DEVELOPMENT OF AMERICAN AND FOREIGN-NATIONAL FEMALE GRADUATE
STUDENTS IN ENGINEERING AT RESEARCH UNIVERSITIES

By

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DEVELOPMENT OF AMERICAN AND FOREIGN-NATIONAL FEMALE GRADUATE STUDENTS IN ENGINEERING AT RESEARCH UNIVERSITIES

Abstract

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Women continue to be underrepresented among engineering faculty despite decades of reform and intervention. To understand why more graduate women do not pursue careers in academia, this mixed methods study focuses on the experiences of women currently in graduate engineering programs, and how the graduate culture shapes their development and decisions about future careers. The study includes data from 110 U.S. and international women enrolled in graduate engineering programs at research-intensive universities.

As women experience graduate engineering programs, their views of themselves and their relationships with others develop. Graduate women who experience engineering cultures that encourage collaboration, confront sexism of any form, value diversity, recognize everyone’s achievements, and assess on performance rather than gender tend to develop positively. Women who experience less supportive graduate cultures struggle to develop solid identities, comfort in partnerships, confidence needed to tackle challenges, and self-authoring capacity. Women enter graduate engineering programs from diverse cultural backgrounds, and their backgrounds shape their responses to the culture of their graduate program. International women face additional challenges in U.S. graduate engineering programs and struggle more in their development.
Overall, women who experience unsupportive graduate cultures are less likely to form positive views of faculty careers, less likely to identify with engineering, and less likely to have the developmental attributes needed to succeed as a faculty member in engineering. Graduate engineering culture influences women’s career decisions both indirectly, through development, and directly, by giving a picture of what an academic career may be like. The findings from the study suggest that practice and policy geared toward increasing the numbers of women among engineering faculty requires cultural transformation that considers the diversity of women who enter graduate engineering programs.
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CHAPTER I: INTRODUCTION TO THE STUDY

The underrepresentation of women in science and engineering is a well-documented and persistent issue (Burke, 2007). The issue is of concern in many sectors because of its implications for social justice and our ability to solve complex global issues (Brainard & Carlin, 1997). Overall, women tend to choose science and engineering careers less frequently, leave science and engineering academic programs more commonly, and progress in science and engineering careers more slowly than their male colleagues. The present discussion focuses on the underrepresentation of women at the graduate level, because it is at this level that there is an influx of foreign nationals, and the underrepresentation of women becomes increasingly apparent (Busch-Vishniac & Jarosz, 2007; National Science Foundation (NSF), 2011). As findings from the present study indicate, departure of women from science and engineering fields is a product of both cultural and individual factors.

The Issue of Underrepresentation in Science and Engineering

A common analogy used to describe the academic progression from grade school to full professorship is a linear pipeline with people “leaking” out all along the way (Mattis, 2007). The pipeline itself represents culture. In physical science and engineering disciplines, women seem to leak out at much higher rate than their male colleagues. The decrease in the percentage of women leads to a situation in which there are the fewest number of women at the upper ranks of academia (Wolfinger, Mason & Goulden, 2008). For instance in 2008, women received 22 percent of doctorates, held 12 percent of full time faculty positions at four year universities and colleges, and held only 5 percent of full professorships in engineering (NSF, 2011). However, the analogy of the pipeline is not wholly accurate in describing academic science and engineering in recent years due to the large influx of foreign nationals at the graduate student
level. Foreign nationals receive 57 percent of doctorates in engineering (NSF, 2011). Foreign-born graduate students tend to remain in the U.S. upon graduation, and in 2008, 74% of new international doctorate recipients indicated intention of remaining in the U.S. following graduation (NSF, 2009a).

Foreign-born female students comprise a significant and increasing proportion of these numbers. Between 1988 and 2008, female foreign national graduate students increased five-fold, while male foreign nationals doubled (NSF, 2009b). Women in engineering disciplines do not come from a homogenous background. Instead, women who hold doctorates in engineering come from multiple cultural pipelines prior to entry into the U.S. science and engineering pipeline at the graduate level. These other pipelines or cultures may vary in support of women pursuing careers in science fields (Sonnert, 1999). Additionally, foreign-born women tend to enter the engineering pipeline later than U.S. women. For instance, while the percentage of engineering degrees granted to U.S. women drops slightly from bachelor’s (17.3 percent) to doctorate (11.6 percent), the percentage granted to foreign national women increases slightly (8.3 percent of all bachelor’s to 10.2 percent of all doctorates in engineering) (NSF, 2011). However, regardless of these differences between foreign-born and U.S. women, all women continue to be greatly underrepresented in comparison to their male counterparts in engineering disciplines.

The underrepresentation of women in engineering disciplines is disconcerting because it decreases the diversity of perspectives and voices in engineering. Lack of diverse perspective and voice decreases society’s ability to tackle complex challenges related to engineering (National Academy of Sciences (NAS), 2006). Although scientists and funding agencies strive for objectivity, they still choose which research projects they believe to be worth pursuing or reporting. If a group does not have adequate representation in a particular field, then it is less
likely that innovation from that field targets the concerns of their community (McLaren, 1991). These social inequities have connections to financial inequities. Overall, engineering professions tend to pay higher salaries than most non-engineering professions (National Science Board, 2010). Financial or wealth imbalance translates to inequity of political power as those with higher incomes exert a stronger force on the global power structure (Brainard & Carlin, 1997).

The underrepresentation of women in engineering also affects ability to solve complex problems related to engineering. Research indicates that heterogeneous groups are better than homogenous groups at solving problems, because increasing the number of perspectives increases the number of potential solutions (Robinson & Dechant, 1997). By limiting diversity within science and engineering, the number of perspectives and potential solutions are also limited.

**Impact of Science and Engineering Culture**

Understanding today’s engineering culture begins with examining the origins of science and engineering fields. From the beginning of modern science, women were excluded from participation in many ways from segregation to discrediting of their ability to understand scientific thought (Lucas, 2006; Rosser, 2008). When the obvious physical barriers to the participation of women began to disintegrate in the latter half of the twentieth century, it became clear that more keeps women from scientific fields than mere legalities.

Science and engineering departments have been described as “chilly” for women (Blickenstaff, 2005). The culture of science is described as being competitive, fixated on objectivity, demanding singularity of focus, and inherently conservative in the acceptance of new ideas (Merton, 1973). Competitiveness and aggressiveness permeate science and engineering cultures, from undergraduate weed-out courses to scientists competing to be the first to discover
or write about some phenomena (Merton, 1973; Seymour & Hewitt, 1997). A fixation on the objective leads to the demeaning of anything viewed as subjective. The objective-subjective binary can be particularly troublesome for women because they are often associated with subjectivity, whereas men are associated with objectivity (Valian, 2000; Willower, 2001). Scientific professions tend to demand undivided devotion to research, in part because the assumption underlying the culture of science is that the male scientist had a female partner at home taking care of family and home concerns (Dean & Fleckenstein, 2007; Wolfinger, Mason & Goulden, 2008). In facing these challenges, women have the additional pressures of being a minority in their field without a role model or mentor to guide them through the experience (Bernstein, Jacobson & Russo, 2010). Each of these cultural aspects of science continues to discourage women from careers in scientific fields.

Indeed, the culture of science and engineering influences the experience of individual women in a multitude of ways. Women often report feelings of isolation (Seymour & Hewitt, 1997), and because of their sense of isolation, they are less likely to seek help (Seymour & Hewitt, 1997). How women explain failures and successes may be influenced by the societal stereotypes that men and particular ethnic-racial groups (e.g. Whites and Asians) are better at math and science. If women believe the stereotypes, they are likely to view minor setbacks as confirmation that they are unfit for a scientific profession (Dean & Fleckenstein, 2007; Schunk, 2008; Valian, 2000). Women’s lack of confidence and self-efficacy tends to compound, contributing to decisions to leave science and engineering disciplines (Brainard & Carlin, 1997).

**Perspectives on Solutions**

Although culture clearly influences the decisions of women, perspectives on how to increase the representation of women in science and engineering tend to target individual
characteristics or experiences. These models, referred to as deficit or difference models, often simplify or ignore cultural factors. Deficit models assume that the reason why women are lower in number is because they are missing something that would allow them to succeed. Difference models assume that characteristics of women make them inherently different than men in relation to performance and persistence in science and engineering. These perceived differences may be inherent biological differences or they may be inherent lack of interest in science and engineering (Sonnert, 1999).

An alternative to deficit and difference models are development models. Development models emphasize the changing nature of individuals’ characteristics and the influence of culture on these changes. Development models can provide insight into how women came to have certain characteristics and what environment or culture might cultivate those characteristics (Evans, Formeny, Guido & Renn, 2010). Since culture affects individuals and their development of characteristics that contribute to decisions to leave science and engineering, the developmental approach indicates that a cultural shift is needed before diversity is realized in these fields (Litzler, Lange & Brainard, 2005; Sonnert, 1999). The present study uses post-colonial theory to deconstruct power and knowledge structures of scientific fields, and psychosocial and self-authorship development theories to understand the impact of cultural structures on graduate women in engineering and their career-related decisions.

**Research Needs**

Women continue to be underrepresented in science and engineering despite years of concern and intervention following the lifting of overt legal barriers. Today’s perpetuation of the exclusion of women occurs through the guidance of a historical sociology of science. The sociology and culture of scientific fields exert considerable influence on individuals and may
lead to their decisions to leave academic science or engineering careers. Consequently, consideration of both the experiences of individuals and the cultural context of those experiences is crucial when designing initiatives aimed at increasing the number of women in science and engineering.

With regard to culture, the experiences and developmental pathways of women prior to graduate studies in engineering are diverse. In addition to the wide diversity of experiences within the population of U.S. graduate women, nearly half of PhD students in engineering are foreign-born (NSF, 2011). The experiences and socialization processes of these women have largely been unexplored (Gardner, 2010).

The ability to design initiatives that consider both individuals and their culture requires research to identify specific aspects of culture that affect individuals’ experiences and decisions. Rather than basing research in this study on a deficit or difference model, a focus on characteristics that develop over time is more appropriate. There is a need for a comprehensive model that includes the connections between culture, individual characteristics, and career decisions. Using a holistic model, this current study uncovers specific steps that could increase diversity and the representation of all underrepresented groups in science and engineering.

**Summary of Study**

The current study provides insight into how engineering culture shapes women’s development and career decisions. Additionally, the study compares the experiences and development of U.S. and foreign national women in the context of graduate engineering programs. The overall research question that guides the current study is “How do the cultural contexts of engineering departments influence the development and decisions of women in
engineering?” The following secondary questions address different aspects of the overall question:

1) What is the relationship between participation in academic engineering graduate programs and psychosocial and self-authorship development?
2) What is the relationship between graduate engineering student development and intention to pursue a career in academic engineering among female graduate students?
3) In what ways does the development of U.S. and foreign national women differ?
4) What cultural factors of engineering departments influence development and intention to continue in academic engineering among female graduate students?
5) Do U.S. and foreign national women experience the culture of engineering departments in different ways?

The two-phase mixed methods approach used in the current study (Creswell & Plano Clark, 2007) gives a comprehensive account of how the culture of engineering influences the development and career decisions of female graduate students. The quantitative phase establishes a foundation for understanding the development of a group of female graduate students in engineering, while the qualitative phase explains results from the quantitative phase. A total of 110 female graduate students from three research-intensive universities in the U.S. Northwest participated in the study. Participants came from 15 engineering disciplines and included both U.S. and international students. Overall, findings describe relationships between graduate engineering culture, development, and career decisions of participants.

More specifically, the quantitative portion of the study unravels connections between development and particular engineering cultures and between development and career intentions. A combination of three instruments assessed development and career intentions: 1) the Measure
of Psychosocial Development, 2) a modified Career Decision Making Survey, and 3) a measure of intentions of pursuing a faculty career. Results reveal cultural factors related to development and show differences in the development patterns of international and U.S. female graduate students.

The qualitative phase builds on quantitative data obtained in the first phase. It explores the stories behind the numbers specifically considering three interacting factors of 1) department culture, 2) development, and 3) career motivations. The interview protocol is semi-structured with open-ended questions (Creswell, 2008) and the 26 interview participants are a subset of participants from the quantitative phase chosen for their ability to represent particular demographic groups. Questions follow-up on participants’ responses to the development survey to explain significant or surprising results found during the quantitative phase (Creswell & Plano Clark, 2007). Questions also explore participants’ motivations for career decisions and the influence of engineering culture on these career decisions, paying particular attention to any differences between U.S. and international women. Analysis of interview responses explains participants’ survey responses, providing insight into which cultural attributes of graduate engineering program support their female students’ development and increase the likelihood that they choose a faculty career.

Overall analysis integrated quantitative and qualitative findings to answer research questions. Findings tie together to give an overall picture of the relationships between graduate engineering culture, development and career choices of female engineering graduate students. The present study shows a complex and interconnected relationship between culture, development and career choice.
Significance

Despite decades of intervention and funding, the representation of women in engineering remains low. Numerous studies provide a fragmentary explanation for the disparity, often focusing entirely on individual characteristics rather than broader cultural factors. Research inadequately addresses the issues faced by international female graduate students, which are a major and increasing percentage of engineering students. The study present delves beneath the surface and considers the root causes of the low numbers of women in engineering from multiple cultural backgrounds.

The intent of this study is to consider the underrepresentation of women in engineering holistically, including the nature of the engineering pipeline as well as the nature of those who flow through it. The study exposes systematic interventions that could transform the culture of the sciences and ultimately increase diversity within science and engineering as a whole. In the end, increasing the representation of women in the sciences is not just about increasing the numbers of women, but about developing a culture that encourages diversity and persistence of diverse people in the sciences. In other words, increasing the representation of women in engineering requires transforming the pipeline itself. This research gives great insight into how we understand and address the issue of underrepresentation in engineering as a whole.

The study also clarifies similarities and differences among different groups of women in engineering. Study participants came from diverse cultural backgrounds, including at least 10 different countries. The current study aims to understand differences in how cultural background impacts perceptions of culture, development, and career decisions of female engineering students. In particular, the study considers the differences in response to culture development,
motivations, and career decision-making between U.S. and foreign-born graduate students within the engineering culture. Chapter V includes in depth discussion of these findings.

The overall intent of the study is to more fully understand the culture of engineering and how that culture could be affecting development and ultimately be contributing to the underrepresentation of women. To address the issue of women’s underrepresentation in engineering, concurrent consideration of culture and the effect of culture on U.S. and foreign female engineers is necessary. The mixed methods research approach used in the current study allows for concurrent analysis, forming a deeper understanding of a crucial element of this issue: how culture specifically impacts the development of female engineering graduate students.

The remainder of the study consists of a review of the literature relevant to graduate women in engineering (Chapter II). Chapter III details the research context, theoretical framework, design and methodology. Chapter IV describes overall patterns of development and career decision-making among study participants, while Chapter V focuses on the experiences, development patterns, and career choices of international participants. Chapter VI specifically considers how culture influences graduate engineering women. The study concludes with Chapter VII, which discusses the overall implications of the study and gives recommendations for future research and practice.
CHAPTER II: LITERATURE REVIEW

The focus of the literature review is to more fully understand the underrepresentation of women in engineering. The literature review begins with an overview of the issue and impact of underrepresentation in science, technology, engineering, and mathematics (STEM)\(^1\) as a whole. The discussion then turns to the history of STEM and the role of colonialism in shaping the culture and sociology of science fields. The review of literature includes theories used in the present study to understand socialization within academic engineering and how the cultures of science and engineering fields may influence individuals. The literature reviewed in this chapter is divided into six main topics including (1) the impact of underrepresentation, (2) the history of science, (3) the sociology and culture of scientific fields, (4) post-colonialism and science, (5) socialization, and (6) development in the context of science and engineering fields. The review concludes with a discussion of the initiatives used to increase women in scientific fields and areas related to the underrepresentation of women in STEM in need of further research.

**Impact of Underrepresentation**

Despite numerous initiatives aimed at increasing the representation of women, underrepresentation of women continues in most STEM disciplines in the U.S., particularly at

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\(^1\) Although this study will focus on engineering disciplines, most literature related to culture and implications of culture refers to engineering within some aggregate of science, technology, engineering and mathematics or STEM. There is great variety within STEM fields; however, these fields have traditionally been grouped because of shared historical and theoretical roots. Additionally, since engineering is applied, engineering students are exposed to physical sciences, technology and mathematics. Examining the culture of STEM as a whole provides context for understanding the culture of academic engineering specifically.
the higher ranks of academia and in engineering. For instance in 2008, women earned 22 percent of doctorates in engineering, held 12 percent of full-time professorships at 4-year universities, but only 5 percent of full professorships, and other disciplines had similar patterns. A frequently used analogy to describe the educational progression from grade school through full professorship and beyond is the pipeline (Mattis, 2007). The pipeline analogy has two major components: the contents, which represent individuals progressing from primary education through academic leadership, and the pipeline itself, which represents culture of an academic program and the field as a whole. In considering why individuals leak from the pipeline, it is important to include individual (contents of the pipeline) and cultural (the pipeline) characteristics. Transition points between different levels of academia are areas of particular “leakage” (Alper, 1993; Grandy, 1998; Mason, Goulden, & Wolfinger, 2006). These points include entering a post-secondary institution, continuing through “weed out” science classes to graduation, entering graduate school, moving into a faculty position, and transitioning through steps in the promotion and tenure process.

The image of the pipeline is linear and unidirectional with people “leaking” out all along the academic progression, so that the number of individuals at the end of the pipeline is fewer than the number at the beginning of the pipeline (Mattis, 2007). However, this view of the pipeline is not entirely accurate for STEM fields, into which there is a large influx of foreign nationals, beginning at the graduate level. For instance, foreign nationals received 6 percent of bachelor’s degrees in engineering, but they received 57 percent of doctorates in engineering in 2008 (NSF, 2011). Most foreign nationals choose to stay in the U.S. after receiving their doctorate, so that nearly half of doctoral engineers employed in the U.S. are foreign-born (NSF, 2009a). The addition of international students complicates the image of the academic pipeline.
and indicates that women in engineering have multiple academic backgrounds prior to their entry into U.S. graduate engineering programs. That is, the “contents” of the pipeline are varied and more complicated than a homogenized notion of “women.”

The numbers of foreign-born women in STEM are increasing. Between 1988 and 2008, female foreign nationals increased five-fold, while male foreign nationals doubled (NSF, 2009b). Whereas the percentage of engineering degrees to U.S. women drops slightly from bachelor’s (17.3 percent) to master’s (13.5 percent) to doctorate (11.6 percent), the percentage increases slightly for foreign national women (8.3 percent of bachelor’s in engineering, 9.5 percent of master’s in engineering, 10.2 percent of doctorates in engineering (NSF, 2011)). Women in engineering disciplines come from many countries and backgrounds, and consequently multiple cultural pipelines prior to entry into the U.S. academic engineering pipeline at the graduate level. Since women’s access to science careers varies greatly in cultures and science systems of different countries, foreign women have experiences which differ from that of U.S. women prior to entry into the U.S. educational system (Sonnert, 1999). Although the patterns between U.S. and foreign-nationals differ, the number of women declines at each educational transition point, including from graduate education to employment as faculty.

I focus on graduate education for three reasons. First, graduate education represents a season of major academic socialization and preparing to shift from being a student to being faculty (Gardner, 2005), as discussed in greater detail later in this chapter. Second, it is at the pivotal transition point of graduate school that there is a large influx of foreign national women into the engineering pipeline (NSF, 2011). Figure 2.1 represents the addition of international students with a bifurcated pipeline, although the real situation is more complex as international students enter U.S. academia all along the pipeline. Third, the percentage of all women in
engineering drops by about 55 percent between receipt of the doctorate in engineering and employment as faculty at a 4-year university (NSF, 2011). Whereas the decrease of women in engineering has many likely explanations, some possible explanations lie in the experiences of women during their graduate education.

![Figure 2.1: Structure of the engineering academic pipeline with a large influx of foreign national students at the graduate level](image)

When considering the underrepresentation of all women in STEM, it is important to clear some commonly held false beliefs. One commonly held belief is that now that explicit discrimination and physical barriers to participation are unlawful, it is only a matter of time before the percentages of women and minorities in STEM reach levels of representation (National Academy of Sciences (NAS), 2007). Indeed, women and minorities enter higher education at a much higher rate than in previous generations, and increasingly they are choosing to pursue degrees in STEM fields. However, a closer look reveals that the situation is not so promising. First, it appears that the gains at the undergraduate level do not translate to substantial increases at the faculty level (NSF, 2009a). The numbers of women and minorities among STEM faculty remain woefully low and have seen minimal gains since the inaction of major anti-discrimination legislation (NAS, 2007). As Kulis, Sicotte and Collins (2002) discuss, a low supply of women with doctorates cannot fully account for the underrepresentation of women
among faculty in physical science and engineering, and increasing the number of women who receive doctorates in STEM disciplines will not necessarily translate to a greater faculty representation. Second, the gains are primarily in specific fields, such as social and biological sciences, and not as much in other fields, such as physical sciences and engineering (NAS, 2007; NSF, 2009b; Valian, 2000). Again, supply of doctorate-holding women cannot alone explain these disciplinary differences (Kulis, Sicotte & Collins, 2002).

Increasing diversity within STEM is more than increasing the numbers of the underrepresented as a whole. A great deal of diversity exists within the group labeled “underrepresented.” Frequently, including in the current discussion, the issue of underrepresentation of women and minorities are grouped together in regard to the issue of underrepresentation in STEM. Although women and minorities share a common history in regard to STEM in that they were both excluded, the causes of the current disparities and solutions for increasing their numbers in STEM are not necessarily the same. The possible misperception that women and minorities share the same concerns can lead to programs and initiatives targeting all underrepresented groups based on research that really only looked at one group. Instead of grouping them together in research, it is more appropriate to study them separately, looking for similarities and differences (Seymour & Hewitt, 1997). Similarly, women in STEM come from a diversity of backgrounds; yet, women’s experiences and perspectives are usually considered one in policies, research and conversations. The practice of labeling all women and all minorities as one group acts as an erasure of extensive diversity of backgrounds and concerns (Lewis, Menzies, Najera & Page, 2009; Mohanty, 1984), concerns which need to be addressed to increase diversity in STEM.
The continued use of the metaphor of the pipeline may itself contribute to problems associated with underrepresentation of particular groups in science. The reality of STEM careers is much less linear and much more flexible than the one-way-in, one-desired-outcome description of the pipeline analogy. Individuals may choose to enter STEM professions rather than continue in academia and they may choose to re-enter at a later date. These alternative pathways also increase the overall diversity in STEM (Dean & Fleckenstein, 2007; NAS, 2007). However, since the faculty of STEM departments will guide the tone and nature of the next generation of STEM professionals, they are a crucial element to understanding the current disparities in STEM (Bernstein, Jacobson, & Russo, 2010).

Another criticism of the pipeline analogy is that it tends to focus exclusively on individuals rather than including consideration of the culture influencing those individuals. These discussions may mistakenly assume the nature of the pipeline or culture is unchangeable or constant. Individually, women in academic STEM come from a variety of cultural backgrounds. Yet, despite their cultures of origin, they are all immersed into STEM culture. In getting to the root causes of the continued disparities in the sciences, it is important move beyond the supply aspects of the pipeline to consider STEM culture, as well as the experiences of women in STEM culture.

Broadly speaking, culture includes expected, learned, expressed, reproduced, and commonly held experiences, meanings, values and understandings within a group (Alvesson, 2011). It is the “shared rules governing cognitive and affective aspects of membership in an organization, and the means whereby they are shaped and expressed” (Kunda, 1986, p.1). In this case, the “organization” of interest is academic STEM, and more specifically academic engineering. Both “academia” and “engineering” have set cultural constructs, which may or may
not be present in the context of a graduate engineering program. However, in understanding the specific culture of graduate engineering, literature regarding the broad cultures of academia and of science is instructive.

