the students at professional conferences. Some of the women faculty members served on doctoral students' dissertation committees, assisted them with the process of seeking employment, and provided them with "work-life balance" advice. Women students reported that these junior faculty were more approachable and more likely to give them career advice as a friendly and supportive "outsider."

Community building and networking usually originates during undergraduate years. The communities and support networks of woman scientists and engineers are extensions of their undergraduate institutions where they were first socialized into their fields of study. Graduate school provides women doctoral students with a platform to establish and expand their individual networks beyond their departmental and institutional boundaries. Some of these networks are built on the collegiality established between more advanced women doctoral students, some are based on inter-campus collaborations, and others are built through interacting with women

faculty members at conferences. Many student participants discussed the tremendous amount of assistance and feedback they received from postdoctoral researchers in their research groups. In certain departments, such as space sciences and space physics, there were non-tenure-track research associates dedicated to writing NASA grant proposals and collaborating with researchers from national labs and the industry. Many research participants regarded these researchers as approachable mentors in their doctoral programs.

In the process of graduate school socialization, national, institutional, disciplinary, and departmental cultures all affect the processes and outcomes of graduate education (Clark, 1987, 1993; Tierney and Rhoads, 1994). While in the majority of cases here student and faculty relationships and interactions are influenced by WRU's culture in general, the funding-centered physical sciences culture and industry-involved engineering model also comprised a large part in mentoring doctoral students in their programs. National culture was controlled at the design of this study. However, given the diverse national and cultural backgrounds that the U.S. science and engineering workforce entails, students and faculty also revealed the influence of their international network and meshwork of scholars on the students' development in their doctoral training process.

The concept of "community" was determined to be a significant strategy for the women doctoral students' interviewed for the study with which to cope with their initial stage of the doctoral socialization process and later as major resources for career advice and professional development. These communities were primarily established between women doctoral students, women faculty members, and women staff researchers from different institutional and cultural backgrounds. Mentoring relationships occurred among these "communities" and offered a unique angle to examine doctoral women students' protégé-mentor experiences in graduate

school. Advice and feedback that these students received through these networks and meshworks influenced their career decisions to a large extent. This concept challenged the traditional definition of "graduate school mentoring" where most interactions occur between doctoral students and faculty members.

While many women interviewees discussed positive interactions with their faculty mentors in both formal and informal settings, some women students shared struggles and barriers in their doctoral programs caused by negative mentoring, implicit gender bias, and hidden sexual harassment, all of which hinder women's professional growth and positive career outlooks. Many women participants expressed disappointment regarding interactions with their advisors. Many discussions touched upon the gap between advisors' outstanding research reputations and the quality of their protégé-mentor interactions. Some discussed the importance of taking the initiative to create an environment for mentoring activities to occur and to negotiate for themselves when it came to research, publication, and teaching responsibilities.

One common struggle that women doctoral students faced was the feeling of being ignored by their advisors, which contributed to a lack of guidance and direction during graduate school. Not everyone found the perfect advisor to work with in graduate school, and when the relationship did not work, the women were less likely to be in a position to negotiate and more likely to switch advisors. They were more likely to suffer from a dysfunctional advising relationship and had trouble communicating their intention to change advisors to another's whose research interests and personality might be a better match.

Discrimination and bias take more implicit forms that are embedded in everyday practices, conferences, informal social events, and career prospects. Women students shared their strategies of uniting as a community of women to help each other survive and thrive in a

multi-faceted and complex graduate school environment. Some women student participants shared their dilemmas that occurred when collaborating scholars, who in some cases may be prospective employers of the students, asked them out. Both women faculty and students in this study pointed out biases and harassment initiated by male colleagues in their fields. These barriers were reported to take implicit forms, which posed challenges for women students to seek the appropriate help to overcome such difficulties.

RQ2: How do faculty working with women doctoral students in the physical sciences and engineering define and participate in protégé-mentor relationships?

RQ3: To what degree and in what ways does the gender of the faculty mentor influence the protégé-mentor relationships in the specific case of women doctoral students (protégé) in physical sciences and engineering?

Male faculty participants did not spend much time discussing the particular concept of "protégé-mentor relationships." One male physical sciences professor publicly mocked this concept and expressed his indifference to such activities in his teaching of doctoral students. His view was fairly representative among male faculty interviewees. They considered the visible quantity of publications, research progress, and the ability to secure research funding to be the primary factor in their fields and affecting the training of doctoral students. However, women doctoral students participating in this research reported they have many concerns about balancing an academic career and domestic life, yet they chose not to discuss these concerns with their male advisors, turning instead to women faculty in their departments or outside of their institution. Male faculty members interviewed did not speak of work-life balance at all, while women faculty spent a good deal of time discussing multiple cases in which they were approached regarding concerns related to work-life balance by doctoral women students with

whom they had infrequent previous interaction. In fact, male professors interviewed expressed negative feelings towards women's decisions to leave academia. Many of them regarded a woman's decision to start a family or have children as "distractions" and "setbacks" to women's careers. Some also indicated that entering industry was a subordinate option to becoming an academic. Their comments reflecting this train of thought were observed and discussed by women doctoral students in this study and negatively affected these students' communications and interactions with their male advisors when they sought to discuss career issues.

The data from this study unveiled major mentoring gaps between women doctoral protégés and the more senior and renowned professors. Based on women students' perceptions, more senior professors, both female and male, are less likely to spend a significant amount of time on mentoring and discussing academic and career related concerns. Junior women faculty members in this study reported that they are more likely to be approached by women doctoral students in their departments and consult students on work-life balance and stress related concerns. Among the women protégés who had strong academic career aspirations, the gender of their doctoral advisor did not influence their academic career decision-making process to a large degree. However, all women students who decided to pursue an academic career had women mentors in various capacities to provide necessary academic and psychological support. In the studied physical sciences and engineering departments, some common approaches for male professors to encourage their students in pursuing academic careers are related to the training of writing grant proposals, publishing journal articles, and involving them in collaborative research projects with other major institutions. While senior women faculty members are less likely to consider women protégés' concerns of work-life balance and stress to be a major focus of their protégé-mentor relationships, women assistant professors are more

likely to place more significance on coaching their women protégés in these areas. Women students also discussed that they are more likely to be included in collaborative research projects by faculty mentors who are an assistant to early associate academic ranks. Many of them pointed out the contrast between their assumptions that working with senior faculty would provide them with more research and networking opportunities, and the reality that they receive less interactions and mentoring from more well-known faculty advisors.

RQ4: How do the protégé-mentor relationships influence deliberations, considerations, and aspirations related to the pursuit of academic careers?

RQ5: Does the gender of the faculty member influence doctoral students' interest in pursuing academic careers?

The data from this research project revealed a strong nexus between women's graduate school support networks and the decision and desire to pursue an academic career. Some women who were fortunate to be part of a supportive academic community utilized the support and resources to survive and thrive in a male-dominated environment. The data collected from both women doctoral students and faculty of both genders illuminated five major areas that are closely related to women doctoral students' academic career aspirations under the influence of their protégé-mentor relationships: (1) interactions and communications with advisors, (2) observations and speculations, (3) postdoctoral positions, (4) academic, industry and national laboratory comparisons and rationales, and (5) finance and funding. Among these areas, women students' concerns over work-life balance and the funding side of academic professions seemed to prevail in the consideration of future career paths. However, faculty views on women students' decisions about whether or not to pursue an academic career differed drastically between female and male participants. All five male faculty members interviewed expressed regrets over their

women students who decided not to pursue an academic career and described "starting family and having children" as the primary "distraction."