**History of Science**

Understanding the culture of STEM requires a grasp of the history that built that culture and the mechanisms that sustain it. Modern science came out of the enlightenment, a period that emphasized the separation between mind and heart, objective and subjective (Merton, 1973). Historically, women were excluded from participation in sciences in a number of ways. The dominant culture viewed women as lacking competency in regard to scientific matters, so they viewed this exclusion as appropriate (Loomba, 2005; Rosser, 2008). Similarly, racial minorities were legally not permitted to engage in most scientific work. Segregation of women into separate schools allowed for instruction in the sciences focused on a women’s domestic role and role in preparing sons as future citizens and leaders (Tolley, 2003). When they did engage in academic science, women struggled to have their research viewed as valid by the scientific community or on par with the work of their male colleagues (Loomba, 2005; Rosser, 2008). While the physical barriers to the participation of women in STEM began to fall in the mid-1900s with the civil rights and women’s rights movements, the culture that formed in response to the history of sciences continues to flourish (Rosser, 2008).

**Sociology and Culture of Science**

Merton (1973) suggests that the history of science left a significant imprint on the culture or sociology that has prevailed through the centuries. The mostly invisible framework of the sociology of science guides modern scientists and their interactions. Merton described four lasting tenets or assumptions of the sociology of science. The first tenet he described is
Communalism. *Communalism* is the idea that everything that a scientist produces is for the common good of the scientific community. The scientist’s only exclusive benefit comes from being the first to discover some phenomenon or at least the first to write about it. The importance of having primacy rights leads to a competitive culture where scientists vie to be the first or to have the most firsts to demonstrate competence. A second tenet is universalism (Merton, 1973). *Universalism* is the concept that science is above social constructs and societal influence. The assumption is that science by nature is objective, and anything subjective is unscientific (Merton, 1973). The exaltation of the objective or empirical links the sociology of science to the theoretical framework of positivism (Crotty, 1998). Much like modern science, positivism was a product of the Enlightenment. The positivist perspective asserts that all knowledge is posited or absolute. Science then provides a way to elucidate unambiguous and certain knowledge about the world (Crotty, 1998).

*Disinteredness*, the third tenet of the sociology of science, is an assumption that the scientist’s primary life pursuit is his scientific work. He is to have disinterest in other pursuits, such as family or home life. The assumption of disinteredness flows from a period in which the scientists were men who were either single or had a wife at home to support the family. The fourth tenet is organized skepticism (Merton, 1973). *Organized skepticism* refers to the self-checking mechanisms of science. Scientists must heavily scrutinize another’s work before its acceptance as knowledge. This system of checking and scrutinizing leads to a culture that is inherently conservative when it comes to acceptance of new ideas (Merton, 1973).

The sociology of science contributes to the culture of academic STEM departments, including engineering departments. The literature generally describes the environment of engineering departments as “chilly” due to a number of challenges, obstacles and biases in
regard to underrepresented groups (Blickenstaff, 2005; Tang, 2000). Overall, the literature
describes modern scientific culture as presuming objectivity, full of unconscious biases,
aggressive, lacking in flexibility for family, and lacking in female role models.

The fixation of STEM culture on the objective and the appearance of objective leads to
the demeaning of anything viewed as subjective. The objective-subjective binary is particularly
troublesome for women because of culturally based schema in the U.S. and Western science,
which associates women with subjectivity and men with objectivity. Due to the underlying belief
that science is objective, dominant culture considers men better suited for science related
professions than women (Valian, 2000; Willower, 2001). Yet, across the globe, assumptions
about masculinity and femininity vary widely (Sallee, 2011).

Evidence of these culturally based schemas and unconscious biases in the sciences show
up in the evaluation of resumes and even in the writing of reference letters (Trix & Psenka, 2003).
Additionally, they can lead to an inequity of rewards and incentives, as men are more often given
the benefit of a doubt than their female colleagues (Valian, 2000). Women who persist in STEM
may experience a double bind. On one hand, they feel compelled to be aggressive, assertive, and
competitive to receive grants, get leadership positions, and advance in their discipline. At the
same time, if they do assert themselves, their colleagues view them as abrasive and lacking
collegiality (Rhode & Williams, 2007).

Overall, gender socialization provides a smoother and more natural path for men to
pursue engineering than it does for women. Although men tend to choose engineering because of
encouragement to “tinker” with mechanics since childhood, women tend to choose engineering
for practical reasons, such as ability in mathematics and often have had fewer experiences related
to engineering (McIlwee & Robinson, 1992).
The literature describes STEM culture as dominated by competition and aggression. The need for competition and aggression is directly traceable to the assumption of communalism and the push for primacy rights. The career of the faculty researcher rests on the ability to discover and write about a phenomenon first (Merton, 1973). If the researcher competes well and receives coveted grants, then that faculty member advances up the hierarchy of academia (Sallee, 2011). Even at the undergraduate level, students learn that science is about competing, as they compete to be at the top of the grade curve and receive the desired grade (Seymour & Hewitt, 1997; Merton, 1973).

One of the tenets of the sociology of science is the assumption that the scientists’ primary aim is the advancement of science in a particular area (Merton, 1973). The assumption precipitates an expectation that scientific research should take precedence over other areas of life including personal interests and family. Because science’s foundation came in an era in which male scientists had support at home from female partners or did not have families at all, the continuance of this expectation is a significant concern for those in dual-career relationships. For women, the assumption is that when she decides to have children, she will leave her STEM career (Dean & Fleckenstein, 2007; Williams, 2004; Wolfinger, Mason & Goulden, 2008).

Since they are so few in number, women often face a situation in which there are limited role models or mentors that have experience dealing with being a minority in STEM. Students look to models for clues on how to behave as part of the socialization process (Sallee, 2011). These role models and mentors are crucial as individuals face cultural schemas, expectations and pressures that assert that they do not belong in STEM (Bernstein, Jacobson & Russo, 2010; Grandy, 1998).
In summary, the culture of STEM conflicts with the societal image of a woman. The essentialist cultural image of women is as the primary caregiver. Women struggle to negotiate conflicting demands to walk the line between softer images of femininity and the competitive aggressiveness of STEM. Whereas the cultural view of women is that she is inherently subjective, science insists that she be objective. The messages put together say that she does not belong in scientific fields, which reinforces the isolation of women in these fields. The knowledge and beliefs systems of STEM culture clearly connect with the history of science. Post-colonial theory is helpful in understanding the establishment and perpetuation of these historical systems.

**Post-colonialism and Science Culture**

Post-colonialism is a theoretical framework that describes independence and oppositional thinking of people formerly dominated by a colonizer (Carter, 2004). Colonialism, in the strictest sense, refers to the conquest and political control of other people’s land and goods (Loomba, 2005). In a looser sense, a colonizer is a group that has an established political, economic, ideological or cultural privilege over another group (Carter, 2004). An unbalanced social structure influences relationships between those who would otherwise be peers (Rocco & West, 1998). Although the “colonizer” may initially take control forcibly, it is often maintained through more subtle practices. One of the most powerful of these is “knowing,” as in knowing about a people through study or claiming to know what is best for that people. Throughout the colonial period, science played a crucial role in the process of knowing. The assumed universality and objectivity of science bolsters claims of colonizers that their knowledge and knowledge systems are superior to those of the colonized (Ashcroft, Griffiths, & Tiffin, 2007a).

Many colonizers do not recognize their privileged status; others believe themselves entitled to that privilege or they simply do not care (Evans, Forney, Guido, Patton & Renn,
2010). Whereas the oppressed are more likely to recognize their status as under-privileged, oppression can still be invisible and go unnoticed by colonized and colonizer alike (Loomba, 2005). Invisible forms of oppression includes references such as “normal” or “standard,” with those not fitting the mold cast as substandard or even deviant (Evans et al., 2010). The process of normalizing the colonized reinforces the underlying hegemony or power structure. The border maintaining the binary distinction between colonized and colonizers is strictly protected (Figure 2.2), regardless of the terms used to describe the binary. Other terms that describe the colonization binary include civilized and savage, and normal and abnormal (Carter 2004, 2006; Loomba, 2005). Some colonized individuals associate with the normative values and “knowledge” established by the colonizers (Figure 2.2), despite the tendency of those values to cast them as abnormal or lacking in some way. Other colonized individuals may resist these normative values. Either way, the colonized are outside the inner circle of colonizers who determine the shape of culture as a whole (Figure 2.2).
Figure 2.2: Colonial structure dictates that colonizers or privileged individuals form the center of “normal” culture, and which sets the shape for all individuals. Some colonized individuals associate or compromise with the colonizers’ idea of “normal.”

The literature establishes the impact of culture on the experiences of women in STEM (Brainard & Carlin, 1997; Valian, 2000; Sonnert, 1999). Critiquing the culture of STEM is crucial in understanding why women are underrepresented in STEM. The history of STEM and the mechanisms that maintain culture are foundational to this critique. Science is at the same time an artifact and an agent of colonial ideas (Carter, 2004). Evidence of the effect of colonialism is in the nature of the sociology of science, including assumptions of objectivity and universality. It is also in the perpetuation of an image of the scientists as being white, male, and detached from subjectivity (Harding, 1991; Merton, 1963). Rigid views and definitions of “women” as inherently subjective, relational, or home-centered also have roots in the constructs of colonial science, which emphasizes binary opposites such as self/other and male/female
(Carter, 2004). Women who remain in male-dominated STEM fields may feel pressure to conform to male-centric cultural norms. As the privileged method of knowledge acquisition, science purposely and inadvertently contributes to the continuation of racism and sexism (Loomba, 2005; McClintock, 1995).

I use post-colonialism to critique and explain the situation in STEM for three reasons. First, it connects the history of STEM with the current culture of and views of women in STEM (Carter, 2004). Second, it explains how the graduate student socialization process and privileged view of scientific knowledge perpetuate structures of dominance and power within scientific fields such as engineering (Ashcroft, Griffiths & Tiffin, 2007b). Third, post-colonialism provides commentary on the binary thinking rampant in science. Post-colonial analysis exposes binaries experienced by graduate women, such as female/male or subjective/objective, as problematic and value-laden (Carter, 2004). Post-colonialism also problematizes certain dualistic categories currently used in sciences, which essentialize very diverse groups, such as all women regardless of their cultural background or identity. The dominant group, represented by engineering men in the current study, view women as “others,” abnormal and needing the assistance of the dominant group. In the process of “othering”, the significant diversity of the “others” is lost (Mohanty, 1984).

**Socialization**

The perpetuation of science culture through the centuries occurs through the process of socialization. Whereas culture includes the activities and behaviors of a group, socialization is the development of individuals as they become familiar with and adopt the activities and behaviors of a group (Tierney, 1997). Socialization is also the development process whereby individuals assume the behaviors, values, beliefs, knowledge and perceptions of norms needed to
negotiate and find acceptance into a particular group (Gardner, 2010). The process is inherently stressful for the newcomer (Gardner, 2010; Van Maanen, 1984). In STEM, the process of socialization works throughout the training process, but socialization for the faculty role occurs primarily through graduate education.

Graduate students are simultaneously socialized to the graduate school environment, the role of the graduate student, and their future professional role (Golde, 1998). The graduate student experience, and therefore the socialization process, is not the same for all graduate students but factors associated with discipline, institution, and position or stage within the graduate program influence student socialization (Gardner, 2010; Golde, 2005). Women in STEM may face many gender-specific obstacles including a lack of mentors to which they can relate and a lack of encouragement. The lower rates of self-esteem among female graduate students in the sciences may relate to these challenges (Sonnert, 1999).

Problems with socialization have been associated with decisions to leave graduate programs (Gardner, 2007; Golde, 1998). STEM fields, such as engineering, often have low graduate student completion rates (Gardner, 2010; NSF, 2011). Although these lower completion rates impact the environment for all students, they may disproportionally affect women, as they struggle to find needed support (Sonnert, 1999). Indeed, it has been found that the attrition rates for underrepresented populations are higher in many disciplines (Council of Graduate Schools, 2004; Lovitts, 2001; Nettles & Millett, 2006).

In STEM fields in particular, socialization includes an increasing expectancy that the graduate student be independent and competitive (Merton, 1973; Sonnert, 1999). They need to demonstrate some level of disinterestedness with other life pursuits, and that they can withstand the scrutiny of organized skepticism to reach graduation (Merton, 1973). Depending on the
discipline, the socialization process may continue through to a post-doctoral experience (Gardner, 2007, 2010). Finally, the initiate enters a faculty position for a last round of tests to assure socialization into the sociology of science. As new faculty members move through the tenure process, they are tested on ability to compete for firsts, to eschew subjectivity, to put their scientific career above other life pursuits, and to persist through organized skepticism (Merton, 1973; Tierney & Rhoads, 1994). As women are socialized into this highly aggressive and competitive culture, gender-specific obstacles, isolation, and a lack of support may lead to their decisions to leave engineering graduate programs.

**Development and Graduate Women in Engineering**

Socialization is inherently a process of development, as newcomers learn to adapt to and adopt a new culture (Gardner, 2005). The colonial imprint in STEM culture influences the socialization experience for everyone, but especially those from historically excluded groups. Women may experience the colonial imprint directly through continued marginal status, or may experience it through cultural constructs about science and who should engage in science. These experiences may contribute to women’s career decisions (Harding, 1991; Valian, 2000). In contrast, highly supportive faculty-student relationships and strong collegiality in a department, lead to lower drop-out rates (Gardner, 2010; Golde, 2005; Weidman & Stein, 2003).

At a basic level, the continued low numbers of women in STEM, contribute to feelings of isolation among women in these fields. Because they frequently lack role models or perceive few of their colleagues that could understand their situation, women often report feelings of isolation (Seymour & Hewitt, 1997). The undertones of dominant culture suggest that “normal” women will have less ability in science and math, and consequently, advisors often discourage bright young women from pursuing difficult science courses. Later, these women are less prepared than
their male colleagues (Seymour & Hewitt, 1997). Because women may also have a sense of isolation within their discipline, they are less likely to seek help (Seymour & Hewitt, 1997). Lack of confidence and self-efficacy tend to compound, and they may choose to leave STEM to pursue a field in which they perceive their ability to be higher (Brainard & Carlin, 1997). Social pressures to provide for a family placed on men may motivate men to persevere in a discipline despite feeling overwhelmed. However, women are generally less likely than men to experience these social pressures. Feeling isolated and lacking confidence, a woman is more likely to feel free to switch to a different career path (Leslie, McClure & Oaxaca, 1998).

How a person attributes failures and successes may also play into decisions to leave STEM disciplines. For instance, if a woman believes that she is not very good at mathematics, and then receives a poor grade on an exam, she may associate that relatively minor failure to her own inherent inability (Valian, 2000). If that same woman received a high grade on the same exam, she would attribute that success to something external, such as luck in studying the right things. Conversely, a person who believes that they are in strong in mathematics is likely to construe successes as confirmation of this ability and attribute failures to external conditions. Women who believe the culturally based stereotype that men and particular ethnic-racial groups (e.g. Whites and Asians) are better at math and science, are likely to view minor setbacks as confirmation that they are not fit for a STEM profession (Dean & Fleckenstein, 2007; Schunk, 2008; Valian, 2000).

Attribution of success to luck, despite evidence to the contrary, is part of the Imposter Phenomenon (IP) (Felder, 1988). Individuals experiencing IP believe that they have progressed academically because of external conditions beyond their control. They fear being discovered as an imposter and so they isolate themselves further, hiding what they see as weaknesses rather
than seeking assistance. Some studies indicate that the prevalence of IP is especially high in STEM fields, particularly among women (Felder, 1988; French, Ullrich-French & Follman, 2008; Pell, 1996). The combination of feeling like an imposter, being isolated, and believing cultural stereotypes often leads to the perception among women that they do not fit into STEM and their colleagues do not want them to remain. These characteristics lead some women to decide to leave STEM (Grandy, 1998; Seymour & Hewitt, 1997).

Characteristics that can contribute to individuals leaving academic STEM are not innate, but rather constructed over time and in response to their experiences both in STEM and in other parts of their lives. Development theories depict the construction and increasing complexity of individuals’ thinking and feeling capacity. Theories by their nature simplify complexity and cannot represent the diversity of individual and cultural paths (McEwen, 2003). However, they can serve as a launching point for research exploring the impact of culture on individuals. Colleges in the United States traditionally focus on students’ occupational preparation and acquisition of subject matter competence (Lucas, 2006; Pascarella & Terenzini, 2005). However, success in science disciplines also requires the ability to think critically and creatively, to consider diverse perspectives, and to choose ethical pathways. Development theories not only shed light on how individuals respond to the culture of STEM, but also how STEM culture shapes the characteristics of tomorrow’s scientists. Three major areas of development theory are psychosocial development, cognitive development, and developmental synthesis models (Evans et al., 2010).

Psychosocial development refers to what people think about themselves and their relationships with others (McEwen, 2003). In relation to STEM, it encompasses the development of several characteristics implicated in decisions regarding a career in STEM including
confidence, self-efficacy, feelings of isolation and fitting-in, and identity (Evans et al., 2010). Erikson (1950) theorized that psychosocial development proceeded along a set path. At each of the eight stages of development, a person experienced a development crisis, which they could successfully resolve by understanding both ends of a spectrum and the necessity for both. Examples of crises include isolation versus intimacy and identity versus identity confusion (Erikson, 1982). Other psychosocial theorists have described the process of development as being flexible, for example, Chickering (1969) and Chickering and Reisser (1993) describe seven vectors or directions of psychosocial development. Individuals may change in several of these areas simultaneously and in some cases may seem to reverse in direction (Chickering & Reisser, 1993). Research indicates that characteristics associated with psychosocial development do influence decisions to leave STEM (for example Brainard & Carlin, 1997; Leslie, McClure, & Oaxaca, 1998; Pell, 1996; Seymour & Hewitt, 1997). However, when these characteristics develop is less clear.

An element of psychosocial development is identity development (Evans et al., 2010). Identity is multi-faceted and includes how an individual views self in relation to gender, race, cultural origin, occupation, and other areas. Most people have multiple identities or aspects of their identity. These identities may complement each other or they may oppose each other. How a person understands the multiple aspects of self and whether or not they have one unifying sense of self has significant impact on the decisions they make (Erikson, 1982; Stewart, 2002), including career decisions. For instance, an African American woman studying science may simultaneously negotiate her racial identity, gender identity, identity as a scientist, as well as other forms of identity. Since the cultural based stereotype of a scientist is a white male, which
conflicts with at least two aspects of her identity, she may struggle to bring all the aspects of self together under one unified sense of identity.

Cognitive development describes how people think and how they know what they know. A major theorist in the area is Perry (1970). Perry described a progression of how people view knowledge. He theorized that people begin seeing the world dualistically and rely on authorities for knowing right and wrong. People develop through multiplicity to finding commitment in a world of contingent knowledge. Because Perry’s work focused primarily on a privileged, white male population (Evans et al., 2010), Belenky, Clincy, Goldberger and Tarule (1986) did further research that included females and less privileged participants. They found that, in relation to cognitive development, self, voice, and mind were all intertwined. They proposed a progression of perspectives on knowledge ranging from being silenced in the knowledge construction process, to being receivers of knowledge from authority, to finally constructing knowledge by melding subjective and objective understanding (Evans et al., 2010). Because cognitive development is about how people think, some research in the area, including research about critical thinking, has been well-received by the scientific community (e.g. Bransford, Brown & Cocking, 2000). However, connections between cognitive and psychosocial development theory receive less attention in the literature.

Development synthesis models include cognitive and psychosocial development with the understanding that how a person thinks affects what they think about themselves and others, and vice versa (McEwen, 2003). Development models are useful because they consider the development and decisions of individuals holistically. In relation to STEM, these holistic models recognize that a person’s decision regarding their vocation and life’s ambition includes more than a decision regarding a career in STEM (Baxter Magolda, 2008; Braskamp, Trautvetter &
Ward, 2006). The development synthesis model of self-authorship has particular relevance to the issue of underrepresentation in STEM.

Self-authorship is the ability to define one’s identity, sense of knowledge, and relation to others internally (Baxter Magolda, 2008). In self-authorship, the components of interpersonal, intrapersonal, and cognitive intertwine and develop in unison. Kegan (1982) originally hypothesized the importance of self-authorship and Baxter Magolda built upon his model following a longitudinal study. Individuals are said to begin at a point in which they look entirely to external authorities for determining who they are, how they know, and what their relationship with others should look like. At a crossroads, the individual finds that definitions and views given by different authorities conflict. This leads to a turn inward, as an individual begins to understand their internal voice. Gradually, they become committed to their self-authorship and can balance the input of others with their internal voice (Baxter Magolda, 2001, 2008). In the final stage, described as social consciousness, view of self is transitional and in reaction to social environments (Zaytoun, 2010). It is this realization that allows for construction of self as being comprised of privileged and oppressed identities (Jones, 2010).

The self-authorship model is particularly useful when considering the conditions in STEM. Culture influences the interpersonal element of self-authorship, and the cultural context in which a woman lives and works affects her identity as well as how she views and constructs knowledge (Pizzalato, 2010). Second, research suggests that self-authorship can lead to the persistence of marginalized individuals in challenging situations (Pizzalato, Chaudhari, Murrell & Podobnik, 2008). Self-authoring capacity could lead to the persistence of women as they face the challenges of STEM culture (Assessing Women and Men in Engineering, 2009).
A holistic view of development recognizes that how a person develops and the decisions they make are complex. Developmental outcomes influence and are the result of an interaction between individuals and their environment (Evans et al., 2010; Renn, 2003). In the context of STEM, culture likely impacts individuals’ affective development and their decisions to leave STEM fields. Understanding the support mechanisms and developmental pathways of underrepresented individuals is essential to a discussion of why there continues to be so few women in STEM.

**Perspectives on Solutions**

Despite the obvious impact of culture on the decisions of individuals, perspectives on how to increase the representation of women in STEM tend to target individual characteristics and experiences. These interventions usually come from either a deficit or difference model. Deficit models assume that the reason why women are lower in number is because they are missing something that would allow them to succeed. Two major areas in which women have been called lacking are in finances and in background and training in math and science. Difference models assume that characteristics of women making them inherently different than men in performance of science. These differences may be inherent biological differences or they may be innate lack of interest in STEM (Sonnert, 1999). In keeping with post-colonial thought, those in power perceive deficits and differences as problems that need their expert repair. In this way, those in power, or the colonizers, maintain dominant structures of knowledge and power.

Difference and deficit models lead to interventions targeted at women to help them overcome these deficits or differences to succeed and persist in STEM. Examples of interventions that take a deficit approach include scholarships and grants that help individuals overcome financial barriers. Special programs targeted at getting women interested in STEM or
providing them special resources after they come to college can follow either deficit or
difference models, depending on the aim of the program. Although these programs do provide
women with coping tools, they also tend to reinforce stereotypes that label them as less capable
in STEM. To avoid these implications, women often choose to avoid these programs to blend
better with the dominant culture and avoid appearing unintelligent or overly needy (Seymour &
Hewitt, 1997; Sonnert, 1999). When women do take advantage of special programs and funding,
it may even contribute to the woman feeling like an imposter because of the sense that she would
not have succeeded without the special help (Clance, Digman, Reviere & Stober, 1995).

Another type of intervention, built from deficit and difference models, helps women
balance work and family. Although implementation of these types of interventions could occur at
a cultural level, they often focus on individuals viewed as needing special accommodations.
These interventions include measures such as maternity leave or “stop-the-tenure-clock” for
women wanting to slow the tenure procedure when they have a baby. Again, these measures are
helpful, but women often do not take advantage of them to avoid the stigma of needing special

Development models provide an alternative to deficit and difference models.
Development models emphasize the changing nature of individuals’ characteristics and the role
of environment in influencing those changes (Evans et al., 2010). By emphasizing the
interconnection of the development of individual characteristics and cultural environment,
development models show how a cultural shift could lead to more positive development among
women in STEM. If the culture shapes the development of individuals in a way that contributes
to their decisions to leave STEM, improving the representation of women in STEM must include
cultural changes as well as individual interventions implemented at the cultural level (Litzler,
The post-colonialist lens (Carter, 2004) provides a framework for deconstruction of power and knowledge structures influencing the experience of women in the culture of modern science and engineering cultures, while not ignoring the diversity of individual women in engineering. The developmental model provides structure for understanding the ways in which culture influences individuals.

**Conclusions and Research Needs**

Underrepresentation of women in STEM continues despite years of concern and intervention following the lifting of explicit legal barriers. The largely invisible sociology of science perpetuates the exclusion of women. The sociology and culture of STEM exert considerable influence on individuals and may lead to their decisions to leave academic STEM careers. It is consequently important to consider the experiences of individuals and the culture that affects those experiences when designing initiatives aimed at increasing the number of women in STEM.

The ability to design initiatives that include considerations for individuals and the culture requires research to identify specific aspects of culture that shape individuals’ experiences and decisions. Rather than basing the current research on a deficit or difference model, development models that focus on identity and characteristics constructed over time are more appropriate. Although development of students at the undergraduate level is well-studied, less research has explored development at the graduate level (Gardner, 2009), particularly in consideration of gender issues (Sallee, 2011).

In view of the effect of colonialism and role of science in perpetuating discriminatory structures, avoidance of homogenizing the issues faced by diverse women is essential. Women in STEM departments in the U.S. clearly come from diverse cultural backgrounds; the most
obvious delineation is between domestic and foreign-born women. The experiences and development of foreign-born women in the sciences has largely been unexplored. This present research explores the experiences and needs of foreign-born women as well as the experiences and needs of U.S. women. Research needs to consider all women in engineering, not viewing women as uniform but diverse, with diverse perspectives and experiences.

Finally, there is a need for a holistic model that includes the connections between culture, individual characteristics, and career decisions about STEM fields such as engineering. Using a holistic model uncovers specific steps that could increase diversity and the representation of all underrepresented groups in engineering. The current study, as described in Chapter III, uses a holistic model to consider a specific aspect of underrepresentation of women in STEM. Using a post-colonial and developmental framework, the study considers how a culture historically and demographically dominated by men impacts the experiences and development of U.S. and foreign-born graduate women.
CHAPTER III: METHODOLOGY

Study Purpose

The issue of underrepresentation in engineering is broad and complex. The focus and purpose of this current study is to examine relationships between culture, development, and career choices of female graduate students in the context of the historically male-dominated field of engineering. Study participants are female engineering graduate students at research intensive universities. Graduate students are the focus because while the experiences and development of undergraduate women is well explored, fewer investigators consider the development of graduate women and specifically those women in STEM (Gardner, 2010). The study also includes both foreign-born and U.S. women, because given the prevalence of foreign national women in receiving doctorates, it is essential to include the stories of international women in U.S. graduate engineering programs. Although women remain underrepresented in other scientific fields (e.g. physical sciences and mathematics) (NSF, 2011), engineering students are an appropriate focus because they often have exposure to these other areas in which the representation of women is particularly low. The current chapter discusses the methodology used to understand the experiences, development, and career decisions of graduate engineering women including study questions, the methodological framework, the theoretical framework, specific research design, and plans for analysis.

Study Questions

The overall research question that guides this study is “How do the cultural contexts of engineering departments influence the development and decisions of women in engineering?” The following five secondary questions address specific aspects of the overall question: 1) What is the relationship between participation in academic engineering graduate programs and
psychosocial and self-authorship development? 2) What is the relationship between graduate engineering student development and intention to pursue a career in academic engineering among female graduate students? 3) In what ways does the development of U.S. and foreign national women differ? 4) What cultural factors of engineering departments influence development and intention to continue in academic engineering among female graduate students? 5) Do U.S. and foreign national women experience the culture of engineering departments in different ways?

**Methodological Framework**

The methodological framework reflects the nature of the research questions. Although questions one through three are relatively straight-forward and are addressed through a quantitative survey, questions four and five, as well as the overall question, are open-ended and require a qualitative approach. Since the nature of the research questions is mixed, a mixed methods study was a pragmatic approach to take in this study.

The mixed methods approach was appropriate for this study for three reasons. First, a mixed methods approach allowed for a complete analysis of the overall research question, providing needed information about women’s development and the culture that influences that development and their career intentions. Second, the combination of methods gave the study greater breadth and focus than it could with either type of study alone. Whereas the qualitative component explains the context in a way a quantitative study could not, the quantitative component provides the numbers and conditions needed to find patterns in engineering departments (Creswell & Plano Clark, 2007; Ivankova, Creswell & Stick, 2006; Johnson & Onwuegbuzie, 2004). Third, a multifaceted explanation is useful in reporting study results to the mixed audience who may have interest in these study findings.
Theoretical Framework

Theory can deconstruct complex issues into key concerns. Since the issue of underrepresentation in engineering involves both cultural and individual factors, this study uses a meld of theories addressing cultural and individual aspects (Figure 3.1).

<table>
<thead>
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<th>Theoretical Framework</th>
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<tr>
<td><strong>To understand the culture of engineering</strong></td>
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<td>• Post-colonialism (Carter, 2004; Loomba, 2005; Merton, 1973; Mohanty, 1984)</td>
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Figure 3.1: *Theoretical framework melds three theories to understand culture and the development of individuals.*

To frame the experiences of women in engineering culture, the study takes a post-colonial perspective. Overall, the role of post-colonial theory in the present study is to critique culture in graduate engineering programs, in particular culturally based structures of dominance and how those are tied to knowledge (Loomba, 2005). Although discussions of post-colonial theory as it relates to the sciences often includes a critique of science itself (e.g. Carter, 2006; Harding, 1991), these critiques are largely beyond the scope of this discussion. Regardless, post-colonialism is appropriate in consideration of the issue of women’s underrepresentation in engineering for three reasons. First, it accounts for and explains the role of history in shaping the current culture of engineering. Second, it includes descriptions of mechanisms that shape and maintain cultural constructs. Third, it is versatile enough to characterize the situation of many underrepresented groups in engineering. At the same time, post-colonialism explains the
The problematic nature of categorizing all of women as a homogenous unit. It shows how binary categorization could serve as an erasure of diversity within underrepresented groups (Carter, 2004; Loomba, 2005; Mohanty, 1984). Post-colonial theory informs particular aspects of the study including the methodology, aspects of data collection, and analysis. Study methodology focuses on giving voice to women in engineering to speak and interpret their own experiences. By acknowledging diversity of perspective as well as allowing for diversity of engineering cultures, the current study rejects homogenized views of engineering culture and of women in engineering programs. During data collection and analysis, post-colonial theory provided a framework for understanding colonial constructs (such as binary definitions of men and women) within engineering cultures and the responses of women in those cultures, including those inadvertently complicit in the perpetuation of colonial views in the sciences.

The study uses development theory to interpret and clarify the ways in which women respond to engineering culture, and how these responses may influence future career choices. A number of the reasons given for women leaving STEM, including feeling isolated, poor self-confidence, lack of self-efficacy, conceding to social pressures, identity confusion, and insufficient commitment and purpose, relate to developmental outcomes (Bernstein, Jacobson & Russo, 2010; Brainard & Carlin, 1997; McIlwee & Robinson, 1992; Pell, 1996; Seymour & Hewitt, 1997; Valian, 2000). The present study uses development theory to explain the formation of characteristics and motivations that have influence on women’s career decisions. In particular, the study uses psychosocial development theory (Erikson, 1950, 1982) and self-authorship theory (Baxter Magolda’s, 2001, 2008) to understand relationships between culture and the development of graduate engineering women.
Erikson’s psychosocial development theory guides an exploration of what people think about themselves and their relationships with others, specifically in the areas of initiative, confidence, identity, comfort in partnerships, desire to make a positive difference, and life purpose (Erikson, 1950, 1982). Baxter Magolda’s (2001, 2008) self-authorship theory considers how people think, particularly related to ability to internally define identity, relations to others, and beliefs. Using self-authorship theory, this study explores the relationship between self-authoring capacity and persistence of women in engineering despite challenges to competency and identity, as described in other studies (e.g. Pizzalato, Chaudhari, Murrell & Podobnik, 2008).

To understand different aspects of the possible influence of culture on graduate engineering women, the study uses psychosocial and self-authorship development theories together.

My own theoretical perspective comes from a belief that although absolutes exist, they are ultimately unknowable. Consequently, human knowledge is a construction based on a collection of perspectives. Diversity of perspectives is valuable, because greater numbers of perspectives lead to clearer knowledge constructions. In the current study, I construct an understanding of the experiences and development of graduate women in engineering from their responses to development surveys, interviews, and general information about the engineering programs included in this research.

The overall theoretical framework used to structure the study and its analysis is a meld of post-colonialism, development theories, and my own constructivist theoretical lens. While post-colonial theory focuses on culture, development theories focus on individual responses to culture. Using a constructivist approach, I tie post-colonial and developmental interpretations together to understand the relationships between culture, development, and career decisions of graduate engineering women.
Research Design

Overall Design

The study takes a two-phased mixed-methods approach in which the qualitative phase explains and elaborates on findings from the quantitative phase (Creswell, 2008). The study began with the quantitative phase, which provides background for overall analysis. However, the qualitative phase, in which participants elaborate on their responses to surveys, is the primary focus of the overall analysis. In the language of mixed methods studies, this is a quant→QUAL study with the capitalized QUAL representing the emphasis of qualitative findings and methods in overall analysis (Creswell & Plano Clark, 2007; Creswell, 2008). Through findings from the study, I construct an understanding of the relationships between culture, development, and career decisions of graduate women in engineering.

Sites

Study participants are graduate students from engineering departments at selected universities. The three selected universities are in the U.S. Northwest, and assigned the pseudonyms of Public University, State University, and Flagship University. All three universities are public, land grant universities classified by the Carnegie Foundation as being Doctoral/Research-Extensive (McCormick, 2001). These universities represent a type of university in which there is particularly high underrepresentation of women (e.g. research intensive) (NSF, 2009a). All three universities are located in small college towns, or towns dominated economically and culturally by the presence of the university (American Society of Engineering Education (ASEE), 2012). Narrowing to include only universities with similar characteristics limits variability associated with the type of university rather than between different groups of female students. Since the study includes only high research universities,
findings may be limited in terms of generalizability to widely divergent types of universities (Creswell, 2008).

Public University ranks in the top 100 graduate engineering programs (US News & World Report, 2012). In 2011, Public University had graduate engineering enrollment exceeding 650 students in five engineering departments. Of all enrolled graduate students in 2011, 27% are female, 48% were international students, and 53% of female graduate students were international students (ASEE, 2012).

Similar to Public University, Flagship University ranks in the top 100 graduate engineering programs (US News & World Report, 2012). In 2011, Flagship University had graduate engineering enrollment of over 800 students in 6 engineering departments. In 2011, 19% of all enrolled students were female, 39% were international students, and 47% of female graduate students were international students (ASEE, 2012).

Although State University’s engineering is similar to Flagship’s and Public’s in many regards, it was a smaller program, with a total enrollment in 2011 of about 450 students in 6 departments. It ranks in the top 150 graduate engineering programs (US News & World Report, 2012). Of all enrolled graduate students in 2011, 13% are female, 20% were international students, and 22% of female graduate students were international students (ASEE, 2012). Of State’s female graduate students, over half were at a satellite campus or in the distance program.

Consent and Access to Participants

To obtain introduction to female graduate students, I first met with college and/or department leaders at each university to discuss the study and request permission to conduct the proposed study in their unit. Approach to contacting students varied by university, because of differences in university and college policies. At Public and State Universities, engineering
college leaders provided lists of currently enrolled female graduate students. At Flagship University, an engineering college leader forwarded my emails to currently enrolled female graduate students. As incentive for participation, each participant could enter a drawing for a $100 visa gift card.

Before participant contact, the Institution Review Board (IRB) of the involved universities gave consent for research at the university. Additionally, each participant signed a consent form prior to beginning quantitative instruments.

Since development of the qualitative phase occurred after initial analysis of quantitative results, I obtained additional assent from universities’ IRBs before proceeding with the qualitative phase. After explanation of the purpose of the study and assurance of confidentiality and anonymity, participants signed an additional consent form for the qualitative portion of the study (Creswell, 2008).

Participants

Participants included U.S. and foreign-born female graduate students currently enrolled in engineering departments at the three sites. Overall, 110 students participated in the quantitative phase, and of these, a purposeful sampling of 26 students also participated in the qualitative phase. Because the qualitative phase purposed to explain quantitative results participants included those who could elaborate on specific results from the quantitative results (e.g. high and low scorers in each area of interest). Additionally, the qualitative participants included participants from major demographic groups including every major engineering discipline, 11 master’s and 15 doctoral students, 9 international students and 17 U.S. students, and at least 7 students from each university.
A total of 25% of graduate women at Public University participated in the study. Participants in the quantitative phase included graduate women from all five departments, and of the 46 participants, 57% were international, and 65% were in doctoral programs. The mean age of participants is 27.0 with a standard deviation of 4.1. The qualitative phase included 8 participants from Public University. At least one participant from each department at Public University and three international students participated in the qualitative phase.

A total of 30% of female Flagship University graduate students participated in the study. Survey participants included graduate women from all five departments and of the 46 participants, 39% were international, and 35% were in doctoral programs. The participant’s mean age was 26.4, with a standard deviation of 5.2. The 11 students who also participated in the qualitative phase represented four of Flagships’s departments and included four international students.

A total of 31% or 18 students from State University participated in the study. Participants represent graduate women from all five departments, 28% were international, and 22% were in doctoral programs. On average, State University participants are older than Flagship or Public University participants; the mean age of participants was 31.6, with a standard deviation of 8.7. A total of 7 students also participated in the qualitative phase. Qualitative phase participants from State University represented all departments, included 2 international students, and four students from a satellite or distance campuses.

**Quantitative Methods**

The quantitative phase provides information about participants’ development and career intentions. Specifically, the quantitative aspect of the study addresses the first three research questions: 1) What is the relationship between participation in academic engineering graduate
programs and psychosocial and self-authorship development? 2) What is the relationship between graduate engineering student development and intention to pursue a career in academic engineering among female graduate students? 3) In what ways do the development of U.S. and foreign national women differ?

**Quantitative Instruments**

To address these questions, participants answered questions in a set of three survey instruments associated with the development and intentions of graduate students. Participants received the three instruments as one survey package, and the entire survey package took approximately 30-40 minutes to complete. Before any graduate women in engineering took the survey, a pilot group took the survey and provided feedback regarding survey structure and length. The pilot group included female graduate students in non-engineering fields, male engineering graduate students, and international graduate students. Based on pilot group comments, I adjusted wording on the third section of the survey and added a supplemental sheet containing definitions of words that could be problematic for non-native English speakers.

**Measure of Psychosocial Development (MPD)**

The first instrument was Measures of Psychosocial Development (MPD) developed by Hawley (1984). MPD is a self-report survey that measures psychosocial development according to Erikson’s psychosocial development theory (Erikson, 1950, 1982). Results of the survey include scales determined by 112 statements. Examples of statements include “stick to tried and tested,” “self-sufficient,” and “easily distracted.” Participants rate personal conformity to these statements from “Not at all like me” to “Very much like me,” which correspond to scores of 0 to 4. Statements include multiple positive and negative statements for each stage of psychosocial development. Results of the survey break into eight sub-scales that correspond to the eight
development crises/stages described by Erikson and one total or overall scale. To ease interpretation of the measure, the present study considered only resolution scales, which measure the degree of conflict resolution for each of Erikson’s stages. Calculation of the resolution scales involves subtracting the negative scale from the positive scale for each stage of psychosocial development, and the total resolution scale is a sum of scores for each psychosocial development stage. The possible range of scores for each sub-scale is -25 to 25, and the possible range for the total score is -200 to 200. Average total score for women ages 25-49 is 111 (Hawley, 1988). A participant who had successfully resolved psychosocial conflicts at each of the eight stages would obtain high positive scores and low negative scores, which would yield high resolution stage scores and a high total score. MPD has adequate test-retest reliability, internal consistency and construct validity (Hawley, 1988). It has been validated with people from a wide age range, as well as with both men and women (Hawley, 1988). Given the wide age range of graduate women in engineering (NSF, 2011), MPD is a more appropriate measure than other psychosocial development measures designed for traditional-aged undergraduates, such as the Student Developmental Task and Lifestyle Assessment (SDTLA) (Winston, Miller & Cooper, 1999).

Modified Career Decision Making Survey (Modified CDMS)

The second instrument was a modified portion of the Career Decision Making Survey (Creamer, 2010), a questionnaire initially designed by an NSF team exploring factors that predict women's desire to pursue careers in information technology (Creamer, 2010). Because the design of CDMS purposed to measure self-authorship among women choosing whether or not to pursue a career in scientific field, it matched the intent of the current study. E. Creamer gave permission to use and modify CDMS for the study. Because CDMS’s original design targets undergraduate students, modifications to the questions to make them fit with the experiences of
graduate students were necessary. For example, “career counselor” became “advisor or dissertation/thesis committee chair.” The survey has a total of 18 questions measuring development in the three dimensions of self-authorship (intrapersonal, interpersonal, and epistemological), and includes specific questions for each of the three phases of self-authorship development (external formulas, crossroads, and self-authorship). Assessing self-authoring capacity using this modified version of the CDMS included three steps. The first step was calculation of an average score for each phase and dimension combination (e.g. average score for external formulas questions on the intrapersonal dimension). The next step added average scores for each phase of dimension. For example, average scores for external formulas in intrapersonal, interpersonal, and epistemological dimensions became one total score for external formulas. Finally, assessment of the pattern of total scores for external formulas, crossroads, and self-authorship led to an assessment of the individual’s overall self-authoring capacity. Specifically, the phase in which the participant had the highest overall score (by greater than 1 point) represented the students’ self-authoring phase. “Indistinct” represented cases in which there was not a clear overall authoring pattern. “Transitioning to self-authorship” indicated that the participant had equally or nearly equal scores for crossroads and self-authorship. “Bimodal” represented cases in which the participant scored equally or nearly equally for external formulas and self-authorship. The modified Career Decision Making Survey (Creamer, 2010) used in the present study is in Appendix A. Appendix B includes an example of calculation of self-authorship development.

Career Intentions

The third instrument was a short assessment of intentions to pursue further academic training or a faculty position (see Appendix C). Although intention to pursue an academic career
path may not exactly match actual levels of persistence, research indicates that intention regarding future career plans is a good predictor of actual behavior (Daly & Dee, 2006). The third instrument assesses career intentions directly, with students indicating likelihood to pursue further education or an academic career in engineering on a scale of not at all likely to very likely. The instrument also assessed comfort and surety of career intentions with questions that asked participants for their satisfaction with decision to study engineering and satisfaction with career plans.

Quantitative Analysis

Analysis of quantitative results considers the relationships between two major variables, development and career intentions, as well as comparing development or career intention by the demographic groups of university, degree level (master’s or doctoral), citizenship status, discipline, age, and proximity to main campus. Analysis includes review of descriptive statistics, including percentages and means by demographic group. Since variables include both categorical and interval level data, statistical tests of relationships between variables include factorial ANOVAs, independent t-tests, and Spearman’s correlations, with the type of statistical test depending on the nature of the variables tested (Field, 2009). The alpha level for all statistical tests was .05 and all statistical test hypotheses were bidirectional. Because the described study is not experimental in nature, validity of the study is largely dependent on the validity of the measures and appropriate use of the measures.

Developmental theory (Baxter Magolda & King, 2012; Erikson, 1950; Hawley, 1988) guided interpretation of developmental scores. I give particular attention to areas in which participants from different groups (i.e., U.S. versus international participants) scored significantly different, and areas in which a significant relationship between development and
career intentions exists. In relation to psychosocial development scores, I also focused on areas in which overall mean scores had significant differences with their age profile or expected average psychosocial development scores for their age and sex (Hawley, 1988). To interpret these differences in development, I use descriptions of characteristics of development stages or profiles, and reflect on the implications of these characteristics in the context of a graduate engineering program.

**Qualitative Methods**

Results from the quantitative phase informed and provided background for the qualitative phase. The qualitative phase explored three main areas related to the experiences and consequent development of women in engineering: 1) development, 2) career intentions, 3) influence of engineering culture. Interview responses in each of these intertwining areas specifically address the following research questions: What cultural factors of engineering departments influence development and intention to continue in academic engineering among female graduate students? And, do U.S. and foreign born women experience the culture of engineering departments in different ways?

**Interview Protocol**

The qualitative phase began with construction of the interview protocol. The interview format is semi-structured with open-ended questions (Creswell, 2008) and takes about 30-60 minutes to complete. The interview protocol concentrates on three themes representing the interacting factors of development, intention, and culture. The full interview protocol is in Appendix D.

In the development section, questions tie directly to the participants’ scores on the development surveys. The design of interview questions explains significant or surprising overall
findings of the quantitative phase (Creswell & Plano Clark, 2007), and questions ask participants to elaborate on cultural factors that theory indicates may influence their development.

Developmental theory guides the nature and structure of the questions. For example, survey results indicate a significant difference between international and U.S. master’s students related to initiative vs. guilt and psychosocial developmental theory suggests that low scores in this area may relate to a fear of mistakes (Erikson, 1950). The following question explores that finding and asks students to consider it specifically in the context of their graduate engineering program: “Related to your research and engineering, do you fear making mistakes, being weak or inadequate?” Additional development-related questions are included in the full interview protocol (Appendix D).

The second theme of the interview seeks to understand the reasons behind participants’ intentions to leave or stay in academic engineering. An example of a question that addresses this theme is the following two-part question: “I see you said that you are not at all/somewhat/moderately/very likely to pursue a career as a faculty member. Can you tell me a little bit more about your career plans in general? What motivates you to continue or discontinue pursuing a career in academic engineering (as faculty)?” Questions also focus on general motivations and career decision-making processes, to better understand the role of self-authorship development in the decisions students make about their careers.

Third, the interview protocol focuses on the role and impact of engineering culture on participants. Post-colonial theory guided construction of questions related to culture and questions took an inductive approach, emphasizing the voices of women in engineering rather than narratives about women in engineering. Questions explore how foreign and U.S. women perceive the culture of their departments, how connected they felt to others in their department,
and how they feel they “fit” in the department and discipline as a whole. Questions in this section also expand on results from the development surveys. For instance, one question asks, “How do you think that [your department] culture influenced your choices on the survey?”

The semi-structured nature of the interview protocol also allows participants to express additional information related to what they thought of the survey and issues related to women in engineering, in general. These side comments often inform overall analysis and understanding of the role of culture in the development and career decisions of the participants. Participant comments also reveal the diversity of women’s perspectives related to their experiences in engineering.

*Qualitative Analysis*

Analysis of qualitative results considers the relationships between three major variables, culture, development and career intentions. Analysis also includes ways in which women’s cultural and developmental background moderate relationships between culture, development and career intentions. Analysis of interviews began with transcription and uploading of interview transcripts to qualitative analysis software program, ATLAS.ti (2012). I read all interview transcripts and developed an initial list of codes that described the content of the interviews. The next step involved coding all portions of interviews relevant to the study. As necessary, I added codes to the initial list of codes to accommodate ideas not adequately covered by existing codes. Interview coding focused on participant’s development, career intentions, and experiences in graduate engineering culture, as well as any differences between foreign and U.S. women. In evaluation of participant responses, particular focus was on the influence of engineering culture on individuals’ construction of their knowledge and beliefs about self and others.
In interpretation and coding, developmental and post-colonial theory guided interpretation of participant comments. For example, a participant’s experience in which colleagues misjudged her role based on her gender received a code of “false dichotomy,” which reflects the colonial model of viewing individuals as either normal or abnormal (Carter, 2004; Evans et al., 2010). Another comment in which a participant talks of being “different” in various life roles received the code of “identity confusion,” since psychosocial development theory suggests that a characteristic of identity confusion is disparity in behavior between life roles (Hawley, 1988).

After initial coding, I evaluated codes and collapsed similar codes. I used coding density, or the frequency of use of a particular code, to determine which codes to emphasize in analysis and reporting. Coding in ATLAS.ti allowed for viewing when particular codes overlap or occur in the same interview. For example, analysis considered the relationships between overall description of culture and participant’s description of “fit” within their department. I used the theoretical framework to identify and interpret these connections between codes. I then grouped codes into themes or major findings (Creswell, 2008) using the ATLAS.ti qualitative data analysis program (Creswell & Plano Clark, 2007). After determination of major themes, I generated lists of quotes related to those themes. A review of these quotes led to specific interpretations of the views and experiences of graduate engineering women, as reported in the following chapters. Quotes from participants remain in the participants’ exact wording, except when meaning is unclear, to increase authenticity of analysis (Lincoln & Guba, 1985).