Female professors interviewed discussed their approach to encourage women doctoral students to enter academia, a process that involves validating their concerns and letting them know that it is not easy to pursue an academic career as a woman. Yet, they all shared personal stories with the women students who approached them. Based on interviews with the students, they sometimes experienced some "biased comments" from faculty members at group research meetings. These "biased comments" focused on previous women doctoral students who had decided not to enter academia due to their concerns over work-life balance issues. Many interviewees reported that their male professors portrayed this kind of phenomenon as "disappointing" and "not scientist like." The women doctoral students acknowledged that this kind of experience made them even less willing to share their planned career trajectories or to communicate with their advisors.

Although all women doctoral students participating in this study had various degrees of interaction with their advisors, the communication of career trajectories between protégés and mentors was mostly ambiguous. A common pattern revealed that women doctoral students who had career aspirations to teach at a community college or a four-year college received limited feedback on such decisions from their male advisors. This phenomenon was due to their advisors' preference for them to become faculty at research universities.

All student participants had been in their doctoral programs for at least three years. However, only a small number of them discussed their career trajectories with their advisors. On the other side of the protégé-mentor relationship, faculty advisors reported struggling with the dilemma of "being blamed for pushing everyone into academia" versus catering their

mentoring strategies to students' career aspirations." Thus, they are less likely to initiate conversations regarding career planning unless students bring up the topic.

Many women doctoral students form their own career speculations based on observing other peers' career outcomes and their advisors' research, grant applications, and teaching activities. Many of the students interviewed expressed concerns pertaining to "long work hours," the "ability to secure external funding," "the pressure to support research labs and graduate students" and their degree of "passion and dedication about research." These aspects were identified by students participating in the interviews as the major reasons they changed their minds or chose not to consider pursuing an academic career.

Taking multiple postdoctoral positions in the fields of physical sciences is regarded as a common practice before a Ph.D. recipient obtains her/his first position. Almost all professors and doctoral students in the physical sciences discussed the necessity of having one or more postdoctoral positions. However, if a Ph.D. recipient takes too many postdoctoral positions, potential employers may become skeptical about the delay in assuming a more permanent position and possibly value them less; several of the women in my study hold such a perception. The requirements for postdoctoral positions in engineering did not appear to be the same based on data collected. Many women student interviewees revealed the fact that it was common for someone to enter industry or academia directly after their doctoral programs. It is more likely to be the case for someone who ends up going into the private sector as discussed by both faculty and student participants.

Many women participating in the interviews offered insights regarding the comparisons between career in academia, industry, and government research laboratories. Some of the most compelling reasons for women students to choose academic careers were related to the high level

of autonomy, academic freedom, and the stability associated with a university salary and benefits. For women who decided to work towards an academic career upon graduation, they were more likely to be attracted by the interaction and mentoring experiences with undergraduate students. Almost all women interviewed fulfilled teaching duties for one year or more during their graduate studies and acknowledged that this teaching experience provided them with a clearer perspective regarding whether or not they would pursue a career in academia. Data demonstrated that women students who did not choose academia as their first career choice reported more interest in entering industry. Women physical sciences students in this study were more likely to join the workforce by entering national laboratories upon graduation.

This study revealed that one of the major benefits that interactions with senior peers and the establishment of networks with junior woman professors bring to women doctoral students is effective advice on work-life balance in academic careers. This theme emerged again and again as these women discussed the evolution of their career aspirations. Work-life balance evolved from "an idea or assumption" in these women's minds to a "reality" that they needed to face as they accumulated more experiences in graduate school and were close to completing their doctoral programs.

Data from this study revealed that women are more likely to question their own ability to secure external funding; this seems especially true for those who consider becoming faculty members one day. Many participants' views on research funding reinforced the long-standing emphasis of research universities to place great stress on the ability of faculty to secure funding from the government and private sector. However, many women in my study felt that the skills and knowledge to be successful in such areas were not well developed during their doctoral training. While the lack of training in grant application activities might affect both women and

men, this study focused on the unique strategies women employ to cope with this kind of situation. For example, many women students discussed their informal collaboration with women postdoctoral researchers and research associates in their departments. In most cases, these researchers provided constant feedback on these women's research funding proposals for their postdoctoral positions.

Many women student interviewees had already decided to not pursue an academic career, prior to even having a career related discussion with their advisors. Some faculty members do not seem interested in allocating significant amounts of their time to holding such discussions. They normally avoid bringing up the topic of career unless students initiate such conversations. Women faculty interviewed pointed out that they were more likely to be pursued by women doctoral students in their departments and asked work-life balance related questions. Male professors, on the other hand, were least likely to speak to their students about the various facets of academic careers. They were perceived by their women students as "working machines" who resided in the office all the time. Several women doctoral students even speculated that some male professors must have a stay-at-home wife who can take care of the house and children.

The data unveiled a communication gap between faculty and women doctoral students. Over half of the women interviewed had never held a career related conversation with their advisors. The ones who had such conversations only reported having had it during their last year of doctoral studies. Almost all students interviewed agreed that they wished they could have had such conversations earlier with their advisors to be better prepared for the competitive job market. Yet, the practice was extremely rare in the physical sciences and engineering doctoral programs under study.

Disciplinary differences were revealed when it came to common career moves upon completion of doctoral programs for students in the physical sciences and engineering. Women physical sciences students discussed the necessity of obtaining postdoctoral positions before graduation. They reported that it was fairly common for physical scientist doctoral graduates to take two or even three postdoctoral appointments before landing permanent jobs as a scientific researcher or an assistant professor. The quality and reputation of the research team with which they did postdoctoral work was extremely crucial. The ones who failed to work with renowned research groups in their fields ended up in a "limbo" stage, where they kept pursuing more and more postdoctoral positions, but could not find a permanent appointment. In contrast, women doctoral students in engineering departments hardly discussed the practice of being a postdoctoral researcher. Many women in engineering discussed their options to secure an industry career, which did not require them to have any postdoctoral working experience. Some women shared their observations about how some of their previous peers who graduated earlier were able to obtain an assistant professor position right after graduate school.

Compared to women doctoral students in engineering, the women in the physical sciences were less likely to have industry options. For the ones who decided not to pursue academic careers, the majority were planning to pursue work at various governmental laboratories. Some hope to become scientific researchers at a laboratory, potentially relying on NASA funding or other short-term revenue sources.

Not surprisingly, one of the main reasons women doctoral students avoid the academic career path was attributed to their concerns about work-life balance. All women except one discussed their desire to start a family, have a stable income, and raise children. Yet, they all

perceived academic careers to be the least friendly towards this kind of practice. They compared the options of going into industry, governmental research laboratories, and academia and concluded that governmental labs and industry were more likely to provide them with greater security and plenty of free time to spend with their significant others and children. Importantly, female and male faculty in the study held completely different views on this issue. Women professors shared their strategies to mentor women doctoral students who approached them regarding conflicts between work and family. These women faculty were more likely to validate these concerns and acknowledge the necessity to worry about such issues. But they would also use their own anecdotes and experiences to explain to these students how they could still achieve as much as male faculty members and potentially have a successful and enjoyable life in academe.