**Overall Analysis**

Final overall analysis linked findings from quantitative and qualitative phases to address the research questions. The goal of the analysis is to paint a comprehensive view of the
relationships between graduate engineering culture, participants’ affective development, and participants’ career intentions. While the surveys provide specific information about the development of graduate students in engineering disciplines, the interviews shed light on the cultural context shaping that development, and helped to explain differences between international and U.S. women. Examination of connections between findings from the qualitative and quantitative phases allowed for the formation of an overall model describing study findings.

Figure 3.2: Triangulation of findings for overall analysis of research questions.

A post-colonial lens helps to deconstruct what participants reported about engineering culture and considers how structures of dominance impact the experiences and consequent development of women in engineering. Although the analysis seeks to highlight commonalities in the experiences and development of graduate engineering women, women in engineering are not homogenous. Overall analysis includes discussion of differences in perspective between groups and highlights the diverse perspectives of graduate engineering women. Analysis of overall findings summarizes participants’ descriptions of the culture of their graduate engineering program and considers how the colonial model of science may be expressed in modern engineering. Finally, analysis of overall findings includes reflection on how the normative views of an engineering culture can influence women’s perceptions of self, social relationships, and what counts as knowledge. The developmental approach provides a framework for connecting personal perceptions to decision-making processes and constructing an overall model describing study findings.
Triangulation of quantitative and qualitative findings provided trustworthiness to the analysis (Lincoln & Guba, 1985). In the present study, findings used in triangulation included interviews, surveys, and university profiles. Overall, the findings are supported by themes grounded in statistical findings and interview quotes. I report evidence that contradicts themes and major findings of the study, including any quantitative and qualitative findings that conflict.

To add trustworthiness to the study (Creswell & Plano Clark, 2007), I indicate my role in the study as an educational researcher and as a former female graduate student in the sciences. My lens is at once informed by the perspectives of those in science, the experiences of being a minority in my field, and knowledge of educational theories. My approach to the present research posits that development in a particular direction (e.g. toward identity formation and confidence) is better than development in the other direction (e.g. toward identity confusion or sense of inferiority).

The study aims to examine the continued underrepresentation of women in engineering despite decades of research and initiatives to increase their numbers. The intent is to understand how women respond to engineering culture, which has been historically dominated by men, both demographically and culturally. Using a mixed methods approach, participants responded to surveys and interviews to express their views of the relationships between culture, development, and their career intentions. The following chapters describe different aspects of the relationship between culture, development and career decisions of women in graduate engineering programs. Chapter IV speaks to the development and career motivations of graduate engineering women. Chapter V focuses on the experiences, development and career intentions of international women. Chapter VI highlights the culture of graduate engineering programs included in the study. Finally, Chapter VII provides overall findings and recommendations for research, policy, and practice.
CHAPTER IV: DEVELOPMENT AND MOTIVATIONS OF FEMALE ENGINEERING GRADUATE STUDENTS

As women experience graduate engineering programs, their views of self, their views of relationships with others, and their views of knowledge evolve. The present study uses psychosocial development theory to describe the content of participants’ views, and self-authorship theory to describe how participants define their views. The focus of the chapter is on the developmental patterns of graduate engineering women. The chapter describes relationships between women’s development and graduate engineering culture, and between development and career motivations. The chapter begins with consideration of the role of development in shaping women’s responses to experiences in a graduate engineering program. To determine if differences in development patterns are attributable to demographic characteristics including discipline, degree level, university, age, and participants’ citizenship status, the chapter includes discussion of variations in development by these characteristics. After a review of various development patterns of graduate women, the discussion shifts to ways in which development influences the career motivations of graduate women by reviewing the primary career motivations discussed by participants.

How Development Shapes Response to Graduate Engineering Culture

Motivations influencing career decisions of female graduate students stem from the interaction of culture and individual development. Decades of research indicate that career decisions of women are difficult to predict (Creamer & Laughlin, 2005). Yet, understanding how women make decisions and what beliefs underlie their decisions provides insight into why women choose to pursue less traditional careers, such as academic careers in engineering. Graduate women vary in how they interpret and respond to the culture of their graduate
engineering program. Findings indicate that development in the areas of self-authorship, confidence and identity influences how participants react to negative aspects of their graduate engineering programs. As women develop self-authoring capacity, confidence and strong identities, they exhibit greater resilience in the male-dominated field of engineering and greater certainty in decision-making.

**Self-authorship Development**

The construct of self-authorship is useful to describe how women respond to the culture of traditionally male-dominated disciplines and make decisions about whether to stay or leave (Creamer & Laughlin, 2005). Self-authoring individuals use their own inner voice to define their identity, to determine what counts as knowledge, and to understand their role in society (Baxter Magolda & King, 2012). Self-authored views of self, knowledge, and relationships are less susceptible to external influences than externally authored views, including those based on discouraging messages from peers and authorities (Baxter Magolda & King, 2012).

A portion of the survey analyzed participant’s self-authoring capacity. The high percentage of self-authoring among female engineering graduate students in this study (43%) is unsurprising given their persistence in engineering despite biases against women in engineering. Other patterns of authoring among participants include external formulas (7%), crossroads between authoring according to internal and external sources (8%), transitioning to self-authorship from crossroads (21%), indistinct (10%), and bimodal authoring patterns (11%) (Figure 4.1).
Self-authoring participants define their identity as female engineering graduate students internally, and consequently describe the culture of their department as having little influence on how they view themselves and their ability to pursue a career of their choosing. For example, Inna, an international student from Flagship University, talks about her response to having her competency questioned because of her gender or appearance: “It's painful, yes. You want to cry. But, after you think about [it]...basically it makes [you] stronger…I mean [thinking about it] even makes me more confident.” Because Inna “knows what she knows” and authors her own identity, she is able to identify sexist behavior from colleagues and does not internalize their assertions. Participants describe self-authoring as challenging, as perceptions of knowledge and career options expand. Diane from State University spent several years out of academics working and rearing children. She describes differences between working in academia and in a professional setting: “Working in a company or whatever, procedures are generally spelled out and you're just given the procedure you need to perform and you know what the outcome is going to be.” In comparison, she talks about her need to find her own way in graduate school:
What procedures do I need to perform to get there? How do I get those? How do I even find those? So, it's more of, more challenging that way. And also, kind of questioning yourself...I think that's the most challenging part for me, to work on stuff on my own and trust my own stuff.

In the process of finding her way through her research, she has discovered different views of knowledge and her research. These different views of the same engineering “problem” underline the importance of questioning science’s power in determining what counts as knowledge (Ashcroft, Griffiths, & Tiffin, 2007a). Diane uses her internal voice to negotiate different views and discern her path. She concludes, “I do now enjoy just taking a prospect and go with it the way I think it should go. That was initially uncomfortable for me…but at this point and I think moving forward, that's a pretty cool thing.” Because of the comfort with following her internal voice that Diane developed during her graduate career, her interest in pursuing an academic career increased: “I do like the atmosphere here at the university…It feels so open and people are open to different things.” Self-authorship also plays a major part in the decisions Public University student Amanda makes about her career. She says,

I think that when I make major life decisions, of course my family is a big deal. But also, is it in the path that I have set for myself? So, like I really plan ahead and I always have a set plan as to where I want to be in 5, 10 years, whatever. So, am I going in that direction, or am I completely straying off from it? So, I think that's the most. If it's where I want to go, is it leading to where I want to go.

While self-authoring students speak of their ability to trust their internal voice sufficiently to guide their responses to input from parents or faculty (Baxter Magolda & King, 2012), other
students expressed difficulty in deciding career direction when external authorities and internal voices conflict.

Overall, participants’ survey scores indicate that 7% of students define views of self, knowledge, and relationships using external formulas, and 8% of students define views using internal and external voices (crossroads) or are indistinct (10%) in their authoring patterns (Figure 4.1). Initially, many participants in Baxter Magolda’s longitudinal study investigating self-authorship accepted an externally defined view of who they should be without exploring other options (Boes, Baxter Magolda & Buckley, 2010). For example, Lindsay a student that studied at both Flagship and State universities, describes why she studied engineering: “My dad got me to go into engineering. ‘It doesn't matter what engineering, just go into engineering, because you love math.’ And he was right-I do love math and problem-solving. They picked that up from a very early age.” Baxter Magolda and King (2012) note that “Students who are not yet able to author their inner psychological lives often allow external influences to derail their academic goals, jeopardize their identity development, or ruin their relationships” (p. 13).

Gradually, individuals move from an entirely external basis for determining life direction to constructing and cultivating an internal voice in the process of developing self-authorship (Baxter Magolda & King, 2012). For Lindsay, cultivating an internal voice meant making her engineering career into something that better fit her personality, and she now feels her internal voice maps her career path. Other participants expressed difficulty in confidently choosing a career path in the crossroads stage between trusting internal and external voices. Hua, an international student from Public University, expresses a sense of feeling trapped by the conflict between external and internal voices in regard to her career choices:
I am really struggling in choosing the career. I think something about money, something about my parents or my husband, like my family members, because they expect me to go to, to keep to research in universities…Possibly I should just go through this way. This will make everybody happy. And possibly, I will be happy with that.

The way Hua’s describes how she makes decisions corresponds to the “cultivating the internal voice” position of crossroads. Baxter Magolda and King (2012) describes “the ability to distinguish one’s own point of view from that of others” as “tenuous” (p. 78). In contrast, Liang’s comments imply a cultivation of her internal voice. She refers to external authorities as sources to consult and consider, but stills feels a conflict between these external sources and her internal voice as she chooses her career path: “Make my own decision, yeah. But even though I make my own decision by myself, it's still like the conflict is still there. I still need to consider those factors.” Liang’s consideration of others’ voices while making the ultimate decision based on her internal voice signals a move toward self-authorship (Creamer & Lauglin, 2005).

Another group of participants had a pattern of meaning-making that did not readily fit into any of the generally recognized stages of self-authorship development (as described by Baxter Magolda & King, 2012). Variations in development pattern serve as a reminder of inherent diversity of graduate women and the need to resist over simplification of the development process. Graduate students that did not fit standard self-authorship categories answered some questions in ways characteristic of individuals following external formulas and other questions in ways characteristic of self-authorship. However, participant responses did not indicate association with the crossroads stage of development. A total of 11% of individuals showed this bimodal self-authorship development (Figure 4.1), which avoided responses associated with crossroads. A hallmark of the crossroads stage is acceptance of a multiplicity of
views, values and beliefs (Baxter Magolda & King, 2012). The empirical nature of traditional or colonial science asserts that all knowledge is certain and verifiable (Cobern, 2000; Merton, 1973). The bimodal response pattern may stem from this traditional view of knowledge. Women who adhere to a colonial perspective may reflect a discomfort with uncertainty and privilege knowledge obtained through the scientific method (Carter, 2006). Participants’ bimodal response to survey questions may indicate that they have developed the capacity to identify and consider their internal voice, but still have not developed a complexity of meaning-making that accounts for multiple opinions and varying points of view. A second explanation for these survey results is that participants defer to external authorities in one or more dimensions measured by the survey used in the study (epistemological/knowledge, interpersonal/identity, or intrapersonal/social relations), but rely on the internal voice in other dimension(s). Baxter Magolda (2010a) notes in regard to narratives from a longitudinal investigation of self-authorship, that movement toward self-authorship often varied by developmental dimension. Achieving growth in one dimension of self-authorship before the others can make the decision-making process confusing, since the three dimensions intersect (King & Baxter Magolda, 2005). Chelsey, from Flagship University, self-authors along the epistemological dimension, yet demonstrates confusion when she considers future career decisions as she continues to look to external sources to define her identity. She relates her inward struggle:

I am hesitating right now. But, I don't know, I wouldn't be here if I hadn't made some really big decisions… So, I totally doubted myself. What if I made the wrong choice? What if this [degree] isn't going to make me happy like [my former boyfriend] would have? What if I just ruined my life because I made this huge commitment to school
instead of to this guy? I think that made it really hard for me to want to make commitments, because I was like, man, what if?

When asked about her career path, Chelsey instead speaks of her parents’ and advisor’s careers, ultimately making career decisions based on the views of these external authorities. As individuals increase in self-authoring capacity, they are able to mediate external influences as they internally define their own path (Baxter Magolda & King, 2012).

These findings related to self-authorship provide insight into how the experiences of women going through the same graduate engineering program may have differing psychosocial development, including self-efficacy and identity development. Women with different self-authoring capacities can be likened to two hikers taking different paths through a forest. Although the experiences are similar, women who rely on external authorities to define their views are more strongly influenced by the culture of graduate engineering programs.

**Confidence and Approach to Mistakes**

Development of confidence also moderates the influence of graduate engineering culture by shaping how women approach their own mistakes, weaknesses, and criticism. For some participants, mistakes and criticism, particularly those related to research, stimulated a self-imposed isolation. Other participants viewed mistakes and criticism as motivating self-improvement. The differentiated response is tied to participants’ confidence, which develops before graduate school and continues to be molded through experiences during graduate school.

Kelly, a doctoral student, compares her own response to criticism to that which she sees from male colleagues:

Less confidence means that when you get some kind of scolding and no tolerance for any kind of mistake, I think a man's general reaction tends to be, 'well it wasn't my mistake, it
was your mistake.' This kind of bantering back and forth goes on. Whereas, women generally tend to be 'oh I suck, I still suck.' I'm going to go back to my office now.

Kelly talks of how her confidence has decreased during her graduate program, which in turn causes her to isolate herself more from her colleagues. In comparison, Elise’s self-imposed isolation appears to be related more to lack of confidence she brought into her doctoral program.

I think I fear not making an impression more than messing up. There's a lot of support, in terms of getting questions answered and getting work reviewed if you want it to be and stuff. I just, it's like I don't want people to spend time on me if I can't make an impression. You know, if I am not helping out. They help me out, and if I am just barely getting by, they're kind of wasting their time on me.

Regardless of whether low confidence develops before or during graduate school, participants indicated that a lack of confidence and fear of disappointing others led to withdrawing from social interactions with colleagues. These informal collegial networks greatly influence the success of graduate student in understanding norms and expectations of the discipline (Gardner, 2005, Xu & Martin, 2011). Additionally, it is through these collaborations that graduate students and early-career professors form a reputation and visibility within their discipline (Xu & Martin, 2011). Without these connections, women may struggle to establish an academic career (Fox & Mohapatra, 2007).

In contrast, women with high confidence, particularly related to research, view mistakes and criticisms as motivational and tend to welcome interactions with colleagues. Doctoral student Inna speaks of her reaction to finding that she has made a mistake.
We can all make mistakes. We are not robots. And actually, I am very happy if I can find mistakes in my research, because that means that there is one mistake less. So, I am very happy that I can improve it. So, I am not afraid to make mistakes.

Diane talks about how she feared her inadequacies at first, but gradually, her experiences in a supportive research group have shown her that making mistakes is part of research. “I probably felt like making a mistake was more detrimental [in the past]. My project going through it, now obviously after several mistakes, it's not a horrible thing….I'm not afraid of that anymore.” Similarly, Erin says “I'm not worried about making mistakes.” Instead, she says, “I think my biggest inadequacies come from not realizing when to ask people for help. So, if I know that I'll be fine as long as I remember [to ask for help].” When Erin senses a weakness in a particular area, it motivates her to form stronger ties with her engineering colleagues at Flagship University.

According to Erikson’s psychosocial development theory (Erikson, 1950, 1982), several stages of psychosocial development contribute to an individual’s confidence. Of these, stage 3, initiative versus guilt, and stage 4, industry versus inferiority, are most relevant to graduate women in engineering. A Pearson correlation coefficient showed a strong positive correlation between these two confidence-related stages of psychosocial development, $r(110) = .66, p < .01$. Characteristic of development toward “initiative” is having a strong motivation, and act with self-initiative. In contrast, women developing toward “guilt” tend to fear making mistakes, and their fears bind them making action difficult. In the following stage of development, women developing toward “industry” have a strong sense of competence and ability to tackle challenges, while those developing toward “inferiority” have low confidence leading to a “lack of ambition” (Hawley, 1988, p.9). Erikson (1980) describes stages of development as “constantly lost and regained” (p. 128). Although Erikson indicated that the climax of both of these stages occurs in
childhood, interviews in this present study indicate ongoing development in these stages of development associated with confidence.

Interview comments also demonstrate the relationship between confidence and desire to connect with colleagues. Women who develop toward psychosocial “isolation” prefer to isolate themselves because of perceived threats to their identity. Conversely, women who develop toward “intimacy” welcome interactions and committed partnerships, because of a strong sense of identity. Both initiative versus guilt and industry versus inferiority scores correlated with intimacy versus isolation scores, $r(110) = .290, p < .01$, and $r(110) = .233, p = .01$, respectively.

If the culture of an engineering program works to build student confidence, graduate women will have greater openness to healthy collaborations with their colleagues and the freedom in which to form a strong central identity. The formation of a strong integrated identity is central to the overall development and strength of decision-making among graduate women in engineering.

**Struggle with Identity**

In the study, ability of participants to establish a central identity strongly correlates ($r \geq .325$) with all other stages of development, indicating the centrality of identity in the psychosocial development of graduate engineering women. Understanding how and why women develop identity is crucial to describing how culture affects development and likewise how development influences response to the culture of engineering programs. Seymour and Hewitt (1997), in a study exploring why female undergraduate students leave engineering, found that identity was involved with women’s sense of belonging and confidence. Seymour and Hewitt (1997) note that women entering undergraduate engineering programs with confidence, taking their “sense of identity for granted,” quickly “began to feel isolated, insecure, intimidated, to question whether they ‘belonged’ in the sciences at all, and whether they were good enough to
continue” (p. 451). Results from the current study indicate a similar connection between the identity of graduate women in engineering and their confidence and sense of belonging.

Erikson described the conflict between identity and identity confusion as an effort to reconcile how one is viewed by others with how one views self. In this reconciliation, they seek to find a “sense of continuity” and one central identity that links all of their life’s roles (Erikson, 1963, p.261). An established identity gives solid ground for career choice and commitment (Munley, 1977). Many participants described their struggle in merging their identity as engineers with their identity as women. Shirley, who works as she completes her master’s and had survey scores that indicate identity confusion, talks about how she feels a need to change to fit with other engineers. “I think more than anything else, my focus is so much on relationships and people. And when I get to work, it isn't that way anymore. I put on a professional hat and you go into a more working mode.” Etzkowitz, Kemelgor, and Uzzi (2000) argue that women need relational, collegial departments as safe places where they can take risks associated with innovation and find belonging and connection. For women like Shirley, a relational department may also be a safer place to explore and solidify identity.

Hua, a participant with low self-confidence and scores indicating identity confusion talks about the links between her confidence and identity. She says, “I'm kind of having problems with that, because I only want to show a part [of myself] to some specific group… I think that's because I'm not confident enough to show all my aspects to everybody.” Part of Hua’s hesitation to reveal herself comes from confusions about who she is and wants to be. “I feel there's a gap, I feel like I don't know who am I, and I don't know who I want to be. That's a really frustrating thing, because I am kind of exploring who am I.” Like Shirley, the disconnected personal dynamics of her department have made Hua’s identity crisis difficult to resolve. Because her
advisor discourages her from discussions with those outside her research group, she does not have any with whom she can discuss her identity struggles, let alone resolve them to form a solid integrated identity.

In contrast, Lindsay talks about how her confidence has grown as she answered questions about her identity.

I've grown more confident in knowing exactly what I want and who I am. In part, honestly, it's because, in the last two years ago, it was two years ago that I actually came out as being gay. And, I think that's a big part. Before then, I always felt that I wasn't quite comfortable in my own skin.

Lindsay indicates that within her department “there's a lot of support and guidance.” And consequently, she was able to find a central identity that incorporates all of her life roles, and does not sense that she needs to change persona to fit into engineering. Lindsay says her advisor “really pushes you to do what you want,” in other words does not push her to look like a traditional engineer but gives her the support and freedom to pursue a career that fits with her identity. Similarly, Chelsey senses that she differs from other engineering graduate students in skills and personality. However, these differences do not affect her confidence, identity, or sense of belonging. “I know what my skills are. So, I'm just trying to find a way to apply them in this field that I've chosen.” Instead of seeing herself as a misfit, her engineering program, which emphasizes interdisciplinary collaboration, convinces her that her differences are actually assets to her colleagues. Chelsey’s department reflects a shift consistent with a post-colonial perspective that individuals are each different, and their diverse perspective have real value in modern science and engineering (Carter, 2006).
Tabitha also feels that she does not fit the mold of an engineering graduate student she sees at Public University. However, a sense of inadequacy makes Tabitha unsure about who she is and where she should go in the future.

I feel like there's this set of successful characteristics that people say you should have. I see myself as a lowly little graduate student, nothing like any of them. I'm stuck in this mire, never successfully getting anything done… Then definitely I have hesitated to make major commitments, I guess because I feel I need to weigh them more or I'm not sure if I will make the right decision. A lot of times, I like to just wait and see what happens. Choosing to do nothing is really never a good option.

Instead of actively planning her future, Tabitha hesitates because she is unsure if her beliefs and feelings will change, which is a hallmark of identity confusion (Hawley, 1988). Clearly, Tabitha’s identity confusion influences her certainty about career decisions.

Indeed, formation of a central identity seems to increase satisfaction with career plans. A Spearman's Rank Order correlation between identity/identity confusion score and participants’ satisfaction with career plans indicated a moderate to low positive, but significant, correlation between identity score and career plan satisfaction, \( r_s(108) = .377, p < .001 \). These findings reveal how uncertainty about overall identity makes definitive decisions regarding career plans difficult for female engineering graduate students. For example, Shirley explains why she remains unsure and unsatisfied with her career plans. “I hesitate more because do I really want to do this?...It's more do I really want to do that or just stay comfortable where I am.” Much like Tabitha, Shirley prefers a passive career planning approach, stemming from an underlying lack of identity confidence. Jamie, a master’s student who recently committed to a PhD program, also indicates that her doubts about the solidness of her beliefs and feelings affect her career planning.
I feel like I'm just not sure. Oh, what if I don't like this anymore? What if I don't like getting my PhD anymore, I want to change to do something else? How easy would it be to change my mind if I do this? I don't want to make a decision. What if I don't like it anymore? I suddenly wish, I don't know why I would suddenly not like it if I liked it up to now.

Jamie’s identity confusion makes it hard for her to make concrete decisions about her future. In contrast, Jackie, a doctoral student with a strong central identity, talked about her confidence in her direction. “I’m pretty confident with what I want and how I am going to get there. And, I'm pretty happy with that, with who I am and how my life is working out.” Similar to participants in the present study, Kush and Cochran (1993) found that as the identity of their participants became solid, they had greater motivation and a stronger basis from which to determine a career path. Graduate women’s ability to form a central identity may be helped or hindered by the culture of their graduate engineering program.

**Differences in Developmental Response to Graduate Engineering Culture**

Graduate students develop as they interact with the environment of their graduate engineering program. Consequently, differences between the cultures of different engineering programs can lead to differences in the development of graduate students in those programs. For example, women from one university in mechanical engineering experience a different culture than women in a mechanical engineering program at a different university. Similarly, culture may vary by discipline, degree level (master’s or doctorate), or campus location (local, branch or distance). Developmental response to engineering culture may also depend on student characteristics such as age and background. Comparing participants’ development in relation to these factors builds a multifaceted and meaningful understanding of how graduate engineering
cultures influence women in graduate level engineering. While the discussion includes comparisons of development by university, degree level, discipline, location, age, and citizenship (Table 4.1), the intent is not to suggest that individuals within these categories are uniform, but rather to emphasize diversity and differences among “graduate women in engineering.”

Table 4.1: *Self-authoring of participants and chi-square test of independence results by key demographic characteristics*

<table>
<thead>
<tr>
<th></th>
<th>percent self-authoring</th>
<th>$\chi^2$</th>
<th>$\Phi$</th>
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<tbody>
<tr>
<td><strong>by university</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>52.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>44.4%</td>
<td>13.723</td>
<td>.186</td>
</tr>
<tr>
<td>Flagship</td>
<td>32.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>by degree</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>master's</td>
<td>41.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doctoral</td>
<td>44.0%</td>
<td>5.294</td>
<td>.381</td>
</tr>
<tr>
<td><strong>by discipline</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>biological systems and agricultural</td>
<td>60.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>civil and environmental</td>
<td>30.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrical and computer</td>
<td>42.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mechanical and material science</td>
<td>44.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chemical and bioengineering</td>
<td>37.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>other engineering fields</td>
<td>71.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>by location</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on main campus</td>
<td>40.9%</td>
<td>3.691</td>
<td>.595</td>
</tr>
<tr>
<td>off main campus</td>
<td>52.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-25</td>
<td>37.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26-30</td>
<td>50.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31-35</td>
<td>16.7%</td>
<td>24.314</td>
<td>.229</td>
</tr>
<tr>
<td>36-40</td>
<td>66.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41 and over</td>
<td>40.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>by citizenship</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S. citizen</td>
<td>44.3%</td>
<td>8.310</td>
<td>.140</td>
</tr>
<tr>
<td>International</td>
<td>40.8%</td>
<td></td>
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</table>
Variations by University

Although all of the universities included in the study have similarly high research intensity, ranking of their engineering program, disciplinary offerings, and rural location of the main campus, engineering programs at the three sites differ in overall culture of their engineering program, which may in turn influence development. Analysis indicates that participants at Flagship University had the highest average psychosocial development scores. However, when student citizenship status is taken into account, differences between universities narrow. Due to the extensive differences between U.S. and international students in regard to development and response to culture, Chapter 5 includes an in depth discussion of findings related to foreign-born students, and analysis throughout this chapter accounts for these differences.

U.S. participants at Flagship University and Public University had similar average total psychosocial development scores (M=113.0, SD=36.0; and M=109.8, SD=35.2, respectively), while State University students scored lower on average (M=96.2, SD=36.0). International students had lower average total psychosocial scores at all three universities studied. Among international participants, Flagship University students had the highest average psychosocial development score (M=92.1, SD=27.9), followed by State University (M=83.4, SD=47.6), and Public University (M=70.5, SD=36.8). A two-way analysis of variance, considering citizenship and university, yielded a non-significant small main effect of university attended on the total psychosocial development score, $F(2,104) = 1.57, p = .212, \omega^2 = .010$ (size of effect as noted in Sheskin, 2004). These results indicate that although overall psychosocial development varies by university, these differences are not significant when citizenship is part of the statistical model (Table 4.2).
Table 4.2: Citizenship x University Analysis of Variance for Total Psychosocial Development

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>F</th>
<th>ω²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) citizenship</td>
<td>1</td>
<td>9.301</td>
<td>.069</td>
<td>.003</td>
</tr>
<tr>
<td>(B) university</td>
<td>2</td>
<td>1.572</td>
<td>.010</td>
<td>.212</td>
</tr>
<tr>
<td>A x B (interaction)</td>
<td>2</td>
<td>1.135</td>
<td>.002</td>
<td>.325</td>
</tr>
<tr>
<td>error (within groups)</td>
<td>104</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Further two-way analyses by each stage of psychosocial development yielded no significant interaction effects between citizenship and university, but two significant main effects of university attended. University attended had a significant, but small main effect on scores for autonomy vs. shame and doubt (Erikson’s stage 2), $F(2,104) = 3.42, p = .036, \omega^2 = .058$ (Table 4.1). The Tukey’s post hoc test revealed that Public students scored significantly lower than Flagship students, $p = .020$, but State University students did not score significantly different from Flagship or Public University students. Features from the environment that may decrease autonomy and increase self-doubt include public shaming, especially when meaningless or arbitrary, and signs (true or untrue) that an individual lacks ability to “stand on their own” (Erikson, 1950). For example, Kelly shares her experience with shaming at Public University: “Mistakes aren't tolerated. In interaction with advisors or other faculty members, if a mistake is made at all, it's immediately pointed out and rubbed in your face as ‘you are obviously not an expert, you need to stop making mistakes.’” Lower scorers in the autonomy vs. shame/doubt psychosocial development stage tend to avoid self-expression, fearing the shame associated with exposure of inadequacy (Erikson, 1950; Hawley, 1988). In a graduate engineering program, a
student with a low score in autonomy may avoid taking risks, especially if they fear that it may reveal a weakness.

University attended also had a small effect on scores for identity vs. identity confusion (Erikson’s stage 5), $F (2,104) = 2.79, p = .066, \omega^2 = .030$. Although this effect was non-significant, a Tukey’s post hoc test was conducted because of an a priori hypothesis regarding differences between universities. The post-hoc showed significantly higher scores from Flagship students than Public students, ($p = .025$). International students in particular had lower scores, which Chapter 5 discusses further. The difference in identity scores between Flagship and Public Universities may indicate that the culture of engineering programs at Flagship in some way provides greater support to women in constructing identity. Conversely, aspects of Public University engineering culture may make it difficult for women to integrate the multiple facets of self (e.g. engineer, woman, graduate student) into one integrated self (Stewart, 2002). The continued colonial emphasis on binary definitions of gender complicates the integration of multiple facets of self and the formation of identity (Carter, 2006). Not having a solid integrated identity may weaken female graduate students’ ability to make commitments, as they fear that their feelings about the decision may change (Hawley, 1988). Lack of solid identity and the accompanying fear may make it difficult for them to decide on a career path and work wholeheartedly toward their goals.

The current study used two measures of development: 1) the modified Career Decision Making Survey (CDMS), which assessed self-authorship development in relation to Baxter Magolda’s theory (Baxter Magolda, 2008), and 2) the Measure of Psychosocial Development (MPD), which assessed general psychosocial development based on Erikson’s theory (Erikson, 1950). While both of these measures assess an aspect of psychosocial development and both
consider how individuals view themselves and their relationships with others, CDMS focuses on self-authorship and the way individuals define views of self and others, while MPD focuses on psychosocial development and what views of self and others individuals hold. Although Public University students struggle overall with solidifying an identity, results from the self-authorship portion of the survey indicate that students from Public are more likely to self-author their conceptions of self, relationship with others, and knowledge (Table 4.2). Public University had the highest percentage of participants self-authoring or transitioning to self-authoring among both U.S. (65%) and international participants (42%). While study results suggest that Public University students more frequently author their views of self and others, they are less likely to have solidified their identity than students at Flagship University. One possible explanation for these results is that engineering departments at Flagship provide a supportive environment for identity development. Participant descriptions of the culture at Flagship support this explanation (described more fully in Chapter VI). While supporting identity development, the culture at Flagship University may not support self-authorship development by challenging students to recognize the complexity of knowledge, identity, and social relations (Baxter Magolda, 2004).

By Degree Level

Since commitments and expectations of a master’s programs are different from that of doctoral programs, culture experienced by master’s and doctoral students can vary. These cultural differences may, in turn, influence development. Mean age of master’s (M = 27.1, SD = 6.4) and doctoral (M = 28.0, SD = 4.7) participants nearly matches, so any differences are not directly attributable to age. An independent t-test revealed no significant difference between overall development scores of master’s (M = 99.3, SD = 35.2) and PhD students (M = 91.2, SD = 41.7), t (108) = 1.10, p = .275, d = .21 (Table 4.3). Additionally, independent t-tests by each
stage showed no significant differences between master’s and doctoral students. A two-way analysis of variance, considering citizenship and degree, yielded a non-significant main effect of university attended on the total psychosocial development score, $F(1,106) = .132, p = .717, \omega^2 = .007$. Additionally, two-way ANOVAs on each stage of development yielded no significant main effects of degree level and no significant interaction effects with citizenship (Table 4.3).

Table 4.3: Citizenship x Degree Analysis of Variance for Total Psychosocial Development

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>F</th>
<th>$\omega^2$</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) citizenship</td>
<td>1</td>
<td>16.191</td>
<td>.123</td>
<td>.123</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>(B) degree level</td>
<td>1</td>
<td>.132</td>
<td>-.007</td>
<td>.007</td>
<td>.717</td>
</tr>
<tr>
<td>A x B (interaction)</td>
<td>1</td>
<td>.577</td>
<td>-.003</td>
<td>.449</td>
<td></td>
</tr>
<tr>
<td>error (within groups)</td>
<td>106</td>
<td></td>
<td></td>
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</tbody>
</table>

The lack of difference between master’s and doctoral students suggests that female doctoral students do not possess more or less confidence, clarity of purpose, strength of identity, or ability to commit to concrete commitments than their colleagues pursuing master’s degrees. Master’s and doctoral students vary significantly in likelihood of pursuing a faculty career, $\chi^2(3) = 23.1, p < .001$ (Figure 4.2), and several interviewed master’s students indicated that they viewed their master’s degree as a credential for a professional career rather than as a step toward becoming faculty. However, results indicate that these career motivation differences between master’s and doctoral students do not significantly influence their development.
Figure 4.2: Likelihood of participants pursuing a career as a faculty member by degree level.

Descriptive statistics reveal some differences between master’s and doctoral students with consideration of interactions between degree, university, and citizenship (Table 4.4). These results indicate that the master’s/doctorate dichotomy alone does not influence extent of psychosocial development. However, experiences of master’s and doctoral students may vary by university for U.S. and international women. Although U.S. master’s and doctoral participants did not differ significantly on any psychosocial development scale, international master’s participants scored significantly higher (M=10.19, SD=5.46) than doctoral participants (M=6.21, SD=6.26) in the area of initiative versus guilt, $t(47) = 2.32, p = .025, d = .68$. Low scores in initiative versus guilt indicate a constant fear of making mistakes, and lack of motivation and clear vision regarding what path they want life to take. Hua, an international doctoral student, demonstrates these characteristics. She says, “I feel kind of not that confident in front of people, because that's not my native language, that's not my place.” Additionally Hua indicated that if she gave advice to others from her country about coming to the U.S. “I would possibly suggest that they take a master’s first and test their ability of doing research and handling all of these
Further discussion of struggles unique to international female graduate students is included in Chapter 5.

Findings from the study indicate that factors influencing development are complex, and some groups of students struggle in psychosocial development far more than others (Figure 4.4). For example, international students in all sub-groups scored lower than their U.S. counterparts, U.S. master’s students at State University had much lower scores than other U.S. groups, and foreign doctoral students at Public University scored the lowest of any sub-group. Since the development profile for women in the age range of participants gives an average development score of 111, overall development scores of international women are surprisingly low. These nuanced results may provide insight for administrators seeking to better support their students and recognize areas needing improvement.
Table 4.4: Total Psychosocial Development Scores by Citizenship, University, and Degree Type

<table>
<thead>
<tr>
<th></th>
<th>Mean Score&lt;sup&gt;1&lt;/sup&gt; (n)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Students</td>
<td>108.3 (61)</td>
<td>35.7</td>
</tr>
<tr>
<td>Public University</td>
<td>109.8 (20)</td>
<td>35.2</td>
</tr>
<tr>
<td>Master's</td>
<td>115.7 (7)</td>
<td>35.4</td>
</tr>
<tr>
<td>PhD</td>
<td>106.6 (13)</td>
<td>36.0</td>
</tr>
<tr>
<td>State University</td>
<td>96.2 (13)</td>
<td>36.0</td>
</tr>
<tr>
<td>Master's</td>
<td>90.9 (11)</td>
<td>36.1</td>
</tr>
<tr>
<td>PhD</td>
<td>125.0 (2)</td>
<td>22.6</td>
</tr>
<tr>
<td>Flagship University</td>
<td>113.0 (28)</td>
<td>36.0</td>
</tr>
<tr>
<td>Master's</td>
<td>113.1 (21)</td>
<td>31.5</td>
</tr>
<tr>
<td>PhD</td>
<td>112.4 (7)</td>
<td>50.3</td>
</tr>
<tr>
<td>Foreign-born Students</td>
<td>79.8 (49)</td>
<td>35.7</td>
</tr>
<tr>
<td>Public University</td>
<td>70.5 (26)</td>
<td>36.8</td>
</tr>
<tr>
<td>Master's</td>
<td>90.9 (9)</td>
<td>38.2</td>
</tr>
<tr>
<td>PhD</td>
<td>59.7 (17)</td>
<td>32.0</td>
</tr>
<tr>
<td>State University</td>
<td>83.4 (5)</td>
<td>47.6</td>
</tr>
<tr>
<td>Master's</td>
<td>74.7 (3)</td>
<td>44.6</td>
</tr>
<tr>
<td>PhD</td>
<td>96.5 (2)</td>
<td>67.2</td>
</tr>
<tr>
<td>Flagship University</td>
<td>92.1 (18)</td>
<td>27.9</td>
</tr>
<tr>
<td>Master's</td>
<td>80.9 (9)</td>
<td>24.2</td>
</tr>
<tr>
<td>PhD</td>
<td>103.3 (9)</td>
<td>28.0</td>
</tr>
<tr>
<td>Grand Total</td>
<td>95.6 (110)</td>
<td>38.3</td>
</tr>
</tbody>
</table>

<sup>1</sup>The possible range for total psychosocial development score is -200 to 200.

By Discipline

A number of studies consider how culture varies by discipline (e.g. Austin, 1990; Gardner & Barnes, 2007; Golde, 2005; Lovitts, 2001). To consider how these different cultural contexts may influence development, engineering disciplines of participants were grouped into...
six meta-disciplines including 1) biological systems and agricultural engineering, 2) civil and environmental engineering, 3) electrical and computer engineering, 4) mechanical engineering and material science, 5) chemical engineering and bioengineering, 6) other engineering disciplines. Both one-way ANOVA and two-way ANOVA, including citizenship, revealed no difference in overall psychosocial development score by discipline (Table 4.5). The lack of differentiation by discipline may indicate that psychosocial development patterns are a response to culture at a local level, either department or research group, more than discipline-wide cultural characteristics. Similarly, no significant differences in self-authorship development between disciplines emerged. However, participants from nuclear engineering and engineering management scored the highest on average (71% self-authoring participants), and traditional engineering disciplines such as chemical and civil engineering had the lowest percentage of self-authoring participants. These differences by discipline may result from location specific characteristics, such as the presence of supportive female leaders as in the nuclear engineering programs included in the study. As one nuclear engineering participant spoke of the effect of having strong female leaders in her department, “There’s proof that in this field, you’re not going to be held down by a glass ceiling of sexism, if you’re really competent and really dedicated.” Discipline specific rhetoric, such as the degree of certainty in knowledge displayed in established scientific disciplines (Carter, 2006; Pinch, 1990), may also explain lower self-authorship scores. The view of knowledge as certain and empirically verifiable conflicts directly with the constructivist view of knowledge underlying self-authorship theory. Consequently, lower self-authorship scores among students from certain disciplines may reflect discipline-specific cultural views of knowledge. For instance, Claire, who is transitioning to self-authorship, talks about how taking classes outside of her discipline of mechanical engineering influences her thinking: “I
think it helps me work in teams a little better just remembering that people have different viewpoints, and that's okay.” Student descriptions indicate that the traditional view of knowledge in science as certain and empirically verifiable negatively influences self-authorship development by limiting views to those of experts and authorities. However, in newer engineering disciplines or more interdisciplinary based disciplines, these views of knowledge may be less entrenched. Indeed, comments of participants in some engineering programs seem to indicate a move toward a post-colonial view of science as “smart knowers and imperfect knowledge systems rather than the traditional view of imperfect learners struggling to learn the correct knowledge systems” (Carter, 2006, p. 684). Yet, findings from the present study indicate that constructivist views of knowledge continue to be rare in engineering departments. And, even within the same department, students may have widely divergent experiences based on whether the primary location of their study and research is on or off the main campus.

Table 4.5: Citizenship x Discipline Analysis of Variance for Total Psychosocial Development

<table>
<thead>
<tr>
<th></th>
<th>Df</th>
<th>F</th>
<th>$\omega^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) citizenship</td>
<td>1</td>
<td>15.776</td>
<td>.119</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>(B) discipline</td>
<td>5</td>
<td>.959</td>
<td>-.002</td>
<td>.447</td>
</tr>
<tr>
<td>A x B (interaction)</td>
<td>4</td>
<td>.831</td>
<td>-.007</td>
<td>.508</td>
</tr>
<tr>
<td>error (within groups)</td>
<td>99</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

By Campus Location

About 15% of study participants studied and researched off of the main campus either at a branch campus or a distance location. Since these students completed the majority of coursework and research apart from the majority of students and faculty in their department, their graduate experiences differed considerably from those of their counterparts located on the main campus. Some disciplines, such as engineering management, had a greater proportion of
students in distance programs or at branch campuses. On average, distance participants were older (M = 33.5, SD = 8.32) than main campus students (M = 26.4, SD = 4.30), and the majority of distance students (11/17) came from State University. Despite these differences and the differences in the learning environments of a main campus and a distance or branch campus, independent t-tests reveal no significant difference between main university campus students in overall psychosocial development (M = 94.6, SD = 38.3) and distance/branch students (M = 101.1, SD = 39.3), t(108) = -.643, p = .522, d = .17. Additional t-tests show no significant differences between distance/branch and main campus students on any stage of psychosocial development.

Although Chi-square tests revealed no association between participants’ study location and self-authorship development, more distance/branch campus students had scores indicating self-authorship or a transition to self-authorship (82%) than students on traditional, main campuses (60%). In interviews, participants such as distance student Diane, spoke of their transition to self-authorship. She says, “I do now enjoy just taking a prospect and go with it the way I think it should go. That was initially uncomfortable for me…But at this point and I think moving forward, that's a pretty cool thing.” Diane attributed her transition to comfort with “choosing her own path” to her distance from the supports of the main campus and the need for her to carve her own path.

While on the surface results suggest that distance and main campus students do not differ substantially in psychosocial development and self-authorship development, interview responses indicate variations in developmental struggles and strengths for distance students due to the culture of their engineering programs. Chapter 6 discusses these results further.
By Age

Since psychosocial development is a function of age as well as environment, older students should theoretically score higher on development indices than younger students. Participant age ranged from 22 to 54, with a median for U.S. participants of 25 and for international participants of 26. Participants were divided into five age brackets: 20-25, 26-30, 31-35, 36-40, and 41 and over. Spearman's Rank Order correlations reveal no significant correlations between age and any stage of psychosocial development for domestic and international students.

Additionally, Chi-square tests of independence showed no significant relation between age bracket and self-authoring category (external formula, crossroads, bimodal, transitioning to self-authorship, and self-authorship), $\chi^2(20) = 24.3, p = .229, \phi = .27$. These results may indicate that culture plays a more significant role in the affective development of women than age. The finding that participant’s age was unrelated to development is surprising, since both psychosocial and self-authorship development theories describe development as positively related to age (Erikson, 1950; Baxter Magolda & King, 2012). However, both theories also see development as a lifelong process. These findings may indicate that women in graduate engineering programs do not receive support necessary for affective development and their development remains at a standstill. The lack of development, in turn, influences how they view the culture and experiences of their graduate engineering program (Figure 4.3).

Figure 4.3: Relationships between culture and development
Development and Career Motivations

The development of female graduate engineering students contributes to decisions they make about their career and projections they make about their future career paths. Consideration of the motivations that drive career decisions provides insight into both the developmental position of the women as well as the culture that influences that development. Further, frequently emerging motivations may explain why some women remain in academic engineering, when they perceive a faculty career as harmonious with their values, while others leave academic engineering, when they perceive a disconnect between an academic career and their life values and motivations (Alpay, Ahearn, Graham, & Bull, 2008). As one participant notes, “I don’t think I could have made it this far if I wasn’t motivated.”

Women’s motivations develop over time in response to experiences and life situations. Betsy, a master’s student returning to school after nearly a decade in the workforce and raising children, discusses how her career motivations have changed since her time as an undergraduate student.

I feel like I thought long and hard about what major to go into grad school for and I'm aligned with it. Whereas, before I got into undergraduate, I didn't really know who I was. I didn't know what my goals and values were. I thought it was important to be smart and successful. I realized, after working and doing some [engineering] that that wasn't really important to me.

For Betsy, her identity development allowed for a clear picture of what was important to her, which in turn helped her decide what to study in graduate school. Similarly, looking at why graduate engineering women choose careers can reveal a great deal about their underlying development (Erikson, 1963; Foubert & Grainger, 2006). Major motivations for career choice
that emerged from participants included happiness and making a difference, teaching and research, family concerns, career flexibility, and preparation for a second career.

**Happiness, Fulfillment, Making a Difference**

Participants most frequently mentioned personal fulfillment and “making a difference” as a motivating factor in career planning. For many women in graduate engineering programs, the appeal of academic and professional careers in engineering lies in the potential to make a positive societal impact. In relation to Erikson’s theory of development, the desire to leave a positive legacy most relates to stage 7 of development, generativity versus stagnation. A deep interest and sense of success in improving the world for future generations provides evidence of the movement toward generativity (Hawley, 1988). While some participants saw faculty careers as providing opportunity to make a difference, others saw careers outside of academia as providing more of an opportunity to make a difference.

For example, Erin’s relatively high generativity scores indicate a high interest in making a difference for future generations. She describes her primary career motivation as “you know fulfillment…I was really fortunate to pin down and have a lot of those personality tests and assessments and seeing what I’m good at, what I want to do, and what the world needs me to do.” Erin pursues engineering to meet an internal sense of responsibility to benefit the world in a way suited to her talents. Degree of enjoyment in a career closely connects to feeling like what she does helps others. Similarly, Sema, a doctoral student with high interest in pursuing a faculty career says, “Yes I like to be an engineer, because it makes a difference. I like it. I like what I am doing” (emphasis added). And, Nadia, a mother and foreign-national, reveals her primary career motivation, “I really care about helping people, not only doing something for personal success and those things. The resources that can help people the most, I will be more happier.” When
these women consider possible career paths, they first ask, “Who am I?” Based on their development in identity and confidence, they next ask, “In which career will I have the greatest opportunity to make the most meaningful difference?” Alpay et al. (2008) also notes the importance of “making a difference” for female engineering students. When engineering programs focus attention on cultivating the connection between engineering and potential societal influence, strength of student motivation may increase (Alpay et al., 2008), particularly when female student’s confidence and identity allows them to see their potential influence. Conversely, if female engineering graduate students fail to perceive a connection between a career path and ability to make a difference in the real world, motivation for that career will likely weaken.

Study participants mentioned specific and general ways they envisioned contributing something useful through their engineering careers. Many participants perceived their potential to impact society as higher outside academia than within it, and consequently planned to pursue non-faculty careers. For example, Erin’s career goals revolved around designing prosthetics to improve the quality of life for people with lost limbs. Carmen indicated that her motivation to complete her doctorate came from her desire to improve air quality and monitoring in her home country. “I feel like what I choose to do is meaningful and the options that have come my way are because of something…I'm helping people. I'm doing something to improve technologies and to control this kind of problem.” Similar to Erin and Carmen, many participants spoke of a specific way they felt a career as a professional engineer could make a difference.

However, some women see opportunities to improve the world for future generations through a faculty career. Betsy speaks of her desire to train the next generation of engineers. She says, “I think one of the main reasons I would pursue [a faculty career] is because I want to
develop other women as engineers.” Kelly also indicates that concern for future generations motivates her toward a faculty career:

Leading by positive example is what I am hoping for. I hope that I can influence enough young people to respect each other, to enjoy the work, to work as a community, and to demand that of their peers. Then, maybe I can make a difference.

Kelly’s career goals revolve around changing the culture of academic engineering, specifically encouraging collaboration and respect of all peers, regardless of gender. While “making a difference” strongly motivated many participants’ career decisions, what career they envisioned as giving them the greatest potential to reach this goal varied considerably.

**Teaching and Research**

Some graduate women spoke of specific aspects of faculty life as providing the vehicle for making a positive difference. Of the various roles of faculty, participants most frequently mentioned teaching as a motivation to become faculty and something they anticipated enjoying. Kate from Flagship University talks about what motivates her to pursue a faculty career: “I also just love to teach…It just makes me so happy when people catch on to something and they learn, so that's definitely what I want to do.” Interestingly, many participants focused on the teaching role of faculty (e.g. “I'm going to get a PhD and teach”), while excluding or down-playing other faculty roles in describing why they wanted to pursue a career in academia. The motivation to excel in teaching causes some participants to postpone pursuing a faculty career because they sense inadequacies in their teaching ability. Lindsay says, “I don't feel qualified to just teach out of a book when I don't have any experiences….I want to be able to get that experience out there before I come back to teach.” Others, like Emily from Flagship, redirected their career path after experiencing the de-emphasis of teaching at research-intensive universities: “Had I known now
what I didn't know then, I probably wouldn't have started a PhD in the first place. My main motivation was to teach full time.” For graduate students like Emily, teaching provides the primary motivation to pursue a faculty career. As in studies of other disciplines (Austin, 2002), some graduate students received warnings from faculty not to show too much interest in teaching as it made them seem less serious about pursuing a faculty career. Erin talks about her frustrations about the disadvantages of putting effort into teaching:

I don't want to be in that scenario where it's so, it's a hassle to teach rather than to do research. My advisor said to get a teaching award or a graduate teaching award or something was the kiss of death. Oh that's sad!