The validation process was well accepted by the students interviewed and they admitted that the approach of women professors provided them with more confidence in pursuing academic careers. Several women faculty described the problem of "implicit bias" in their departments, which was created by male faculty member when women faced childcare responsibilities. Women faculty in this study acknowledged that the climate for women in the physical sciences and engineering has been improving for the past two decades and they expect more positive changes in the fields towards women. On the opposite side, male professors interviewed did not discuss their strategies to mentor women doctoral students to prepare them for academic careers. Several male professors regarded "having a family and children" to be a "100% distraction" for women doctoral students and stated women could not achieve as much as they should once starting a family.

Another significant reason for women to withdraw from the option of an academic career was the pressure to secure external funding. Over 80% of the women in this study discussed their concerns regarding one prevalent aspect of an academic career: the necessity to secure external funding to support doctoral students, maintain their laboratories, and buy research equipment or other resources. Closely associated to the ability to secure funding, many students also discussed concerns that their limited knowledge in the field might hinder them from coming up with original ideas, which was perceived to be extremely crucial in the process of funding applications.

As indicated in the discussions on career observations and speculations in Chapter 6, gender and power dynamics seemed to become apparent during my interviews with all five male physical sciences and engineering professors. The consistent pattern was that I spent about the first twenty minutes answering their questions about the methodology and validity of my dissertation research. In many cases, I perceived the situation as them questioning my study and my ability to conduct a research project like this dissertation. Some of the recurring questions fall in the areas of (1) Was your undergraduate degree in engineering/physical sciences? (2) How could you consider "interviews" to be valid data? (3) How old are you? (4) What do you want to do with a Ph.D. in higher education? I felt rather uncomfortable being questioned in such a way as if I was not a hard scientist and thus had no authority to conduct research in the areas of physical sciences and engineering. These kinds of subtle interactions that occurred during my interactions with male faculty in physical sciences and engineering were obvious forms of power and gender dynamics and were also reported by some student interviewees.

7.2 Implications

The practice of forming communities was reported to be an effective strategy for women doctoral students to cope with the initial socialization process of their doctoral programs. The initial reason for the establishment of these communities was due to the lack of explicit guidance for women students at the beginning of their graduate programs and insufficient resources to support the continuous development of these women on both professional and personal levels. Various physical sciences and engineering department student services offices should work closely with faculty advisors to compile particular information about program norms and expectations, career possibilities and trajectories, and even conference and research opportunities for the doctoral students. The findings also suggested that alumni offices at various physical sciences and engineering departments should strengthen their alumni networks and establish career related workshops and events to provide an opportunity for current women doctoral students to connect with alumni and build stronger social and professional networks. Particularly, panels should be held regarding work-life balance in academic careers and the pros and cons of careers at the private sector and governmental laboratories. Particularly, as private sector opportunities continue to attract doctoral women, engineering departments need to be more intentional about helping women doctoral students to build stronger ties to companies; one obvious way is to involve alumni who are working in the private sector. Academic career panels should also be formed with women alumni to provide women doctoral students efficient resources to overcome the fear of entering academia and better prepare themselves for these academic positions upon graduation.

Various physical sciences and engineering departments should also be actively involved in organizing and hosting professional conferences and symposiums to provide more opportunities for women doctoral students to consider and discuss the challenges and opportunities associated with academic careers. More formalized mentoring strategies can also be utilized. For example, postdoctoral scholars and more advanced women doctoral students could exert a strong influence on women doctoral students with workshops and formal mentoring programs established to pair up women doctoral students with postdoctoral mentors in their departments.

Additionally, more formalized programs should be established to bring faculty advisors and doctoral students together for discussions related to careers. Student affairs offices and graduate divisions can be key in organizing such activities, but of course, gaining faculty support through departmental liaisons is critical. Such programs might adopt a dialogical style to encourage open communication among doctoral students and faculty. Topics should focus directly on possible career trajectories and the need for close and ongoing contact between doctoral students and faculty mentors. Physical sciences and engineering departments should also work closely with the sexual harassment prevention office to disseminate relevant information to women doctoral students and provide them with abundant resources regarding reporting sexual harassment related matters. These departments should strengthen collaboration with the counseling offices to offer stress management workshops for women who are intimidated by their academic and work-related environments.

Explicit policies regarding the procedures and practice of changing advisors should be fully established and be formally conveyed to doctoral students so they can be aware of how things work. More information is always better than issues remaining in the dark and student

services offices in physical sciences and engineering departments can go a long way toward removing some of the mystery of advisor-advisee relations. But departmental leaders also have the potential to impact such dynamics, given their closer relationships with the faculty, and can take initiatives to assist and guide faculty in their mentoring roles. Perhaps department chairs can stress annually the need for faculty to hold one-on-one meetings with doctoral protégées to discuss career plans and address the kinds of concerns unique to the experiences of women in academe. Department leaders can even host speakers who might raise the kinds of issues that women doctoral students often must confront through the more informal mechanisms of the doctoral socialization experience. Making important issues, such as finding work-life balance, is always better than leaving them in a shroud of mystery.

Doctoral programs in the physical sciences and engineering, if in fact they are to be geared toward the preparation of future faculty (as opposed to preparing graduates for private sector positions), should make this aim explicit during the student recruitment process. My study indicates that doctoral women are sometimes confused about the ultimate purpose of their socialization and programs need to take steps to assist them in better understanding their options, including during the recruitment phase. For instance, a doctoral program that is designated to train future faculty in engineering would focus more on the theoretical side of engineering knowledge, socializing students more toward pedagogy and research funding applications as opposed to commercial mercerization and the application of their research results, which would be the focus for careers in industry.

The implications suggested by the findings of this study are significant. Yet, it is important to note potential barriers in implementing these suggested changes. I will start this discussion by quoting a male physical scientist who attended my presentation at the annual

conference for American Society for the Advancement of Science. This renowned geologist claimed that there are no economic incentives to encourage changes regarding improving women's experiences in physical sciences and engineering. Certain organizational infrastructure, with connections at both the departmental and institutional levels, could also pose barriers that prevent policies and practical changes in physical sciences and engineering departments. For example, how much authority and power does a Student Service Office have over faculty members who bring in millions of research dollars every year? Can faculty be held accountable to work collaboratively with student affairs' offices to establish written rules on something that they weren't accustomed to? Another clear example would be the idea of organizing professional conferences in the fields of physical sciences and engineering with the focus of assisting women doctoral students with the career decision-making process. Given the large number of conferences in these fields, a conference such as the proposed one needs to find its unique niche in order to attract enough talent and provide effective mentoring for doctoral women. Many physical sciences and engineering departments do not have their own alumni office that keeps track of its recent graduates or keep records of demographic and career data of their recent graduates. This could pose more difficulties when it comes to organizing career workshops that bring in female alumni to mentor current women doctoral students.