Female graduate students who hope to make a difference by teaching and preparing the next generation of engineers spoke of receiving verbalized and implied messages from faculty indicating the low priority of teaching and student learning. Participants’ perceptions of faculty life were narrow and based almost entirely on the atmosphere of the graduate program at their research-intensive university. As in other studies (e.g. Austin, 2002), students’ view that making a difference is incompatible with faculty life can lead them to pursue a career outside of academia or at least outside research-intensive universities. Additionally, graduate experiences that decrease confidence in research compound women’s perceptions that they will not have positive societal impact if they continue in academia to become a faculty member.

Although most participants indicated a draw toward teaching and away from research, some students conceptualized research as providing a vehicle for meaningful change. Sema, a Public University student, speaks of her integrated view of teaching and research: “I like to give the courses and do the research and share my research with people and students and just teach them.” For Sema, the draw of faculty life came from the ability to research significant issues then
share that information with those who need it, including students but also other stakeholders. Others, like Public University student Jamie, remain uncertain that their research will ever contribute anything meaningful. Jamie says that she wants to become faculty to “try to contribute, of course, to science and do ground-breaking research. I don't know if I'll do any, but I guess that's the idea.” As Austin (2002) found in a study of graduate student socialization, graduate students’ difficult career decisions often hinge on their perceptions of self and where they can have the most meaningful career and life.

**Family**

For a number of female engineering graduate students, family provides the greatest career motivation. Participants expressed several motivations related to family including providing for family, benefiting family by making a difference more broadly, and not disappointing family members by failing to meet their expectations. While not all family-associated motivations relate to development, for some women discussion of family concerns in relation to career motivations reflects development in self-authorship or generativity.

For example, several participants mentioned how family expectations figured prominently into career calculations. Input from family may supersede an internal voice in regard to their career for some students who have not developed self-authoring capacity. For example, Hua speaks of how her career path is primarily motivated by the pressure to not disappoint family members. For other participants, not disappointing family members remains a major motivation, but career decisions are ultimately negotiated using an internal voice. Elise says that one of her major motivations is to “make my dad proud and make my family proud,” but she also has career motivations associated with starting her own family.
Concerns about ability to provide for family may also motivate graduate students to consider a faculty career. Elise notes that her life goals depend on her ability to provide financially for a family. As she considers her career options she asks, “How will it benefit my future family?” She wants to ensure that “whatever I do career-wise will support that… I do want to make sure that if I have the opportunity to provide a nice lifestyle for a child, I want to make sure I do.” For others, ability to support other family members provides the motivation to pursue a particular career path. Diane, a distance student from State University also feels a pressure to not let family members down. She says about how her children motivate her, “It almost gives me an urgency. I feel like it's more urgent to do something that influences the world a little bit…like I should contribute something before it’s too late for me.” By making a difference more broadly, Diane hopes to indirectly benefit her children. The strong concern for benefitting future generations characterizes individuals with high development in generativity, or stage 7 of Erikson’s development theory (Erikson, 1950). As Munley (1977) notes, “The identity and generativity crises appear to be of special significance to women, who in developing a career, may have to integrate their more traditional generative role as mothers and bearers of the next generation with a career” (p. 266). Participant narratives indicate that some female graduate students, like Diane, successfully integrate their identities as academic engineers and mothers, and others remain unable to do so in the context of academia. Whether graduate students perceived faculty life as compatible with family responsibilities related strongly to the degree of flexibility they perceived in faculty life.

**Flexibility and Variety**

The perceived flexibility and diversity of faculty work appealed to participants who desired an adaptable schedule for work-family balancing or appreciated variety and new...
challenges. Angela, who is still deciding on a career path, appreciates the ability of faculty to set their own hours. She says, “Even if in the end I find that I am working more hours than I would be if I were doing a nine-to-five job, I also feel that I can choose when those hours are. And, I do kind of like that.” Despite Angela’s struggle with consolidating her identity and committing to a particular career path, she senses that a faculty career will give her the space and freedom to negotiate her identity. Similarly, Chelsey identifies flexibility and ability to refocus as drawing her toward a faculty career:

I want to not do the same thing everyday forever. And I think that academia gives you a lot of flexibility. You teach a class, maybe for a few years. And then you can develop a new class or you can teach a different one. You're always doing different research.

Some students find the flexibility appealing because it allows them to adapt research to personal beliefs. Speaking about why she plans to pursue a faculty career, Inna says, “I like the freedom that you have at the university, being in the university faculty. You can research whatever area you like, right? And nobody tells you what to do. And basically you can choose based on your personal beliefs.” Inna, whose scores indicated self-authorship, appreciates flexibility because it allows her to set her own course. A study by Frome, Alfred, Eccles and Barber (2006) investigated women’s career decisions related to male-dominated fields and found desire for a flexible job the most significant predictor of women’s career decisions. Whether women choose to leave or stay in academic engineering may tie to their view of faculty life and whether or not they see the career as flexible. Most participants in the current study saw a faculty career as offering more flexibility than other career options, and consequently had greater motivation to continue in academia. Participants expected that a faculty position to be flexible, which also made it appealing for a second or post-retirement career.
Second Career

While some participants described academia as their primary career aspiration, other participants indicated interest in pursuing a faculty position as a second career or an “after-retirement” career, as a way to continue “making a difference.” Older participants, like Shirley, anticipated making a career shift within the next few years, and began graduate school for the purpose of preparing for this second career. If Shirley seeks a second career in academia as she plans, she will become part of the fastest growing segment of part-time faculty-retirees from another position (Schuster & Finkelstein, 2006). However, these motivations were not unique to older students, as several younger participants also anticipated taking on a faculty role after a professional career. For example, Erin speaks of her long-term career plans: “I see myself being a faculty member in a long time, like retired or maybe going as an adjunct professor from industry.” For younger participants, the draw of a post-retirement faculty career came from what they saw as a potential to contribute to the next generation of engineers, again pointing to the desire to make a difference as the overarching career motivation of female engineering graduate students. These career ambitions show how the standard view of the engineering academic pipeline is inadequate as it fails to account for these alternative pathways for increasing diversity in engineering.

As administrators endeavor to increase the numbers of women in the higher ranks of academia, understanding how and why women make career decisions is as important as what career paths women choose. Increasing the number of women in the upper ranks of academic engineering will require moving beyond a focus on individuals to the culture that shapes women’s development and career decisions. As women develop self-authorship capacity,
confidence and identity, they choose careers that fit with their motivations, even when it entails tackling challenges and continuing in the male-dominated field of engineering.

**Conclusions**

The development patterns of the study participants varied across different dimensions. These differences appear more localized and individual rather than representative of broad categories or definitions such as master’s/doctorate or age, indicating that cultures of some engineering departments provide greater support for development than others. Chapter VI explores which aspects of culture support positive development among female graduate students. One clear distinction in development pattern is the low psychosocial development scores of international women, which may suggest that engineering cultures and/or prior socialization negatively influence the development of international women. Chapter V discusses the experiences and development of international students in greater depth.

The relationship between culture and development is bidirectional, as culture shapes development and development influences how students experience the culture of their engineering department. The extent to which female engineering graduate students self-author their views of self, knowledge, and social relationships shapes how graduate engineering women respond to their particular departmental culture and self-authoring women have greater capacity to be resilient in the traditional or colonial male-dominated culture of engineering. Identity formation and confidence also influence what women perceive as their role in engineering culture and consequently how they approach career decisions. As women consider potential career paths, self-authorship and aspects of psychosocial development shape motivations and greatly influence how they make decisions. By encouraging self-authorship and healthy
development of identity, confidence and purpose, departments can encourage women to aspire to careers in which they can reach full potential and pursue their life goals.
CHAPTER V: INTERNATIONAL GRADUATE WOMEN IN ENGINEERING

International, or foreign-born, women comprise 46% of graduate women and 11% of graduate students overall in U.S. engineering programs (NSF, 2011). Yet, little research considers their experiences and affective development while in graduate engineering programs. International women’s graduate experiences and consequent development might influence the career decisions of this growing group of students. While the focus of the chapter is study findings associated with international participants, the intent is not to contrast U.S. students as normal and international students as deviant. Rather, analysis seeks to describe experiences of international graduate women and the diverse perspectives they bring to engineering. Literature related to the underrepresentation of women in engineering largely ignores international women’s experiences and perspectives. The present discussion compares international and U.S. women to highlight the diversity of women in graduate engineering programs and the importance of resisting an essentialized view of “women.”

The chapter begins with a review of demographic characteristics of international participants. Although participants are from diverse countries, they share many similar experiences in their adjustments and reactions to U.S. graduate engineering programs. Among these, international participants commonly expressed a need for belonging and connection within their engineering departments. Distinctions in the psychosocial development of international participants may shed light on how international female engineering graduate students respond to U.S. engineering culture and how their development may influence their career decisions.

Demographic Characteristics of International Participants

International study participants are currently enrolled in engineering departments at three universities in the U.S. Northwest, as previously described in Chapter III. In 2011, the
percentage of international women in graduate engineering programs varied at each study site: Public University, 14.3%; Flagship University, 9%; and State University, 3% (American Society for Engineering Education (ASEE), 2012). Overall, 45% of study participants are non-U.S. citizens (referred to as international students throughout this chapter). Of these, 57% are in a doctoral program and 43% are in master’s programs.

Nine international students participated in follow-up interviews, six of which identified as doctoral students. The study participants that were interviewed came from eight different countries, and had resided in the U.S. for different lengths of time at the time of the interview, ranging from less than 1 year to roughly 12 years in the U.S. Participants came from diverse backgrounds making it difficult to construct conclusions about any one group, but several themes common to international students emerged.

Differences in Educational and Cultural Background

Gender Parity in Native Country

Some international students spoke of how they had not experienced gender bias in engineering until coming to the U.S. Inna describes her department in her native country as having parity of men and women,

The department faculty were probably half and half, half female professors, half male professors. ...It was normal that a woman was a professor. ...Male, female, nobody cares.

You're a student that's all. Here it's a little bit different. This difference is clear.

Inna describes shock on realizing that bright American women in her classes believe that women are inherently less competent in math and sciences. She says about the biases she experiences in the U.S., “It's new and I don't like it. I think it should not be like this.” In comparison to American participants, many of whom mentioned gender bias in their undergraduate engineering
programs, none of the international students mentioned gender bias as part of the educational experiences in their home countries. Angela speculates that many of the gender stereotypes she has experienced in her U.S. engineering program are “cultural, or been developed over the years.” Indeed, although underrepresentation of women continues in engineering worldwide, some studies have shown slight differences in perceptions of women in engineering. For example, Bradley (2000) reported that women in economically less developed countries had relatively higher proportion of women in engineering and other technical fields than economically developed countries. As the economic profile of the country as well as the profile of engineering as an occupation rise, the number of women in engineering drops. In other words, the percentage of women in engineering is higher when the perception of engineering is less prestigious. Although most participants came from countries with fairly high per capita income, all participants in the interview phase of the study came from countries with lower economic profiles than the U.S. (World Bank Group, 2013). Participant accounts indicate that engineering faculty members are no less prestigious in lower income countries; however, professional engineers may not experience the same level of prestige as academic engineers. For example, both Nadia and Hua speak of how their parents pushed them to pursue careers as professors due to the perceived level of prestige and societal impact. Regardless of the reasons, international women may not expect or prepare for the gender stereotypes they encounter in U.S. engineering programs. In addition to adapting to stereotypes about their gender, many international women also talk of their socialization to the more individualistic style of U.S. engineering programs.

Collectivism in Native Culture

Many of the study’s international participants came from countries where collectivism is the cultural norm. Collectivism is a social system in which individuals give central importance to
the group(s) they are part of as opposed to the individuals themselves (Davidson & Foster-Johnson, 2001). In comparison, individualism puts priority on individual goals and bases motivations on individual needs or preferences. Research validates the usefulness of the individualism-collectivism spectrum in understanding work and student behavior (Davidson & Foster-Johnson, 2001; Tan & Goh, 2006).

In 2010, the five top countries of origin for students earning doctorates in science and engineering in U.S. engineering programs were all countries with collectivist-leaning cultures (Kuppens, Realo, & Deiner, 2008; NSF, 2011). Participants described ways in which even the practice of science followed a collectivist model in their home country. When students from these cultures arrive in the U.S. to begin a graduate engineering program, they find themselves in a culture steeped in individualism, since dominant U.S. culture and engineering culture are generally individualistic (Davidson & Foster-Johnson, 2001; Merton, 1973; Sonnert, 1999). Difficulties in adjusting to a strongly individualistic culture are common, as expressed by study participants.

Nadia, a doctoral student, speaks of differences associated with how advisors and advisees interact. “They do not teach us the same way like the professor here. Here, you are totally independent in your study and doing research…In [my home country], you are more dependent on the professor.” New independence can be distressing and confusing as international doctoral student Hua describes,

It's like the supervisor does not take very much care of you, he does not assign you very specific research topic, he does not push you very hard to make it done. So, I was kind of wasting a lot of time in searching around, learning whatever I can, but didn't form a very good PhD research topic. And finally, at the end of the second year I was here, I changed
my topic to another area. So, it's kind of I have to restart, do a lot more work than I expected to do.

For the first two years of Hua’s experience in her doctoral engineering program, she felt lost and uncertain of how to make progress outside of a team. Since individuals in collectivist cultures define their identity by their relationship and position within a group (Tan & Goh, 2006), inability to establish relationships within a group are likely to lead to identity confusion.

The pathway for identity and self-authorship development may also differ for women from collectivist cultures. Specifically, view of self is interconnected with relationships and is not autonomous, as in U.S. culture and in the cultural framework of U.S. academics. The stimulus for true self-authorship development may arise as women from collectivist cultures develop agency and confidence in making decisions that affect both themselves and others (Pizzolato, Nguyen, Johnston & Wang, 2012). However, self-authorship scores indicate that 59% of international participants do not fully self-author. Inability to take action in making career decisions may stem from a lack of self-authorship development and definition of self in relation to others.

Trice (2007) reports that students from highly collectivist cultures that move to a more individualistic culture have a “high need for social contact” and are disappointed when they are not able to form these connections. Although connections do not need to arise from collaborative work, those from collectivist culture tend to display greater comfort with team work (Davidson & Foster-Johnson, 2001). More importantly, women use these social connections to establish identity and understand group expectations (Tan & Goh, 2006). For international students from collectivist cultures, ability to harmonize with colleagues in engineering may be crucial for a
sense of well-being (Trice, 2007). Jazmine, an international doctoral student, speaks of her frustrations with the lack of interaction between colleagues in her U.S. engineering program.

We do not have that much collaboration or involvement, which I do love. So, I feel like more isolated... That's kind of not what I have expected. Because back home, the university where I got my bachelor’s and master’s, the labs are not faculty labs. They're labs for the department, so all the graduate students can use the lab. We used to talk to each other, exchange ideas. We got to know each other. But here, I do not know other graduate students from other faculty or other groups, because there's not that involvement.

Sema also speaks of how the individualistic culture of her U.S. engineering program differs from her experience in her home country, “In [my home country], it's like more people around you. So, you never feel lonely. So, here's like more laid-back, individual. So, I think that is the difference.”

Differences in development and interpretation of social relations give international women additional challenges in establishing a sense of belonging in engineering. Studies show that individuals from collectivistic cultures tend to act individualistic when communicating with those outside of their social group (Tan & Goh, 2006). Consequently, students from collectivist backgrounds may interpret individualist behavior from colleagues in their U.S. engineering programs to mean that they do not belong, which increases their sense of isolation. For women from collectivist cultures, the need for belonging and connection in their engineering programs may be amplified. However, as Hofstede (2001) points out, students from collectivist cultures may be unfamiliar with how to establish friendships and connections in an individualist culture.

**Belonging and Connection**

A major concern of international students in the study is whether or not they belong and fit into their department and college. All of the international participants indicated that they
initially had some level of concern regarding the ability to connect socially with their American colleagues. As they negotiate their engineering department as a new graduate student, they have many questions related to belonging: Should I integrate with Americans or remain with my own cultural group? How do I make friends? Will my language skills be adequate for social interactions? Will I be treated differently because of my nationality or appearance? Gradually, they begin to answer these questions. Fearing the loss of identity and social failure, some withdraw into isolation. A few international graduate women are able to establish relationships and connections with engineering graduate students outside of their cultural group, without losing their own cultural and personal identities. Others try desperately to adapt to their new situation, but sense that they lack the skills they need to connect. Among the skills needed to connect with engineering colleagues the ability to converse in a common language is crucial.

**Language**

For many international students the first hurdle to establishing connections with classmates and faculty in their engineering department is language. As Hua points out, lack of fluency in English is not only a barrier to communication, but also to a sense of belonging.

I feel kind of not that confident in front of people, because that's not my native language, that's not my place. So, I'm not able say whatever I want, and I have to watch people, how do they do it, and I have to learn from them. It's kind of hard.

Yang, Noels, and Saumure (2006) note that confidence in the host country’s language is an important factor in adjustment to the culture of the host country. Carmen, a doctoral student with fluent English, compares her interactions with American students to that of other international students who struggle more with English.
It could be the language. And I feel like we can have discussions about whatever topic in the lab that maybe I understand better than other people who haven't had experience before with it. I feel like they feel more comfortable and they will tell me, let's go for a beer, and things like that. But, not with the other [international students].

Malaya, another international student with fluent English, talks of the relationship between language and a sense of belonging in engineering. She says, “I can relate to the not being able to speak English right away...You know, as a group we're embracing this idea that people are coming in from different countries and we need to welcome them into this group.” In the same way that Malaya speaks of her empathy for the struggles of other international women, American women may also feel a kinship with both male and female international students.

**Connections Between International Students and Women**

If the stereotype of an engineer is a white male (Harding, 1991; Ward, 2008), then neither women nor the majority of international students, who are non-white, fit the mold. In addition to not sharing skin color with the majority of students, international students have additional markers setting them apart as a minority, including possible differences in language, religion, and other traditions. In some cases, the shared experience as minorities in engineering leads to camaraderie between international students and U.S. women. Claire, an American student, spoke of the connection she felt with international students in her program, “Talking with [international students], they've had similar experiences as I have had. So...we're in it together.” Similarly, Betsy, another American student, talks of how her interactions with a male international student reduced her sense of isolation.

Perhaps because I was able to relate to him and empathize, it made his experience better.

It's not just women that feel isolated in engineering. It's minorities in engineering; it's
anyone who's different than a white male, basically. So, that helped me understand that maybe I'm not as alone as I think I am. Even though we didn't have a lot to talk about and he had a lot of communication problems, we were able to relate to each other.

Interestingly, Betsy and Claire are from State University, which had the lowest percentage of international students (20%) of universities included in the study. Comments from other participants, both American and international, indicate that when there are greater numbers of international students, camaraderie between women and international students of both sexes is less likely to develop.

Despite the possible solidarity between women and international students as demonstrated by these stories, international women in the current study and others (Trice, 2007) often express difficulty establishing initial connections. Unsure of how to relate to their colleagues, international women may struggle to integrate into graduate engineering programs in the way they desire.

Integration

Jazmine, a master’s student, talks of her desire to integrate with American colleagues in part because she intends to stay in the United States following graduation. However, she says, “I still sometimes think I cannot make, you know, make friendships easily. I don't have many friends here. So, sometimes I start to think, what's wrong? What should I do? How can I fix it?”

Other international study participants had similar questions, counting the number of American friends they have made on one hand. Hua shares her concerns, “I don't know if I am doing good. I still feel like I am a foreigner. I'm not really one of them.” Despite Jazmine and Hua’s fears that the isolation they experience is the result of something they are doing “wrong,” lack of integration and connection may have just as much to do with informal structural factors within
engineering programs, such as emphasis on individual achievement or de-emphasis of the collective good.

Kate, an American doctoral student, notes, “I've noticed this in several science departments, [faculty and students] seem to segregate by nationality or ethnicity.” The cultural homogeneity of research groups of which Kate speaks contributes to the difficulty in integrating experienced by graduate women in engineering. Although usually not intentionally formed (Trice, 2007), members of a research group, including the lead faculty member, are often composed of individuals from the same country or region. When this occurs, international graduate women lack regular contact with American peers. Small or non-collaborative research groups can also contribute to international women’s isolation. Sema describes her first unsuccessful graduate experience as isolating. Now in a larger, more collaborative research group, she finds it much easier to integrate, “When I switched to this department, since I had more tools available and more people around me to learn more, it made a really positive impact on me.” For both international and American participants, the interactions that occur when international women are able to integrate is a highlight of graduate school. As Tabitha, an American participant, says, “One of the good things about being in grad school is getting to make friends across cultures and getting to talk with students.” The success of international women adjusting to cultural differences and forming meaningful connections in U.S. engineering programs influences their psychosocial development.

Psychosocial Development

Developmental outcomes are the result of an interaction between individuals and the culture or environment that surrounds them (Renn, 2003). Both cultural factors in students’ country of origin and nuanced challenges in graduate engineering culture potentially shape the
psychosocial development of foreign-born female graduate students. Psychosocial development theory presents a way to understand how women may change in response to culture. Erikson described psychosocial development along eight stages, each of which can resolve in either a positive or negative direction (Erikson, 1950). Measures of Psychosocial Development (MPD) follows Erikson’s theory of development with results including a resolution score for each stage and an overall psychosocial development total score. This section combines survey scores with participant interviews to consider developmental patterns of international women.

Figure 5.1: Psychosocial development of U.S. and foreign-born participants along Erikson’s eight stages of psychosocial development. * indicates significant differences between U.S. and foreign-born participants
Overall, international participants scored significantly different than U.S. students on the overall or total index of psychosocial development. In an independent-samples t-test, a significant difference existed between the scores for U.S. students ($M=108.34$, $SD=35.74$) and international students ($M=79.76$, $SD=35.68$) on the total psychosocial development score, $t (108) = 4.17$, $p < .001$, $d = .80$. Additionally, international women scored significantly lower ($\alpha = .05$) than U.S. women in six of eight psychosocial development stages measured by the survey (Figure 5.1). These scores indicate that international women resolve psychosocial conflicts, such as identity versus identity confusion, differently than their U.S. counterparts. Differences in psychosocial development may contribute to distinctions in how international women respond to the culture of graduate engineering programs and approach career decisions. Psychosocial development scores of international and U.S. women differed most strongly in resolution of three stages: 1) industry versus inferiority (confidence), 2) identity versus identity/role confusion, and 3) integrity versus despair (purpose). Differences in these development stages may reflect ways in which international women experience the culture of their graduate engineering programs.

**Sense of Competency or Inferiority?**

Successful negotiation of the industry versus inferiority area of development is crucial in the formation of self-confidence and sense of competency (Evans et al., 2010; Hawley, 1988). According to Erikson’s theory (1950), most participants experienced the climax of the industry versus inferiority crisis during childhood. Therefore, the experiences of international participants prior to entry into a U.S. engineering program likely contribute to low levels of confidence. However, since development is an ongoing process (Hawley, 1988), women continue to work out this important area of development throughout their graduate studies. International participants ($M=17.90$, $SD=5.96$) scored significantly different than U.S. participants ($M=11.41$, $SD=5.98$) in the resolution of the industry versus inferiority stage.
SD=5.71) on the industry versus inferiority scale of the survey, $t(108) = 5.79, p < .001, d = 1.11$. Mean scores among international participants indicate low self-confidence, which may be expressed as procrastination, avoidance of difficult tasks, and passivity. Hawley (1988) notes that low scorers may feel need to constantly move and accomplish tasks, while they avoid challenging tasks and maintaining a low sense of competency. Participant interviews confirmed and explained these tendencies among international women with low industry versus inferiority scores.

For example, Hua’s sense of competency and self-confidence continues to decline in response to her experiences in graduate school. In particular, she despairs about her research ability, fearing that research competency may never come. She describes her struggle with “whether I am doing good in research. Will I be really competitive in this area?” The culture of her individualistic department and research group does nothing to ease her concerns. To the contrary, she describes struggling to learn independently.