The aforementioned potential barriers that may hinder the implementation of the suggested improvements by this dissertation could provide Science and Technology Studies scholars with new directions for future research inquiries. One future research project could examine these potential barriers that hinder various departments from establishing special mentoring programs that encourage women doctoral students to pursue careers in academia.

7.3 Limitations and Future Research

This study was based on research conducted at one research university in the United States. Although the ethnographic facets of the methodology captured important aspects of the culture and daily interactions within the women doctoral student community at WRU, the findings nonetheless reflect one particular university located in the western region. Additionally, the sample size of 25 students and 10 faculty members is somewhat small given the total number of women doctoral students in physical sciences and engineering programs throughout the United States.

Among the student participants, the sample was limited to women participants. There were no male participants among the students interviewed and adding them would have provided a better opportunity for comparing gender-based challenges faced by doctoral students in these fields. Future studies could potentially adopt a larger sample size in terms of both student and faculty interviewees and hence strengthen the ability to draw more definitive conclusions. Students and faculty from both genders should be interviewed and studied for the next step of this study. Such a practice could provide contrast by which to compare the experiences, challenges, and protégé-mentor relationships in doctoral programs in physical sciences and engineering.

At the beginning stage of this study, I planned to incorporate an "advisory panel" formed by a subsample of my interviewees to share some of my findings with and use their feedback as a form of triangulation tool or member check. However, as data collection moved forward, I gradually realized that women doctoral students at one institution form a very tightly knit community. If I were to share any information related to my findings with an advisory panel, I

would likely place my study in violation of the human subject rights promised as part of the IRB requirements; specifically, I might have compromised their confidentiality and anonymity. Thus, the advisory panel, which had the potential to strengthen the authenticity of my findings, was not implemented. However, future multi-site studies could be conducted in a manner in which advisory panels or possibly focus groups involving research subjects could be formed as a potential source for data checking and playing a confirmatory role in the data analysis. If additional research is conducted at multiple institutions, the formation of student and faculty advisory boards is suggested to serve as a data triangulation tool in the data collection and analysis process.

Tierney and Rhoads (1994) suggested the importance of national and institutional culture in the study of academic profession socialization processes. Thus, future research is suggested to expand the sample to institutions of all types and at different geographic locations in the United States and abroad. A multi-site comparative study is recommended to further explore the nexus between women doctoral students' graduate socialization experiences and relationships with their academic career aspirations on a broader scheme. In an age of globalization, in which academic disciplines are increasingly transnational in nature, we need to better understand how doctoral students across national contexts are socialized as the next generation of academics and scholarly leaders.

Future ethnographic and longitudinal quantitative studies could also explore the culture at various physical sciences and engineering doctoral programs and institutions. Longitudinal quantitative studies could further our understanding of the career outcomes of women who have received effective feedback in graduate school and its correlation between their networking ability, publication success, and funding application activities during graduate school and career

outcomes over a more extended period of time.

7.4 Concluding Comments

Although previous research consistently emphasizes the significance of the role that mentoring relationships play in graduate school and their strong influence on doctoral students' academic career trajectories, little was known about the essence of women doctoral students' protégé-mentor relationships in physical sciences and engineering programs and how these relationships affect their academic career aspirations. The major findings of this dissertation study relate to women's experiences, challenges, and coping strategies and sheds light on the current state of protégé-mentoring relationships in physical sciences and engineering departments at one research university in the western United States. The findings highlight the nature of the protégé-mentor interactions and the influence such relationships have on women's decisions concerning the pursuit of academic careers.

Further, though unexpected at the design stage of this study, the importance of community emerged as one of the major findings. The formation of communities of support seems a rather important strategy for women doctoral students in the process of graduate school socialization; this source of support appears critical to further developing protégé-mentor relationships, increasing one's ability to publish, engage in research collaborations, and advance one's career interests. It appeared to be the most important strategy that women doctoral students utilize when they experience dysfunctional advising relationships. Many women's career related concerns and their pursuit of helpful advice were provided by a meshwork of women scientists and engineers whom they met at conferences, cross-institutional research collaborations, and through a range of diverse channels and networks, including, in many cases, those developed during their undergraduate studies.

Informal socialization was very impactful when it came to women's career decision-making processes. Yet, this is the aspect of protégé-mentor relationships that has been mostly overlooked by faculty in physical sciences and engineering departments at WRU. Women faculty interviewed for my study were more likely to be involved in the informal socialization process to mentor women doctoral students and address work-life balance concerns. Some male faculty expressed negative attitudes towards women doctoral students' non-academic career trajectories and tended to ignore work-life balance concerns. They demonstrated their attitudes in daily interactions and research meetings with their students. This created an environment in which it was difficult for women to discuss their doubts about pursing academic careers with their faculty advisors.

This study revealed some hidden barriers that many women doctoral students face in the process of pursuing a doctorate and an academic career. These barriers took the form of implicit gender bias, complex and confusing environments for negotiating unequal treatment, dysfunctional advising particularly in the areas of career development and work-life concerns, and subtle and covert forms of sexual harassment. Acknowledging these unique challenges that women doctoral students in physical sciences and engineering programs face is the first step to assist them, but more direct efforts most also be employed to create an environment more conducive to the success of women in science. Department faculty and academic leaders have a unique and important role to play in addressing such matters.

APPENDIX A: INTERVEW PROTOCOL (FOR STUDENTS)

Demographic Information

1. What do you study? What are your research interests?
2. Which year are you in the program?
3. What is the gender of your advisor?
4. What is your race/ethnicity?

Protégé-Mentor Relationships

4. What do you think makes a good mentor for you personally?
6. Who do you identify as your mentor/mentors (can include or not include your advisor) in graduate school? Why?
7. Please describe your mentoring relationships in your program.
8. In which ways does(do) this(these) mentor(s) interact with you? Please describe in as much detail as possible any related interactions.
9. Please describe the ways your professor(s) guide you through academic progresses, such as research papers, classes, conferences and collaborative research projects etc.
10. In what ways do you think this mentoring relationship is important to you? Why?
11. Are there other women doctoral students in your research team/laboratory? Could you describe what their relationships with their mentors? How do you perceive the differences between theirs and your mentoring relationships? Could you give an example or a story?
12. Could you please describe what your male colleagues' mentoring relationships are like? How are their mentoring relationships different from yours? Could you give an example or a story?
13. How do you perceive your mentoring relationship as a woman? Does being a woman give you advantage/disadvantage when it comes to mentoring relationships?

Career Aspirations

14. What kinds of career trajectories do you have currently and did you have when you entered the program? What are the differences?
15. Have you ever or are you considering choosing an academic career? Can you describe the reasons why you have chosen or not chosen to pursue becoming a professor?
16. How does your graduate school experience shape your academic career plans?
17. What are your primary concerns in your future career decision-making process? Who are the people involved?
18. What kind of role does mentoring play in encouraging/discouraging you in terms of academic career decisions?
19. Please describe mentoring activities that affect your career aspirations?
21. Do you think mentoring activities are important to you when it comes to deciding on a career? Why or why not?
22. Does your program have any specific effort in mentoring women students, specifically, and encouraging them to pursue academic careers? What are they like? How do you evaluate these programs?
23. Do you think the gender of your mentor(s) plays a significant role in your career decision making process? Why or why not?

APPENDIX B: INTERVEW PROTOCOL (FOR FACULTY)

Demographic Information (This information will be obtained by reviewing documents)

1. Department, program
2. Gender/Race/Ethnicity
3. Faculty Rank
4. Research Interests
5. Previous mentoring activity (provided by some professors' CVs)

Mentoring Relationships

6. Please describe major mentoring activities with doctoral students.
7. In what ways do you see mentoring female and male students differently?
8. What is the role of mentoring in your field?
9. Do you think it is important to advise female and male doctoral students differently? Why or why not?
10. Is there any different ways in which you work with male/female doctoral students in your field?
11. What are typical ways in which you interact with doctoral students?
12. How do you normally guide doctoral students through their academic processes, such as research papers, qualifying exams, classes, conferences and collaborative research projects? Do you normally take different approaches when it comes to guiding female/male doctoral students in this process?
13. In what ways are mentoring relationships important to your doctoral students? Are there any gender differences?
14. In what ways do you think mentoring relationships are crucial to you?
15. What are some of the major challenges when it comes to mentoring doctoral students? Do you face different challenges when it comes to mentoring female/male students?
16. In what ways do female/male doctoral students require different mentoring approaches? Could you provide some examples?

Career Aspirations

17. In which ways do your doctoral students express their career aspirations or future career plans to you? Are there any differences among female/male students?
18. What are some of your expectations for female/male doctoral students when it comes to their career paths upon graduation?
19. What if a particular student's career aspirations are different from what you expect him/her to do? In what ways do you cope with this kind of situation? Are there any gender differences? Please give some examples.
20. Why do you think the mentoring relationship is important to students' career aspirations?
21. In what ways do your female/male doctoral students' express their career aspirations? What do you perceive to be the deciding factors that shape their career decisions?
22. How do you mold your mentoring strategies to female/male doctoral students' career aspirations? Could you please give some examples?
23. What happens when a female/male doctoral student decides to change her career paths half way through the program? In what ways do you change mentoring strategies to cater to their needs?

APPENDIX C: JOURNAL ENTRY FORM

DATE:

TIME:

LOCATION:

DATA COLLECTION METHOD: a. Interview b. Site observation c. Other _____

PEOPLE INVOLVED:

BRIEF DESCRIPTION OF THE INTERVIEW/EVENT:

EMERGENT THEMES BASED ON THE CONTENT:

PRELIMINARY COMMENTS AND FINDINGS:

REFERENCES

Anderson, Melissa, and Judith Swazey. 1998. "Reflections on the Graduate Student Experience: An Overview". *New Directions for Higher Education.* 101: 3-14.

Antony, James Soto. 2002. "Reexamining doctoral student socialization and professional development: Moving beyond the congruence and assimilation orientation." In *Higher Education: Handbook of Theory and Research,* edited by John C. Smart. 349-380. New York: Agathon Press.

Allen, Tammy D., and Lillian T. Eby. 2010. *The Blackwell Handbook of Mentoring: A Multiple Perspectives Approach.* Malden: Blackwell Publication.

Altbach, Philip G. 1995. "Problems and Possibilities: The US Academic Profession." *Studies in Higher Education* 20:1-27.

Altbach, Philip G., Robert Oliver Berdahl, and Patricia J. Gumport. 2005. *American Higher Education in the Twenty-First Century: Social, Political, and Economic Challenges.* Baltimore: The Johns Hopkins University Press.

Astin, Alexandra A., and Astin, Helen. S. 1993. *Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences.* Los Angeles: Higher Education Research Institute, UCLA.

Austin, Ann E. 2002. "Preparing the Next Generation of Faculty." *Journal Of Higher Education* 73: 94-122.

Austin, Ann, and Donald Wulff. 2004. *Paths to the Professoriate: Strategies for Enriching the Preparation of Future Faculty* (1st ed.) San Francisco: Jossey-Bass.

Austin, Ann E., Campa III, Henry, Pfund, Christine, Gillian-Daniel, Donald L., Mathieu, Robert, and Stoddart, Judith. 2009. "Preparing STEM doctoral students for future faculty careers." *New Directions for Teaching & Learning* 117: 83-95

Babco, Eleanor L., Betty M. Vetter, Commission on Professionals in Science and Technology, and Scientific Manpower Commission. 2002. *Professional women & minorities: a total human resources data compendium.* Commission on Professionals in Science and Technology.

Barber, Leslie A. 1995. "U.S. Women in Science and Engineering, 1960-1990: Progress Toward Equity*?" The Journal of Higher Education* 66: 213-34.

Biernacki, Patrick, and Dan Waldorf. 1981. "Snowball Sampling: Problems and Techniques of Chain Referral Sampling." *Sociological Methods & Research* 10: 141 -163.

Block, Jeanne H. 1973. "Conceptions of Sex Role: Some Cross-cultural and Longitudinal Perspectives," *American Psychologist* 28: 512-26

Bogat, Anne G., and Robin L. Redner 1985. "How Mentoring Affects the Professional Development of Women in Psychology." *Professional Psychology: Research and Practice* 19: 851-59.

Bogdan, Robert C., and Sari Knopp Biklen. 2003. *Qualitative Research in Education: An Introduction to Theory and Methods.* New York: Pearson Education.

Brush, Stephen G. 1991. "Women in Science and Engineering." *American Scientist* 79: 404-419.

Burg, Carol. 2010. "Faculty Perspectives on Doctoral Student Mentoring: The Mentor's Odyssey". Ph.D diss. University of South Florida.

Burke, Ronald J. 1984. "Mentors in Organizations." *Group & Organization Management* 9: 353 -72.

Clark, Burton R. 1980. *Academic Culture*. New Haven: Higher Education Research Group.

Clark, Burton. 1987. *The Academic Life. Small Worlds, Different Worlds.* New Jersey: Princeton University Press.

Clark, Burton. 1989. "The Academic Life: Small Worlds, Different Worlds." *Educational Researcher* 18: 4-8.

Clark, Burton. 1993. *The Research Foundations of Graduate Education: Germany, Britain, France, United States, Japan.* Berkeley: University of California Press.

Clark, Burton. 1997. "Small Worlds, Different Worlds: The Uniquenesses and Troubles of American Academic Professions." *Daedalus* 126: 21-42

Clark, Richard, Sherry Harden, and W. Brad Johnson. 2000. "Mentor Relationships in Clinical Psychology Doctoral Training: Results of a National Survey." *Teaching of Psychology* 27: 262-68.

Clawson, James G., and Kathy E. Kram. 1984. "Managing cross-gender mentoring." *Business Horizons* 27: 22-32.

COSEPUP (Committee on Science, Engineering, and Public Policy). 1995. *Reshaping the Graduate Education of Scientists and Engineers.* Washington, D.C.: National Academy Press.

COSEPUP (Committee on Science, Engineering, and Public Policy). 2007. *Beyond Bias and Barrriers: Fulfilling the Potential of Women in Academic Science and Engineering.* Washington, D.C.: National Academy Press.

CPST (Committee on Professionals in Science and Engineering). 2006. *Professional Women and Minorities: A Total Human Resources Data Compendium*. Washington, DC : Commission On Professionals in Science and Technology.