I have to get used to a lot of lab equipment to do that. And nobody is training you very well. You have to see what other people are doing and do it yourself… I found I'm really not good at doing experiments.

Instead of building confidence through successful completion of tasks, Hua’s sense of competency erodes each year she continues in her graduate program. Her lack of confidence to complete challenges makes her hesitant to begin them. She talks of her procrastination and “having difficulty in concentrating,” and how nearly everything sounds “much more fun than doing research.” Because of a sense of inferiority, Hua’s research has slowed and she fears her scholarships will end before she completes her research.
Similarly, a lack of confidence leads Angela to procrastinate with challenging tasks. She says that her lack of motivation to tackle challenges comes from a mix of laziness and fear of failure.

I fear certain things and I have to find a way to make myself do them. Because, I know that I will like them. I'll be glad that I did them and I'll enjoy them while I'm doing them. But, there's kind of an uneasiness about it…I'm just going to want to procrastinate. But, I know it will be worth something if I do it.

Angela, too, finds it difficult to concentrate and she admits “I sometimes don't know what I am doing in graduate school, because I don't know if I'm cut out for this.” However, in contrast to Hua, Angela believes the culture of her graduate engineering program builds her confidence. She says, “Lots of mistakes are made. It's definitely scary.” However, “I don't feel too bad about making mistakes, because I find that most people will be understanding about it.” So even though she faces many challenges and often fails, Angela’s confidence and willingness to take on challenges increases as she continues in her graduate program. Angela’s increases in confidence indicates that the supportive nature of her graduate program influences how she views herself and gradually increases her sense of competency.

Conversely, Carmen, an older international student who entered the graduate program with a sense of confidence, senses that her confidence has decreased since entering her current graduate engineering program.

I feel like my confidence within the lab, because of experimental stuff, because I am not used to doing engineering things, and I see how they react to many of the things I do. The confidence in that side has gone a little bit down.
For Carmen, the response of her colleagues to her mistakes decreases her belief that she can successfully tackle difficult tasks and challenges. Because Carmen remains at a crossroads of making-meaning based on external and internal sources, she struggles to maintain confidence. She says, “That's why I try to mentally work out why I'm not going to really let that get to me, because it's a stupid thing,” and yet low survey scores indicate that the lack of encouragement from research group members may have a lingering effect on her self-confidence. The level of confidence not only contributes to willingness to tackle challenges, but also influences students’ views of self and ability to form a cohesive identity.

**Identity**

The fifth stage of psychosocial development involves women asking and answering the question, “Who am I?” (Evans et al., 2010), which relates to the question “Who decides who I am?” in the intrapersonal dimension of self-authorship (Baxter Magolda & King, 2012). For some women, difficulties answering these questions arise as they attempt to integrate who they are in different realms of their life. Others struggle with dissonance between how others view them and how they view themselves (Baxter Magolda, 2010b). Inability to develop a core integrated identity leads to identity diffusion or role confusion (Erikson, 1982). Women with identity confusion may feel lost and weary from switching identities in different life roles. They are uncomfortable in their in their own skin and find it difficult to make decisions and commitments, fearing that basic convictions may change.

Comparing survey scores to average scores for women 25-49 years old (Hawley, 1988), 69% of international participants had lower than average identity formation. International participants (M=7.02, SD=7.12) scored significantly different than U.S. participants (M=12.15, SD=6.87) on the identity versus identity confusion scale of the survey, t(108) = 3.82, p = <.001,
$d = .73$. Since according to Erikson’s theory, the climax of this stage occurs during young adulthood, these scores likely indicate that international women may encounter challenges in forming a central identity during their graduate engineering programs.

One challenge to forming a central identity for female international graduate students comes from reconciling who they were in their native country with a “new” identity in the U.S. Hua describes her identity as in flux.

We are coming from a different country; we're not local people here. So, we may view ourselves as a different. It's so different when you're living where you've grown up. So, it's like you have to check yourself again and see who you really are and what you really want to be.

As international women adjust to the customs and culture of the U.S. and their engineering program more specifically, aspects may conflict with their personal and cultural identity (Zhao, Kuh & Carini, 2005). These conflicting identities can be confusing, and may result in international women isolating themselves as a way to protect their identity.

For some international women, a second challenge in forming a central identity comes from differences in how female engineers are viewed in the U.S. compared to in their native country. Nadia, an international participant with survey scores indicating identity confusion, talks about how some of those in her U.S. engineering program doubt her competency. “It's not clear all the time, but I have this feeling that I want them to forget about it, that I'm a woman.” In contrast, Nadia did not feel that others viewed her as less competent because of her gender in her home country. Nadia also speaks of juggling differing views of what it means to be a “good” woman in her home country compared to the views in the U.S. Consequently, she frequently shifts within her interview, at some points seeing motherhood as compatible with her engineering
career and other times describing them as completely incompatible. Similarly, Angela struggles to reconcile views of women in her home country with those she encounters in her current engineering program. She finds U.S. stereotypes “limiting,” because it inappropriately restricts everyone, making them fit into either the “male” category or the “female” category. Combined with her lack of confidence, Angela finds making concrete decisions, such as those associated with her career, difficult.

Many international study participants indicated that they did not choose to study engineering. Instead, several international women say that their father chose engineering as their career. The lack of control in career choice proved a major barrier to these women forming central identities, as they did not feel as though they fit as an engineer. Liang, an international master’s student, laments, “I am not so into engineer[ing]. But, I know my father's dream was to be an engineer.” Liang’s father decided that she should study engineering to fulfill his dream, and now that she has progressed to the graduate level, she feels stuck in something that does not fit her as a person. She says, “I'm still confused about what I am going to do in the future.” Similarly, Hua describes how her father chose engineering as her career. Because she is good at it, she feels obligated to continue.

I really don't know, because that's possibly the only way I can go. Not all people can go to graduate school, but I am selected. So, that's kind of my choice. I have to go. Then after going to graduate school, I'm kind of getting confused. I have to think about my future. Where should I go? What should I do? And, I'm trying to make myself fall in love with research.

Hua describes her confusion with the dissonance between how she views herself and how her family members view her. She recognizes the difficulties inherent with allowing external voices
to author her identity, yet she lacks the capacity to author it for herself. Baxter Magolda and King (2012) describe this phase as crossroads. Individuals in crossroads “see discrepancies between what others want for them and what they want for themselves, but they lack the confidence in and clarity about their beliefs and values necessary to act on what they want for themselves” (Baxter Magolda & King, 2012, p. 72). Consequently, Hua remains unsure and uncomfortable about her future career path.

Study findings indicate that for international participants like Hua, there are connections between identity development and other stages of development. Analysis of international participants’ survey results indicates a significant correlation between identity development and other stages of Erikson’s psychosocial development including autonomy versus shame/self-doubt (stage 2) \( (r = .64) \), initiative versus guilt (stage 3) \( (r = .53) \), industry/confidence versus inferiority (stage 4) \( (r = .54) \), generativity versus stagnation (stage 7) \( (r = .29) \), and integrity versus despair (stage 8) \( (r = .53) \). These correlations point to the centrality of identity development in the overall psychosocial development of international female graduate students. Women who are unable to resolve these conflicts of identity to form a central identity often feel that their lives are filled with misdirected energies (Erikson, 1982).

**Integrity Versus Despair**

International participants differed from American participants in degree of life regret and view of meaning and purpose. International participants \( (M=11.41, SD=5.77) \) scored significantly lower than U.S. participants \( (M=17.79, SD=5.45) \) on the integrity versus despair scale of the survey, \( t(108) = 5.95, p = .001, d = 1.14 \). The low scores of international participants related to integrity/despair is interesting, given that according to Erikson’s theory, individuals do not experience the climax of this stage until late adulthood. Additionally,
interviewed participants with low scores did not express despair across all facets of life, as is described by Erikson and others (Erikson, 1950; Hawley, 1988; Evans et al., 2010).

Instead, low scoring participants indicated a collectivist view of meaning and purpose. In collectivist cultures, goals and needs of the group supersede those of the individual (Hofstede, 2001). Definitions of purpose revolve around family and close relationships. Hua explains that although her career path does not provide her great meaning or purpose, “The meaning is complex, because that means your life is meaningful to your parents, to your family, to your friends. That's a kind of meaning; they are happy to have you and I'm happy to have all of them.” Similarly, Nadia finds her meaning and purpose in her family: “I think you have this one when you have kids…It's kind of possible. You have purpose and a meaning.” These forms of meaning and purpose were not well represented in the survey (Measures of Psychosocial Development), and unsurprisingly, women from collectivist cultures had lower scores in this area.

However, lower scores among international women may also reflect a lack of control in choosing engineering as a career. Of the lowest scoring participants, all had their major picked for them by a family member in some way. If international participants are unable to establish purpose in their career, they may lack motivation needed to succeed in academic engineering. Understanding the approach international women take to career decisions provides crucial insights for supporting them in academic engineering programs.

Cultural factors from students’ country of origin, like collectivism or family constructs, explain some variations between U.S. and international participants’ development scores. However, culture of an engineering program also greatly influences international students’ development, particularly in the areas of identity and sense of competency. International
women’s development, whether influenced by the culture of their home country or their current engineering program, shapes their career motivations and consequent career decisions.

**Career Decisions**

Career decisions of international graduate women in engineering arise in response to their cultural background and to the culture of engineering programs. Psychosocial development factors, including confidence, identity, integrity, and life purpose, clearly influence career decisions. Additionally, international women may feel their careers constrained by a combination of factors.

**Role of Family in Career Decisions**

Bradley (2000) notes that countries in which women have less freedom to choose their field of study generally have a higher proportion of women in engineering. Several international participants indicated in their interviews that the initial choice to study engineering was out of their hands. As Sema relates, “I think that is something cultural. When your father says, ‘This,’ then you just cannot say ‘no’ and go to some different jobs or areas.” International participants often made career decisions, such as whether to go into science and engineering or humanities, early when placed on a certain learning track in high school. Parents, in particular the father, remain the primary decision-maker in regard to career through to college. Although international women who had not personally chosen to go into engineering indicated greater freedom to choose their career path as students in U.S. programs, family remains a primary factor in all major life decisions. As Liang relates, “Even though I make my own decision by myself, it's still like the conflict is still there. I still need to consider [family] factors.” Similarly, Hua identifies her family as a major factor in her career decisions. In explaining why she intends to pursue a faculty career, she speaks of her family’s expectations rather than her own career goals. Since
Hua has yet to develop self-authoring capacity, external voices continue to dominate her decision-making process. Hua intends to remain in research, despite her lack of confidence and interest in research, to follow the path set by her family. In addition to limitations put on some international women because of irreversible decisions made by parents early in career development, women may sense a general scarcity of available career options.

**Scarcity of Options for International Students**

International female graduate student in engineering sometimes pursue a career in academia simply because they see it as their only practical career option. For instance, Jazmine a doctoral student, cannot return to her home country because of the political situation. She says about her career plans, “I try to be more like a researcher or…work for a research institute or a company. But, if I can't find something in that then the next option is becoming a faculty. But, that's not my first choice.” Although she would prefer to pursue a career in industry, she thinks it is more likely that her career will be in academia. “I may not have many choices,” she explains, “I'm an international student.”

Other international students may feel a scarcity of options due their lack of confidence in tackling new challenges. As Hua, who indicated a high likelihood of pursuing a career as a faculty member, said,

I know that research is difficult, but I really don’t know what I could do other than this. I mean as a PhD student you’re either expected to go to academic places, like universities or research institute or something like this…I don’t know; I’m not very confident in going [to industry].
Although Hua lacked enthusiasm for a career as a faculty member, she felt that she only had two choices and that her research competency was not adequate for industry. She was resigned to a career as a faculty member, either in the U.S. or in her country of origin.

The influence of graduate engineering culture on the career decisions of international women depends on developmental and motivational factors formed before and after their entry into U.S. engineering programs. An understanding of these career influences can help engineering departments in supporting and retaining graduate women in engineering.

**Conclusions**

International women represent a major portion of women in U.S. engineering departments. Understanding their experiences, challenges, development, and career decision-making processes is crucial to ensuring that efforts to increase the numbers of women in engineering focus not on a simplistic view of “women.” International women negotiate new challenges as they enter U.S. engineering programs, particularly challenges related to language, individualistic culture, and biases against women in the sciences. The developmental patterns of international graduate engineering women indicate struggles with confidence, agency, and identity, and these struggles are often exacerbated by the lack of support they receive from their graduate engineering department. In making career decisions, international women find their careers restricted by a number of factors, including not having agency in initial career choice and inability to secure employment outside of academia. Consequently, the international women who enter academic careers as faculty may not be equipped with the confidence and agency required for success in academic careers. To offer solutions for increasing the numbers of women who enter and succeed in academic engineering, calls for understanding the multiple layers of culture women negotiate as part of their graduate experience. For international women, cultural layers
include 1) their native country culture including previous educational experiences and cultural views of the role of women, 2) general U.S. academic culture and associated expectations, 3) general U.S. engineering culture including biases against women, and 4) the specific culture of their U.S. engineering department or research group. Support for women in graduate engineering departments, including international women, requires recognition of the diversity of women in engineering and attention to each of these layers of culture. Chapter VI expands on the idea of cultural layers and focuses on specific cultural practices at the departmental level that support and hinder positive development in graduate engineering women.
CHAPTER VI: INFLUENCE OF CULTURE ON GRADUATE ENGINEERING WOMEN

Research aimed at understanding the continued underrepresentation of women in engineering must take a holistic approach, considering the culture of academic engineering as well as culture’s influence on development and decisions of women. The intent of this chapter is to reveal the ways in which culture shapes graduate engineering women. Multiple layers of culture influence graduate engineering women, including their background or home culture, general engineering culture, general academic culture, and the specific culture of their graduate engineering program. The focus here is on the role of graduate engineering programs in shaping the development and career decisions of women in their programs.

Graduate engineering culture is neither homogenous across disciplines nor static in form. Instead, actions of individuals in engineering departments shape the culture of those departments, influencing whether or not the department is hospitable and supportive of female graduate students. Findings from the study provide insight into the aspects of graduate engineering culture that most positively and negatively influence the development of female students. The chapter includes a comparison of the cultural characteristics of each university included in the study, and then moves to a description of specific characteristics of engineering cultures that shape graduate women’s development. To conclude, the focus turns to addressing the overall research question: How does culture influence the development and career decisions of graduate engineering women?

Cultures of Engineering

The tendency in the literature about engineering programs is to paint engineering culture as uniform and unvarying in some way. The historical depiction of science and engineering
culture shows a consistently objective, and thus value and bias free culture (Merton, 1973). The rationale is that the academic, research sphere can be separated from the home and personal sphere. Because scientific research is supposedly free of emotion, a conclusion is that the academic engineering workplace is similarly emotionless and free of bias (Blickenstaff, 2005). Given the experiences shared in interviews from women in these departments, the culture is clearly not entirely rational and objective.

Other literature related to engineering culture also portrays it as uniform, but uniformly negative for women. This view sees engineering/science culture as discriminating and opposed to femininity by its nature (e.g., Gilbert, 2001; Harding, 1991). Since men founded science and set up the constructs of science, science itself is viewed as male and unwelcoming to women. Yet, the view that engineering culture is always hostile for women seems to conflict with views of some women in the present study who saw the culture of their particular departments as collaborative, welcoming, and even family-like.

Descriptions of engineering culture as either uniformly positive or negative for women define engineering culture and the nature of women too narrowly, failing to account for the diversity of women and differences in culture at the local level. The reality, as indicated by the current study’s findings, is that the women who enter graduate engineering programs are not identical, but come from diverse backgrounds and perspectives. Further, the cultures of graduate engineering programs are not identical and have varying degrees of reception for women. There are some places with definite “women-are-not-cut-out-for-engineering” mentalities and places where women report no unequal treatment. In some departments, male engineering students may view female colleagues merely as potential dates, whereas in other departments that same woman is treated as a valued researcher. Through the current study, one finding is clear: the
The culture of engineering departments is not fixed or definite. Instead, the nature of graduate engineering culture is the result of the actions and attitudes of the faculty, staff, and students that make up a department. The three university sites provide an example of how engineering culture varies at the university and departmental level.

**Overall Culture of Engineering Departments at Three Universities**

Study participants were currently enrolled in engineering departments at three universities in the U.S. Northwest, as previously described in Chapter III. The three universities, given the pseudonyms of Public University, State University, and Flagship University, have similar locations, Carnegie classifications (McCormick, 2001), and disciplinary offerings.

Among the three universities included in the study, Flagship had the highest percentage of graduate women satisfied with their decision to study engineering, (91% compared to 78% for State and 73% for Public). Satisfaction with the decision to study engineering is important since graduate students satisfied with their decision to study engineering had higher psychosocial development. Results of an ANOVA test show a significant influence of satisfaction with studying engineering on psychosocial development score at the p<.05 level, F(4,104)=5.76, \( p = .001 \), \( \omega^2 = .14 \). More Flagship students reported an overall positive graduate experience (10/11 interviewed participants) than either State University (3/7) or Public University (2/8). Public University students most frequently reported a negative overall graduate experience (3/8 interviewed participants), and State University students reported a mixed experience the most frequently (4/8 interviewed participants) of the three universities. Although these numbers are small they give a window into the experiences of graduate engineering women and differences in satisfaction at the three universities.
Descriptions of culture by interview participants integrated with development scores and other survey responses indicate further differences in the overall culture of the engineering programs at Flagship, State, and Public Universities. Differences in engineering program culture may influence development of female graduate students in those programs. Specifically, study findings confirm the connection between positive development and supportive graduate engineering culture.

**Unsupportive Engineering Cultural Characteristics**

As previously discussed the colonial or traditional cultural model for the sciences emphasizes intense competition and scrutiny, derision of emotion, and disconnection between work and home lives (Sallee, 2011; Wolfinger, Mason & Goulden, 2008; Seymour & Hewitt, 1997; Merton, 1973). As women go through graduate programs in engineering, they are increasingly immersed in this culture (Gardner, 2010). Since culture can influence and shape how individuals view themselves and their relationships with others, these perceptions may change over time in a process of development (Evans, Forney, Guido, Patton, & Renn, 2010; Renn, 2003). As Jackie, a doctoral student from Public University notes, “You are very much encouraged to think in the way that engineers think and to be the way that engineers are. And, nobody ever evaluates if that is an acceptable way to think and be.” Jackie’s description of culture at her university reflects the entrenched nature of cultural norms in engineering. This section explores each of the themes that emerged from the words of women who would describe their overall graduate experience as negative or their departmental culture as unwelcoming. Survey results, combined with participants’ descriptions, provide evidence of how these cultural characteristics shape women’s development and career decisions.
Constant Need to Prove Competency

One attribute of departmental culture that can negatively influence the development of graduate women is the persistent need to prove competency. Female graduate students sense they have to measure to a higher standard than their male colleagues. Jamie, an American master’s student from Public University, talks about her experience: “It’s kind of intimidating. I feel like I have to prove myself extra, because being female, it’s typically like, ‘Oh, you probably don’t understand this math.’ Actually I do understand it fine.” Indeed, Jamie’s experience appears to be common for women in traditionally male disciplines, where women report being viewed as nice, but not serious researchers (Katila & Merilainen, 1999). In other words, the cultural norm is to view female engineering students as incompetent until they prove otherwise. Shirley, an older American student from State University described it this way:

You’re testing that kind of attitude…If you can’t ace the test, because you’re struggling in the class, then you struggle through the whole thing, because that attitude doesn’t change for some people…The hardest part is just that attitude that you’re going to suck in classes because you’re female.

Need to prove competency is repeated in any new engineering group. For instance, Inna, an international doctoral student from Flagship, describes her advisor and research group as respecting her research ability, but new colleagues tend to judge her on her appearance. “I mean people that know me and know how I work and know my papers, they don’t care; they know that I can do my work. But, for example, people who don’t know me… they don’t think that the woman can be well-dressed, looking good, and smart at the same time.” Inna’s new colleagues question her value as a researcher due to their narrow view of what it means to be an engineer, a view that equates feminine characteristics with lack of scientific ability. According to Alpay,
Hari, Kambouri and Ahearn (2010), the constant need for women to justify their presence with exceptional ability is common in scientific research settings. Female graduate students are simply held to a higher standard than their male colleagues.

For some women, this culture can lead to self-doubt, particularly when they experience setbacks. Claire, a doctoral student from State University, described her battle with self-doubt in an unsupportive culture and relates, “Yeah, it takes awhile to figure it out that everyone’s failing. And it’s not just you and because you’re a girl.” In Claire’s case, her self-doubt led her to fear asking questions that would reveal her lack of understanding. For women in science and engineering fields, fear of revealing hidden ineptitude is common (Pell, 1996) and may result from Imposter Phenomenon or the belief that “one’s accomplishments came about not through genuine ability, but as a result of having been lucky, having worked harder than others, and having manipulated other people’s impressions” (Langford & Clance, 1993, p. 495). Feeling like an “imposter” and having an exaggerated view of their own lack of competence, female graduate students avoid asking questions and social connections that may reveal their imagined lack of competence. Lopez (2009) notes that women who describe their departments as unwelcoming may show more signs of the Imposter Phenomenon.

Other women develop unrealistically high expectations for themselves, because of the constant need to prove competency. Kate, an American from Flagship, relates, “It’s for so long, I’ve been held to this higher standard that now the higher standard is what I hold myself to.” Similarly, in a study by Ivie and Ephraim (2009), women became increasingly more likely to doubt their ability, despite evidence to the contrary, the longer they stayed in graduate school. To summarize, a culture in which the standard for women is higher and based on gender demands that women constantly prove their competency. The constant need to prove capability not only
results in self-doubt, but also results in isolation among high achieving female graduate students. A sense of isolation may increase in cultures that emphasize competition over connection.

**Competition and Lack of Collaboration**

Given participants’ comments, competition by itself does not seem to negatively affect either graduate women’s development or their perception of their graduate experience. However, when the competition is between individuals identified as part of an individual’s group, or professional family, then the competitive culture seems to have a negative influence on graduate women’s identity, sense of confidence, and satisfaction with academic engineering. Carmen, an international doctoral student at Public University, talks of the struggle she has with maintaining her confidence and identity in the competitive culture:

They’re used to produce, produce, produce, and I don’t think many of them are thinking… I completely understand that that is part of the dynamic that goes through the whole process of grad studies in any lab, a male lab where they are all dudes and want to prove or whatever. So, I don’t have a problem with that, I know that’s the thing. I know who I am. And, I’m pretty sure here in a year and after the summer getting into the lab, I’m going to be able to handle the boys and the things in the same way that they do, so I don’t really feel that terrible.

Although Carmen feels confident in her identity, she also looks forward to the day in which she can keep up with the “boys” in her research group, so she does not feel “terrible” about her own competency in the lab, which is evidenced by her low development scores associated with confidence. Kelly, also from Public, struggles with her confidence due to the competitive culture within her own research group. She explains, “Mistakes aren’t tolerated. In interaction with advisors or other faculty members, if a mistake is made at all, it’s immediately pointed out and
rubbed in your face as ‘you are obviously not an expert, you need to stop making mistakes.’”

Kelly’s response is to isolate herself as much as possible from individuals in her department, because she senses that any attention she might get would be negative.

Other women felt constrained by the competitive culture they saw among faculty. Sema, an international doctoral student at Public University, describes how her advisor responded after she attempted to collaborate with other faculty in the department:

So, those kinds of things were really limiting and bothering me. And, then the next time, when I was going to ask a question, I was like maybe I shouldn’t, then my advisor will be mad at me or something, or just the attitude more like hide your research. Don’t asking (sic) anybody, just do your stuff and I was just kind of limited.

Sema reacted by isolating herself, which eventually led to decreased confidence and overall motivation for research. Discouraged, she made little progress with her research until she transferred to a new department.

The theme of competitive culture also appeared frequently in participant’s descriptions of previous, negative educational experiences. Participants often cited competition without collaboration between colleagues as a reason for women leaving a graduate program or switching research areas. Betsy, an American graduate student from State, speaks of her morale directly after her highly competitive undergraduate experience, “I think that I would have become more introverted, less communicative, and less confident. Because, by the time I graduated, I was pretty beat down on my confidence...I just became a ball of insecurities.” Similarly, Kate describes her undergraduate program as having cutthroat competition. She says simply about her previous department that was in the same academic discipline as her current program, “That was rather depressing environment to be in.” Both Kate and Betsy carry their
past educational experiences into their expectations of what it can mean to be in academic engineering, and consequently, both the past competitive and current collaborative department cultures affect future career decisions.