Creswell, John. 2009. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (3rd ed.). Thousand Oaks: Sage Publications.

Crosby, E. J. 1999. The Developing Literature on Developmental Relationships. In *Mentoring Dilemmas: Developmental Relationships within Multicultural Organizations,* edited by Audrey J. Murrell, Faye J. Crosby, & Robin J. Ely, 3-20. Hillsdale, HJ: Lawrence Erlbaum.

Denzin, Norman K., and Yvonna S. Lincoln. 2000. "Introduction: The Discipline and Practice of Qualitative Research." In *The SAGE Handbook of Qualitative Research*, edited by Norman Denzin and Lincoln Yvonna. 1-32. Thousand Oaks: Sage Publications.

Dreher, George F., and Ronald A. Ash. 1990. "A Comparative Study of Mentoring Among Men and Women in Managerial, Professional, and Technical Positions*." Journal of Applied* Psychology 75: 539-46.

Eby, Lillian T., Stacy E. McManus, Shana A. Simon, and Joyce E. A. Russell. 2000. "The Protege's Perspective Regarding Negative Mentoring Experiences: The Development of a Taxonomy." *Journal of Vocational Behavior* 57: 1-21.

Ehrich, Lisa, Brian Hansford, and Lee Tennent. 2004. "Formal Mentoring Programs in Education and Other Professions: A Review of the Literature." *Educational Administration Quarterly* 40: 518-40.

Etzkowitz, Henry, Carol Kemelgor, and Brian Uzzi. 2000. *Athena Unbound: the Advancement of Women in Science and Technology.* New York: Cambridge University Press.

Fairclough, Norman. 1989. *Language and Power.* New York: Longman.

Foucault, Michel. 1980. Power Knowledge: Selected Interviews and Other Writings, 1972-1977. New York: Pantheon Books.

Fox, Mary Frank. 1998. "Women in Science and Engineering: Theory, Practice, and Policy in Programs." *Signs* 24: 201-23.

Fox, Mary Frank. 2000. "Current Status of Women within the Professions— Organizational Environments and Doctoral Degrees Awarded to Women in Science and Engineering Departments." *Women's Studies Quarterly*. 28: 47-61.

Fox, Mary Frank. 2001. "Women, Science, and Academia: Graduate Education and Careers." *Gender and Society* 15: 654-66.

Fox, Mary Frank. 2010. "Women and Men Faculty in Academic Science and Engineering: Social-Organizational Indicators and Implications." *American Behavioral Scientist* 53: 997-1012.

Gardner, Susan K. 2007. "I Heard it through the Grapevine: Doctoral Student Socialization in Chemistry and History." *Higher Education* 54: 723-40.

Gardner, Susan K. 2008. ""What's Too Much and What's Too Little?: The Process of Becoming an Independent Researcher in Doctoral Education." *Journal Of Higher Education* 79: 326-50.

Gardner, Susan K. 2010. "Contrasting the Socialization Experiences of Doctoral Students in High- and Low-Completing Departments: A Qualitative Analysis of Disciplinary Contexts at One Institution." *The Journal of Higher Education* 81: 61-81.

Gardner, Susan K., and Mendoza, Pilar. 2010. *On Becoming a Scholar: Socialization and Development in Doctoral Education.* Sterling: Stylus Publishing.

Geertz, Clifford. 1973. *The Interpretation of Cultures: Selected Essays.* New York: Basic Books.

Geiger, Roger L. 1997. "Doctoral Education: The Short-Term Crisis Vs. Long-Term Challenge." *The Review of Higher Education* 20: 239-51.

Geiger, Roger L. 2004. *Research & Relevant Knowledge: American Research Universities since World War II.* New Jersey: Transaction Publishers.

Gersick, Connie J. G., Bartunek, Jean M., and Dutton, Jane E. 2000. "Learning from Academia: The Importance of Relationships in Professional Life." *The Academy of Management Journal* 43: 1026-44.

Glaser, Barney. Theoretical Sensitivity Advances in the Methodology of Grounded Theory. CA: Sociology Press, 1978.

Golde, Chris, and Timothy Dore. 2001. *At Cross Purposes: What the Experiences of Today's Doctoral Students Reveal about Doctoral Education.* Philadelphia: Pew Charitable Trusts.

Golde, Chris M. 2005. "The Role of the Department and Discipline in Doctoral Student Attrition: Lessons from Four Departments." *The Journal of Higher Education* 76: 669-700.

Grant, Linda, Kennelly, Ivy, and Ward, Kathryn B. 2000. "Revisiting the Gender, Marriage, and Parenthood Puzzle in Scientific Careers." *Women's Studies Quarterly* 28: 62-85.

Green, Stephen, and Talya Bauer. 1995. "Supervisory Mentoring by Advisers: Relationships with Doctoral Student Potential, Productivity, and Commitment." *Personnel Psychology*. 48: 537-62.

Gumport, Patricia. 1993. "The Contested Terrain of Academic Program Reduction." *Journal of Higher Education* 64: 283-311.

Gumport, Patricia. 2005. "Graduate Education and Research: Interdependence and Strain." In *American Higher Education in the Twenty-First Century: Social, Political, and economic Challenges*, edited by Philip G. Altbach, Robert O. Berdahl , and Patricia J. Gumport, 425-461. Baltimore: The Johns Hopkins University Press.

Haraway, Donna. 1988. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14: 575-99.

Harding, Sandra. 1991. *Whose Science? Whose Knowledge? : Thinking from Women's Lives.* New York: Cornell University Press.

Harding, Sandra. 2004. *The Feminist Standpoint Theory Reader: Intellectual and Political Controversies.* New York: Routledge.

Hartsock, Nancy. 1983. *Money, Sex, and Power: Toward a Feminist Historical Materialism*. New York: Longman.

Hartsock, Nancy. 1998. *The Feminist Standpoint Revisited and Other Essays.* Boulder: Westview Press.

Healy, Charles C., and Alice J. Welchert. 1990. "Mentoring Relations: A Definition to Advance Research and Practice." *Educational Researcher* 19: 17-21.

Herzig, Abbe. 2004. "Slaughtering this Beautiful Math': Graduate Women Choosing and Leaving Mathematics." *Gender and Education* 16: 379-95.

Hollenshead, Carol S., Stacy A. Wenzel, Barbara B. Lazarus, and Indira Nair. 1996. "The Graduate Experience in the Sciences and Engineering: Rethinking a Gendered Institution." In The Equity Equation: Fostering the Advancement of Women in the Sciences, Mathematics, and Engineering, edited by Cinda-Sue Davis et al., 122-62. San Francisco: Jossey-Bass.

Ibarra, Herminia. 1993. "Personal Networks of Women and Minorities in Management: A Conceptual Framework." *The Academy of Management Review* 18: 56-87.

Jaggar, Alison M. 1983. *Feminist Politics and Human Nature*. New Jersey: Rowman & Littlefield.

Johnson, W Brad, and Jennifer M Huwe. 2003. *Getting Mentored in Graduate School* (1st ed.) Washington DC: American Psychological Association.

Johnson, W. Brad, and Nancy Nelson. 1999. "Mentor-Protégé Relationships in Graduate Training: Some Ethical Concerns." *Ethics & Behavior* 9: 189-210.

Jones, Elka. 2003. "Beyond Supply and Demand: Assessing the Ph.D. Job Market." *Occupational Outlook Quarterly* 46: 22-33.

Jorgensen, Danny L. 1989. *Participant Observation: A Methodology for Human Studies.* Newbury Park: Sage Publications.

Kanter, Rosabeth Moss. 1987. *Men and Women of the Corporation.* New York: Basic Books.

Kram, Kathy. 1980. "Mentoring Processes at Work Developmental Relationships in Managerial Careers." Ph.D. Diss., Yale University.

Kram, Kathy. 1983. "Phases of the Mentor Relationship." *Academy of Management Journal* 26: 608-25.

Kram, Kathy. 1985. *Mentoring at Work: Developmental Relationships in Organizational Life.* Glenview: Scott Foresman.

Kim, Young K., and Sax, Linda J. 2009. "Student–Faculty Interaction in Research Universities: Differences by Student Gender, Race, Social Class, and First-Generation Status." *Research in Higher Education* 50 (5): 437–459.

Kuh, George D., and Elizabeth J. Whitt. 1988. *The Invisible Tapestry: Culture in American Colleges and Universities.* Washington D.C.: College Station.

Leslie, Larry L., Gregory T. McClure, and Ronald L. Oaxaca. 1998. "Women and Minorities in Science and Engineering: A Life Sequence Analysis." *The Journal of Higher Education* 69:239-76.

Levinson, Daniel, Charlotte N. Darrow, Edward B. Klein, Maria H. Levinson, and Braxton McKee. 1978. *The Seasons of a Man's Life*. (1st ed.) New York: Knopf.

Lincoln, Yvonna, and Egon Guba. 1985. *Naturalistic inquiry.* Beverly Hills: Sage Publications.

Long, Janette. 1997. "The Dark Side of Mentoring." Australian Educational Researcher 24:115-33.

Long, Scott J., and Mary Frank Fox. 1995. "Scientific Careers: Universalism and Particularism." *Annual Review of Sociology* 21: 45-71.

Lubinski, David, and Camilla P. Benbow. 1992. "Gender Differences in Abilities and Preferences Among the Gifted: Implications for the Math-Science Pipeline." *Current Directions in Psychological Science* 1: 61-6.

MacKinnon, Catherine. 1983. "Feminism, Marxism, Method, and the State: Toward Feminist Jurisprudence." *Signs* 8: 635-658.

Maher, Michelle A, Martin E. Ford, and Candace M. Thompson. 2004. "Degree Progress of Women Doctoral Students: Factors that Constrain, Facilitate, and Differentiate." *The Review of Higher Education* 27: 385-408.

Maxwell, Joseph A. 1996. *Qualitative Research Design: An Interview Approach*. Thousand Oaks: Sage.

McCrorie, Edward, trans. 2004. *The Odyssey.* Baltimore: The Johns Hopkins University Press.

Mendoza, Pilar. and Susan K. Gardner. 2010. "The Ph.D. in the United States." In *On Becoming a Scholar: Socialization and Development in Doctoral Education*, edited by Susan K. Gardner and Pilar Mendoza. Sterling: Stylus Publishing.

Menges, Robert. 1999. Faculty in New Jobs: *A Guide to Settling in, Becoming Established, and Building Institutional Support.* 1st ed. San Francisco: Jossey-Bass.

Merriam, Sharan. 1983. "Mentors and Protégés: A Critical Review of the Literature." *Adult Education Quarterly* 33: 161 -73.

Merton, Robert. 1968. *Social Theory and Social Structure.* New York: Free Press.

Mertz, Norma T. 2004. "What's a Mentor, Anyway?" *Educational Administration Quarterly* 40: 541 -60.

Mertz, Norma T. 2002. "Using Mentoring to Advance Females and Minorities in a Corporate Environment." In *The Organizational and Human Dimensions of Successful Mentoring Programs and Relationships*, edited by Frances K. Kochan. 221-242. Greenwich: Information Age.

Mertz, Norma T. and Shari L Plfeeger. 2002. "Using Mentoring to Advance Females and Minorities in a Corporate Environment." In *The Organizational and Human Dimensions of Successful Mentoring Programs and Relationships*, edited by Frances K. Kochan. 221-242. Greenwich: Information Age.

Money, John and Ehrhardt, Anke. 1972. *Man and Woman, Boy and Girl: The Differentiation and Dimorphism of Gender Identity from Conception to Maturity.* Baltimore: Johns Hopkins University Press.

Millett, John. 1962. *The Academic Community: An Essay on Organization.* New York: McGraw-Hill.

Laura Nader. 1980. *Energy Choices in a Democratic Society*. National Academy of Sciences.

Nader, Laura. 1996. *Naked Science: Anthropological Inquiry into Boundaries, Power, and Knowledge.* New York: Routledge.

Naples, Nancy A. 2007. "Strong Objectivity." In Blackwell Encyclopedia of Sociology, edited by George Ritzer. Oxford: Blackwell Publishing. DOI:10.1111/b.9781405124331.2007.x

Nauta, Margaret M., Douglas L. Epperson, and Jeffrey H. Kahn. 1998. "A Multiple-Groups Analysis of Predictors of Higher Level Career Aspirations among Women in Mathematics, Science, and Engineering Majors." *Journal of Counseling Psychology* 45: 483-96.

National Science Foundation. 2008. *Thirty-Three Years of Women in S&E Faculty Positions.* Accessed on July 25, 2011. URL: http://www.nsf.gov/statistics/infbrief/nsf08308/

Nelson, C. Treichler, P. A., & Grossberg, L. 1992. "Cultural Studies: An Introduction". In *Cultural Studies,* edited by L. Grossberg, C. Nelson, & P.A. Treichler. 1-16. New York: Routledge.

Nelson, Donna, and Diana Rogers. 2004. *A National Analysis of Diversity in Science and Engineering Faculties at Research Universities*. Washington, D.C.: National Organization for Women.

Nerad, Maresi. 1999. *The Academic Kitchen: a Social History of Gender Stratification at the University of California Berkeley.* New York: State University New York Press.

Nettles, Michael. 2006. *Three Magic Letters: Getting to Ph. D.* Baltimore: Johns Hopkins University Press.

Noe, Raymond A. 1998. "Women and Mentoring: A Review and Research Agenda." *The Academy of Management Review* 13: 65-78.

Paglis, Laura L., Stephen G. Green, and Talya N. Bauer. 2006. "Does Adviser Mentoring Add Value? A Longitudinal Study of Mentoring and Doctoral Student Outcomes." *Research in Higher Education* 47: 451-76.

Pickering, Andrew. 1992. *Science as Practice and Culture.* Illinois: University of Chicago Press.

Phillips, Estelle, and Derek Pugh. 1994. *How to Get a Ph. D.: A Handbook for Students and Their Supervisors* (2nd ed.). Philadelphia: Open University Press.

Philips-Jones, Linda. 1982. *Mentors and Protégés.* New York: Arbor House.

Preston, Anne E. 1994. "Why Have All the Women Gone? A Study of Exit of Women from the Science and Engineering Professions." *The American Economic Review* 84: 1446–1462.

Rhoads, Robert A., and Diane Yu Gu. 2011. "A Gendered Point of View on the Challenges of Women Academics in The People's Republic of China." *Higher Education* 63: 733-750.

Rice, Eugene, Sorcinelli, Mary Deane, and Austin, Ann E. 2000. *Heeding New Voices: Academic Careers for A New Generation*. Washington DC: American Association for Higher Education.

Rose, Gail. 2003. "Enhancement of Mentor Selection Using the Ideal Mentor Scale." *Research in Higher Education* 44: 473-94.

Rose, Gail. 2005. "Group Differences in Graduate Students' Concepts of the Ideal Mentor." *Research in Higher Education* 46: 53-80.

Rosser, Sue V., and Taylor, Mark Zachary. 2009. "Why Are We Still Worried About Women in Science." Academe Online (May-June). Accessed on February 12, 2012. URL: http://www.aaup.org/AAUP/pubsres/academe/2009/MJ/Feat/ross.htm.

Rossiter, Margaret W. 1984. *Women Scientists in America: Struggles and Strategies to 1940*. Baltimore: Johns Hopkins University Press.

Schmader, Toni, and Michael Johns. 2003. "Converging Evidence That Stereotype Threat Reduces Working Memory Capacity." *Journal of Personality and Social Psychology* 85: 440-52.

Seymour, Elaine. 1995. "The Loss of Women from Science, Mathematics, and Engineering Undergraduate Majors: An Explanatory Account." *Science Education* 79:437-73.

Smith, Dorothy E. 1974. "Women's Perspective as a Radical Critique of Sociology." *Sociological Inquiry* 44: 7-13.

Starr, Paul. 1982. *The Social Transformation of American Medicine.* New York: Basic Books.

Slaughter, Sheila, and Larry L. Leslie. 1999. *Academic Capitalism: Politics, Policies, and the Entrepreneurial University.* Baltimore: Johns Hopkins University Press.

Smith, Dorothy E. 1984. "Women's Perspective as a Radical Critique of Sociology." *Sociological Inquiry* 44: 7-13

Smith, Dorothy. 1987. *The Everyday World as Problematic a Feminist Sociology.* Boston: Northeastern University Press.

Sax, Linda J., Bryant, Alyssa N., and Harper, Casandra E., 2005. "The Differential Effects of Student-Faculty Interaction on College Outcomes for Women and Men." *Journal of College Student Development* 46 (6): 642–657.

Sax, Linda J. 2007. "College Women Still Face Many Obstacles in Reaching Their Full Potential." *Chronicle of Higher Education* 54 (5).

Spradley, James. 1979. *The Ethnographic Interview*. New York: Holt Rinehart and Winston.

Springer, Leonard, Mary Elizabeth Stanne, and Samuel S. Donovan. 1999. "Effects of Small-Group Learning on Undergraduates in Science, Mathematics, Engineering, and Technology: A Meta-Analysis." *Review of Educational Research* 69: 21 -51.

Stolzenberg, Helen. 2006. *The Dynamics of Doctoral Student-Faculty Advising Relationship: A Study Across Academic Fields.* Doctoral Dissertation. University of California, Los Angeles.

Szelényi, Katalin. 2007. *Doctoral Student Socialization in Science and Engineering: The Role of Commercialization, entrepreneurialism, and the Research Laboratory.* Doctoral Dissertation. University of California, Los Angeles.

Tenenbaum, Harriet, Faye Crosby, and Melissa Gliner. 2001. "Mentoring Relationships in Graduate School." *Journal of Vocational Behavior* 59: 326-41.

Thelin, John R. 2004. *A History of American Higher Education.* Baltimore: Johns Hopkins University Press.

Thomas, W. I. (1923). The unadjusted girl: With cases and standpoint for behavior analysis. Boston: Little, Brown, and Company.

Thomas, W. I. (2002). William I. Thomas on the definition of the situation. In N. Rousseau (Ed.), Self, symbols, and society: Classic readings in social psychology (pp. 103–115). Lanham, MD: Rowman & Littlefield.

Thomas, W. I., & Thomas, D. S. (1928). The child in America: Behavior problems and programs. New York: Knopf.

Tierney, William G., and Robert A. Rhoads. 1994. *Enhancing Promotion, Tenure and Beyond: Faculty Socialization as a Cultural Process.* Washington, DC: The George Washington University Press.

Tinto, Vincent. 1993. *Leaving College: Rethinking the Causes and Cures of Student Attrition (2nd ed.).* Chicago: The University of Chicago Press.

Toutkoushian, Robert K., and Valerie Martin Conley. 2005. "Progress for Women in Academe, Yet Inequities Persist: Evidence from NSOPF 99." *Research in Higher Education* 46: 1-28

Traweek, Sharon. 1988. *Beamtimes and Lifetimes: The World of High Energy Physicists.* Cambridge: Harvard University Press.

Traweek, Sharon. 1993. "An Introduction to Cultural, Gender, and Social Studies of Science and Technology." *Journal of Culture medicine and Psychiatry* 17: 3-25.

Traweek, Sharon. 2000. "Faultlines." In *Doing Science and Culture: How Cultural and Interdisciplinary Studies are Changing the Way We Look at Science and Medicine,* edited by Sharon Traweek and Roddey Reid. 21-48. New York: Routledge.

Turner, Caroline, and Judith Rann Thompson. 1993. "Socializing Women Doctoral Students: Minority and Majority Experiences." *Review of Higher Education* 16: 355-70.

U.S. Department of Education. 2004. *National Study of Postsecondary Faculty, Data Analysis System (DAS).* Washington D.C.: National Center for Education Statistics.

U.S. Equal Employment Opportunity Commission, 2000.

Van Maanen, John E., and Edgar H. Shein. 1977. *Toward a theory of organizational socialization.* Cambridge: M.I.T. Alfred P. Sloan School of Management.

Waldeck, Jennifer, Victoria Orrego, Timothy Plax, and Patricia Kearney. 1997. "Graduate Student Faculty Mentoring Relationships: Who Gets Mentored, How It Happens, and to What End." *Communication Quarterly* 45: 93-109.

Ward, Kelly, and Lisa Wolf-Wendel. 2003. "Academic Motherhood: Managing Complex Roles in Research Universities." *Review of Higher Education* 27: 233-57.

Weidman, John C., and Elizabeth L. Stein. 2003. "Socialization of Doctoral Students to Academic Norms." *Research in Higher Education* 44: 641-56.

Weidman, John C., Twale, Darla J., and Stein, Elizabeth L. 2001. *Socializaion of Graduate and Professional Students in higher education: A Perilous Passage?* San Francisco: Jossey-Bass.

Weil, Vivian. 2001. "Mentoring: Some Ethical Considerations." *Science and Engineering Ethics* 7: 471-82.

Wolcott, Harry. 1975. "Criteria for an Ethnographic Approach to Research in Schools." *Human Organization* 34: 111-27.

Xie, Yu, and Kimberlee A. Shauman. 2005. *Women in Science: Career Processes and Outcomes.* Cambridge: Harvard University Press.

Zuckerman, Harriet, Cole, Jonathan R., and Bruer, John T . 1991. *The Outer Circle: Women in the Scientific Community.* New York: Norton.