Despite a desire for a more collaborative culture, women find that not participating in the competitive culture is sometimes perceived as a weakness. Malaya, a Flagship master’s student talks about the drawbacks of her more collaborative approach, “We can work through the problems instead of blinding competition with one another. But again, that’s also a negative thing, because that’s not how I want to be seen as, just a little kid my entire career.” Malaya fears that others view her attempts to work cooperatively as evidence of her lack of competency, and results in her treatment as a “kid” instead of as a respected colleague. Women like Malaya struggle as they feel their identity as a collaborative woman conflicts with an engineering culture that some participants describe as “male.”

**Male Culture and Differential Treatment**

Most women in graduate engineering programs begin their graduate career expecting that their classes and research groups will be dominated numerically by men. As participant commentary and the literature indicate, gains in the number of women in a department do not translate directly to cultural change (Erikson, 2012). It seems that it is not the percentage of men in a department that makes women feel out-numbered. Instead, it is the perception that they do not fit because of their sex. As Jackie, an American doctoral student from Public University describes, “There’s definitely a boy’s culture that’s palpable, but I’ve never really been a girly-girl, so that wasn’t so much of a problem until people started assuming that I wasn’t a scientist, that I was just part of the background.” In other words, Jackie was not concerned about her status
as the only women in a group of men, until she realized that she is treated differently because of this difference.

Women in male cultures often describe a perception that they are somehow on the outside looking in; because they do not fit the norm, they face exclusion from full participation in their discipline. Exclusionary practices reflect the underlying privilege of male engineers, who fit cultural norms. For example Kelly from Public talks about how rewards for and celebrations of achievements are rarer for women than they are for men:

There’s been plenty of women who have gotten some pretty awesome scholarships and awards in our department and it has not been announced or celebrated in any way. And when the guys typically get the same kind of things, it goes announced, celebrated, it gets put up on the webpage, lots of nice things happen. So, there’s a bias.

Instead of getting commended for successes, women feel that there is greater attention drawn to their shortcomings. Carmen from Public describes how she senses that her presence is tolerated, not welcomed, “You are tired, you get emotional or something like that, it’s like they kind of look and ‘uh, we have to live with this girl here?’” Male cultures view women as weak and not tough enough to handle hard work.

Sometimes engineering colleagues reveal these underlying beliefs verbally. Claire, a State doctoral student from the U.S., gives an example of how faculty single her out, “I would like you off the team” a faculty member once told her, “So I can talk to everybody man to man with the rest of the group.” Other interview participants said that male faculty members confess to them that they are at a loss with how to treat their female students. For example, Sema, a Public University doctoral student, talks about how her new advisor struggles to know how to relate to her, one of his few female students, “Sometimes he is like, you know if you were a guy,
I would just tell everything, now I am thinking because you are sensitive and I don’t know how to have the female students.” Whereas Claire’s situation had the effect of confirming to her that she was an outsider and not welcome, Sema saw the desire to change in her advisor, which made her feel that although she was in a male culture, at some point she may be welcomed as a valuable group member. Unfortunately, not all faculty members encountered by women in engineering indicated a similar desire to adjust their views of women in engineering.

**Overt Sexism and Covert Sexism**

As many participants confirmed, overt sexist behavior is waning (National Academy of Sciences, 2007). However, Claire from State points out that dealing with overt sexism is still a reality for women in some departments, “A lot of people just ignore it, thinking it can’t be happening today because it’s the 21st century.” While many women described sexist behavior as the “exception, not the rule,” it is clear that some departments dismiss sexist comments or behavior more frequently. “There’s a lot of bad behavior that gets perpetuated, because nobody likes to say anything to each other about it and the department doesn’t really want to take the authoritative stand of saying this is not appropriate behavior,” says Kelly about the condescension and critical remarks about her scientific ability she receives from colleagues in her department. Although there are only a few individuals with sexist views or behaviors, other faculty do not intervene to confront the behaviors, which perpetuates a culture that leaves Kelly feeling unwelcomed and untrusting of the department as a whole.

Women in graduate engineering programs may also struggle to prevent internalization of the sexist beliefs pressed on them through these behaviors. Claire relates,
When I had these instances in class with professors not being appropriate, it’s just like, ‘Ah, it’s me again.’ And really, it’s not me. It really kind of shakes me for a little bit and takes me awhile to remember, okay, they’re not being professional. Let’s keep going.

Even occasional experiences with sexism in an academic department can push women into isolation, while affecting their identity and level of confidence. Additionally, some participants, as in other studies, are quick to dismiss subtle forms of discrimination, even when they served to confirm stereotypes (Alpay, Hari, Kambouri & Ahearn, 2010).

While participants described those displaying sexist behavior as uncommon, several participants described discomfort with the perception that they are in some way abnormal because they chose to study engineering. Betsy, an American from State talks about how students and faculty alike frequently commented on how strange it was that she was studying engineering as a woman.

I was constantly confronted with women shouldn’t be engineers and it’s not natural for me to be an engineer. I must be a unique women to be an engineer…I was confronted with it over and over, even by professors who felt that physiologically women weren’t designed to be engineers.

While those who commented used terms such of “unique” and “special,” participants perceived the underlying meaning to be that women in engineering are abnormal women and must have in some way compromised their femininity to study “masculine” engineering.

When women dress or act in ways perceived as feminine, they may find assumptions about them shift. Jamie, an American master’s student from Public, describes behaviors she has learned to avoid as an engineer, “Like with the dressing and like the watching out for the female mannerisms, so you won’t seem so ditzy. Otherwise, you won’t be treated like a professional. I
feel like that.” Other participants talk about how if they dress and act in feminine way while in engineering, male colleagues perceive them as seeking a spouse. Participants describe a need to adapt masculine dress and mannerisms to have their research taken seriously. These comments indicate that the culture of these departments continues to view women who are successful in engineering as exceptions to the norm, maintaining the stereotype that women are ill-suited for engineering.

Unwelcoming Culture

Stereotypes, covert and overt sexism, and the perception that colleagues constantly question competency all contribute to an unwelcoming culture. Kelly, a doctoral student talks about the culture in her department:

I would describe it as awkward at best....If you are a more senior female, the question tends to be why are you still here? What are you doing? Why are you dragging your feet so much? ...So, for that reason, I’m feeling more and more unwelcome here every semester I’m here, still.

Instead of feeling as though her research and contributions are valued, Kelly senses that her continued presence is viewed as proof of her incompetency or laziness. Although she has not let it affect her confidence in herself, how others perceive her has dampened Kelly’s ambition and greatly increased her fear of making mistakes. It’s made it difficult for her to form a central identity as she, in her words, goes “outside of the department to look for my social interactions.”

The lack of welcome has also made her rethink her plan to pursue a faculty career:

I think a lot of times especially within academics...people from outside view us as this ivory tower approach to the world and the reality is that I get beat up every single day in one way or another, whether it’s emotionally or whether it’s having to do with my work,
which I’m not supposed to be emotional about…this has been a long time dealing with
that. And then to have to climb some extra academic ladder, whether it’s tenure or
something else, there’s got to be something fulfilling somewhere along the line,
otherwise it’s not worth it.
Because Kelly views her department as the place where she gets “beat up,” she tends to isolate
herself from others in the department. The isolation, partially self-imposed and partially imposed
by others, decreases her ability to have meaningful professional relationships with her colleagues,
connections she will likely need if she continues to pursue a faculty career. Indeed, appreciation
and welcome from faculty, and particularly an advisor, is a crucial consideration as women plan
their future careers.

Unsupportive Advisors and Faculty

In speaking of their overall graduate experience, students repeatedly commented on the
status of their relationship with their advisor. Students with particularly negative graduate
experiences often cite their advisor as a factor in that negative experience. Ana, a Hispanic
Flagship master’s student, talks about how her passion for her research has waned since
enrollment in graduate school, “I was just thinking about when I started here, I was super excited
to start in my research and learn. And well, with my advisor it’s like I said, it makes it difficult
for me to be excited about it, because I just dread seeing him.” Sema speaks of why she thinks it
is unhealthy to ignore personal differences with an advisor,

I would say mentoring is very important in the graduate studies. I mean, just talking
about from my own experience… It’s like a long term relationship. So, it’s kind of
impossible to just leave your own personal thing and just focus on research and just do it.
One such personal difference was an advisor’s lack of confidence in their female student’s ability. Claire, who is single and does not have any children, explains why an advisor at State doubted her ability to complete her degree, “I really think it was because I was a woman student…He was like ‘My wife only took care of kids, so I don’t know how you’re going to go through your degree.’” Similarly, Betsy, another student from State tells of her advisor’s reaction when she mentioned the possibility of getting pregnant while in graduate school: “He told me that, point blank, he would be very disappointed if I got pregnant.” Both Claire and Betsy cited lack of experience with women in engineering as contributing to the advisor’s assumptions about their female students’ ability to research and do engineering. Although Betsy was able to work with her advisor and reports that their current advisor-student relationship is healthy, Claire described how her now former advisor continued to doubt her competence despite evidence to the contrary, even passing her research to men in the research group.

Although perhaps not as central in the graduate student experience as an advisor, other faculty members also contribute to how hospitable departmental culture is for female students. In particular, participants pointed to the actions or inactions of department and college leaders as setting the tone for expected behavior. Claire, an American from State spoke of her experience with a leader in her college who told an audience that he did not “want to hear about the women’s issues whatever they might be.” While few women indicated hearing vocalizations of this undercurrent of beliefs, many indicated that they felt something amiss. Kelly, an American doctoral student from Public University described the reception she received from faculty and the overall culture of her department:

You don’t quite feel like you belong there, like you should be there, like your advisor wants you there. And then every year that passes, instead of celebrating your successes
and becoming more and more part of the community, part of the fabric of the group, you’re more and more asked, ‘Why are you still here?’ And, I think this combination is heartbreaking.

What these findings from surveys and interviews indicate is that the cultural context of graduate engineering programs does influence the development and career decisions of women. Several cultural factors compound to increase isolation and confuse identity for female graduate students, making academic engineering unappealing as a career including 1) the constant need to prove competency, 2) toleration of sexist and inappropriate behavior by faculty and peers, 3) lack of connection and support. However, results of the study indicate that engineering culture is not uniform across disciplines or colleges.

**Supportive Engineering Cultural Characteristics**

Graduate engineering cultures that support women’s psychosocial and self-authorship development do exist. The themes discussed in this section emerged from the words of women who would describe their overall graduate experience as positive or their departmental culture as welcoming. Survey results, in combination with participants’ descriptions, provide evidence of how these cultural characteristics shape women’s development.

**Collaboration and Connection**

Participants described collaborative or family-like culture as positive and supportive. Consistent with the literature, female graduate students prefer collegial and cooperative cultures that emphasize connections and networking (Chesler & Chesler, 2002; Etzkowitz, Kemelgor, & Uzzi, 2000). Collaborative culture does more than simply make women feel good about their experience, it also increases motivation and self-efficacy. Chelsey, an American master’s student from Flagship University, compares the culture she has experienced in her engineering
department to a non-engineering department: “In engineering, it’s a lot more collaborative. People want to help you. We’re all trying to get through this together. I think engineering is very different, because we’re all experts at our own thing.” The collaborative culture gives Chelsey the sense that her colleagues value her contributions, building her confidence and desire to continue in engineering. She continues on to say “It’s competitive in its own way. But, I would say it’s more like golf where you just want to see how well you can do.” In other words, competition is a motivation for improvement without leading to isolation. Other students described the competition in their department as similar to that in a team sport, where there is a group-level view of success and failure.

Participant comments point to a culture of collaboration and connection as a primary vehicle for improving research quality and research confidence. Interviewed participants referred to their research groups most often as the place where collaboration and connection occur. The level of collaboration at her satellite campus community in comparison to her previous educational experiences excited Diane, an American student from State University: “It’s pretty interesting because you hear other people’s ideas, how they think it would work, just trying to get it off the ground.” Diane attributed her growth in knowledge of a new research area to the collaborative community. Other students describe profound relief when they realized that their new graduate program was not as competitive as those experienced previously: “Then I came here, and I think I came here kind of ready for this to be really intense…I kind of had to step back a little bit and relax a little bit.” Amanda, a Hispanic doctoral student from Public University, speculates that it is the collaboration between students that has made the difference. Similarly, Sema, a Public University international graduate student, described how a switch in departments and research groups improved her research and increased her confidence.
We just share our data; showing and just talking about the research makes it more enjoyable. So, if there is nobody is around, for me, it was like why I am doing this? It doesn’t make sense…If there is something interesting, they may realize that I don’t realize what I’m doing. So, it helps really to improve the research also. And for me, I feel like I am improving myself, too, because when people are around, if there is something that I need to pay attention more, so if someone tells you, then okay, I didn’t think about it. Good, thank you-then, it makes it better.

In departments lacking encouragement of connection and collaboration, women like Sema, lose their sense of purpose, asking questions such as “Why am I doing this?” and not getting a meaningful response. Feedback about her research, both positive and negative, helps her to see the purpose of her research as well as particular methods used.

Sema, whose development scores suggested that she may avoid intimacy out of fear of criticism or other negative consequences, indicated that her new department, in which she had a supportive research group, had the effect of gradually decreasing her sense of isolation, “Here we’re more like a big group. So whenever I have some questions or when I need to learn something new, I find more help here. So, that makes it easier for me to do a job better.” Women with intimacy versus isolation scores leaning heavily toward isolation may have difficulty committing to solid affiliations for fear that it may mean sacrificing their identity and personal values (Hawley, 1988). In the context of academia, a graduate student with high intimacy scores and low isolation scores will feel comfortable with major commitments to a particular institution, as is often required in becoming a faculty member.

Erin and Inna, both from Flagship, had intimacy versus isolation resolution scores that are well above average and leaned toward intimacy. Erin, an American, described the culture in
her department in the following way: “If you’re ever walking down the hall or people poke their heads in labs and say ‘hi.’ So, yeah there is a lot of socialization.” Inna, a foreign national, talks about the community of graduate students celebrating each other’s achievements: “What I really like, I mean engineering department is pretty different, it’s pretty friendly out of the classroom. For example, I mean in our office we have 26 people and we can celebrate someone’s qual passing, prelim passing, so something.” Women who have high intimacy scores are comfortable committing to individuals and affiliations, such as a research collaborator or a university, even if it means some personal sacrifices (Hawley, 1988). Angela, an international doctoral student, summed up how a community that fosters collaboration at Flagship influences her affective development: “I don’t think my classmates are trying to be better and therefore they’re not going to share, and vice versa. So we, so I don’t feel alone if you will. I don’t feel too bad about making mistakes, because I find that most people will be understanding about it.”

**Judged by Capability Not Gender**

Another factor that participants note as contributing to a positive graduate culture is that they felt judged by their ability, not by their sex or gender. “I feel like no matter if you are male or female, you’re going to be assessed based on your performance,” remarked Amanda, a doctoral student from Public University who also indicated that she was “very satisfied with her decision to study engineering. Chelsey, an American Flagship graduate student from a business background, reflected, “I think that’s what matters most in this program, whether people respect your work or not.” She also described frustration with a student displaying sexist behavior: “I mean the fact that I came from a non-engineering background would be a valid reason to say I knew nothing about engineering. But no, it was because I was a girl.” Similarly, Elise, an American master’s student from Flagship, was not adverse to criticism based on her competency,
but was glad that members of her current department did not judge her based on gender, “The only time I felt like an outsider was because of my capabilities, not my gender, so that’s been nice.” Other participants indicated that while they felt judged by their gender in their current environment, they longed for and hoped to eventually work in a place where their colleagues value them for their capabilities in engineering. Claire, an American doctoral student from State University who indicated on the survey that she intended to pursue a faculty career, talked about how she may change her career path based on an experience at a private company: “Knowing that there are places that feel welcoming and they value me because of my technical skills,” and not base assessment of ability based on her gender, “I would love a job like [my private company experience].” Cultures that emphasize evaluation based on performance rather than external characteristics are not only more appealing to women, they also enhance their sense of belonging and consequent commitment to research.

**Inclusive Culture**

Participants also cited a culture inclusive of diversity as enhancing their sense of belonging; they felt welcome where their differences are viewed as strengths. A culture that values diversity is helpful as women struggle with their identity. Lindsay, a Flagship University student who came out as lesbian during her graduate career talks about her experience: “Everyone is super accommodating. It’s like being gay is a non-issue here. And being a woman is pretty much a non-issue as well. It just never really occurs to me, honestly, that I’m a woman in a man’s field.” Although in the culture of Lindsay’s current department, she felt no differential treatment because of her sex or sexual orientation, she had been part of other engineering departments that were not as inclusive. As she pointed out, her sexual orientation is not directly related to engineering; however, it “definitely has to do with how comfortable I felt with myself”
and how I carried myself.” In other words, it definitely affected not only her identity, but also her confidence in all that she did.

Similarly, participants expressed how finding a lack of differential treatment based on beliefs or religion made them feel more welcome. “I’m a Muslim, so I’m a scarfed woman. In the beginning, I was afraid if people would accept me” relates Nadia an international student from State. “And then, I didn’t find anything, just welcoming. So, good.” Similarly, Amanda from Public feared that she would be treated or viewed differently because she is Hispanic: “But the longer that I’ve been, the more it’s got out of mind, because I really haven’t had any experiences with professors or people from town or anything that’s, you know, made me feel any different.”

More generally, women speak of how an inclusive culture makes them feel valued as women. International student Angela from Flagship described her research group like this: “We kind of fit even if we’re different.” Later she commented on how as a woman, “I really have never felt that there is someone taught that you can or can’t do this because you’re female. So, I really haven’t felt that.” Like Angela, Sema from Public University was relieved to find that colleagues did not treat her differently because of her gender. She describes her trepidation upon finding out that her new research group was “10 guys…including my advisor, all male students.” She wondered, “Will it work or not?” To her relief, “Yeah, I fit. I’m a part of the group. And our research is collaborating and completing each other…Now there is no difference, we are all doing the same.”

As is evidenced in participants’ interviews and surveys, the culture of graduate engineering programs can positively influence female students’ development patterns. Collaborative, inclusive, connected cultures that critique men and women using the same
standards tend to enhance confidence and ability to develop a cohesive identity. Additionally, it makes female graduate students feel like they have a place in engineering, even if they do not look like the stereotypical engineer. Chelsey, a master’s student at Flagship who has recently decided to continue her education and pursue a faculty career describes her sense of belonging in engineering and at her college:

I feel like I am at home when I walk around campus. I feel like this is my place and these are my friends. You know, this is my research. I would say that I am a fit, but I am not like your normal person.

Supportive, collaborative cultures positively influence women’s development in engineering graduate programs, giving them a sense of belonging and motivating them to continue. However, non-traditional graduate programs, such as distance or satellite campuses, may face additional challenges in cultivating a positive culture for female graduate students.

**Culture at Satellite Campuses and in Distance Programs**

As campuses become more expansive, they offer different modes of education delivery and location. The number of universities offering distance engineering programs, or programs in which students do the majority of their coursework and research off-campus, is on the rise (Scales, Leffel, & Peed, 2002). Additionally, many universities have branch or satellite campuses, which have much smaller groups of students than traditional campuses. While female graduate students in these programs may face similar development challenges during their time as students, the “engineering culture” varies from that of the traditional campus. This section details study findings related to how women at distance or satellite campuses view their experiences in their engineering programs.
Motivations for Enrolling in Graduate Program

Findings from the study indicate that women in distance engineering programs generally have pragmatic motivations for entering graduate programs and relate more closely with workplace culture than their peers on the main campus. In some cases, graduate women at satellite campuses are motivated to pursue a graduate degree simply to increase their knowledge and take advantage of employer-paid education. Shirley, a master’s student at a satellite campus has been taking one or two courses each year for decades. Describing her motivation for starting her master’s, she says, “I finally went, well this is dumb; I should get something for it when I do it.” Although she has considered using her master’s to help her get a teaching position in her retirement, her main motivation for taking courses is personal edification. Similarly, Lucy explains why she began her master’s program, “Work paid for it. So, you don’t really have any excuse not to. Well, and you know, we are in tough economic times. I thought it would be good to get a little bit more education.” Neither Lucy nor Shirley had a specific career plan associated with the degree they seek, and saw graduate school as a way to build their resume for an unspecified future position.

Other students at distance or satellite campuses had very specific career goals and motivations. These specific career plans often developed as the women worked in the engineering field or spent time at home with children. After receiving their undergraduate degrees, Diane and Betsy spent a few years clarifying their goals before entering a master’s program at State. Diane speaks of how her children influenced her decision to return to school:

I feel like it’s more urgent to do something that influences the world a little bit, just because I, well they kind of harass me about it actually. They say, ‘Mom, it’s getting hot.
Can you fix this global warming? I feel more pressure maybe and more urgency as far as environmental issues, like I should contribute something before it’s too late for me. Diane’s motivation to study engineering at the graduate level is tied to her desire to make a difference, to make the world better for her children. Consequently, how she approaches her research and classes is directed and purposeful. Betsy saw graduate school as an opportunity to have the schedule flexibility she needed to begin a family, while training for an engineering career she felt would be more compatible with having children. The perception of female graduate students that graduate education and a career in academics is compatible with motherhood is interesting given the number of studies discussing the difficulties of balancing graduate studies and family life (for example, Wyss & Tai, 2010). However, along with clarity about her major, Betsy has specific career goals. She says, “I want to develop other women as engineers,” to give the support she felt lacking in her educational experience. “I feel like I thought long and hard about what major to go into grad school for and I’m aligned with it.”

Connection and Isolation

Women in distance programs may feel more isolation academically while simultaneously feeling less isolation socially than their peers at traditional campuses. Distance graduate students are more likely to have families or be embedded in a work culture that is in place before beginning their graduate program. These previously established connections tend to dominate their social activities, giving them a sense of intimacy and ability to establish close relationships in the non-academic context. Meanwhile, they may remain isolated and feel a certain loss of motivation as a result. For example, Shirley describes her frustrations with her distance graduate education:
One of the biggest problems that I’ve had with the distance learning is the non-interaction… I think that’s part of the learning experience, learning from each other. And when you don’t have that interaction, then I don’t think you have quite as much energy, you don’t get that synergy of learning that you do when you’re in a classroom situation. Similarly, Diane speaks of how her research sometimes lacks energy due to separation from her advisor and the majority of her department. “I keep on the literature. And my professor keeps up with the latest stuff that is going on out there. I guess we are isolated in a way. …just because there isn’t anybody else doing this sort of stuff, and there isn’t really anybody here to speak to about it or bounce ideas off of.” Isolation is not necessarily viewed as negative. As Diane points out, although she expected to have more interaction with her advisor and other faculty about how to go about research, “It’s been more I needed to take the initiative and go. So, with the research, move in the direction that I want it to move in. So, that was a little surprising, but not in such a bad way.” She’s found that as she is able to work through research on her own, it builds confidence.

However, for some, the distance or satellite campus setting gave a greater and more intimate sense of connection with research. Betsy talks about her experience at a satellite campus, “It’s just really small. That’s the only way to describe it. It’s like small business. It doesn’t feel like a college, doesn’t feel very much like a college atmosphere.” And yet, because the group is supportive and collaborative, she reports, “I think that the support has, yeah, it definitely has helped my confidence. It makes me think that I’m going to be successful here. No matter if I have a bunch of challenges, I’m not hung out to dry.” Although her research group is small and geographically isolated, the culture of the group gives her confidence and motivation to pursue her career goals.
Women in graduate engineering programs detached from the main campus may experience a very different “engineering culture” than that at traditional campuses. Yet, similar to the traditional on-campus setting, the culture of their program influences their development. How development affects women on and off the main campus may vary because of their past experiences and expectations when entering a graduate engineering program.

**Role of Past Culture in Moderating Response to Current Engineering Culture**

Women do not enter graduate engineering programs with identical development patterns. While graduate students in the same program may experience many of the same cultural factors, the diversity of their background and consequent development influences how they experience those cultural factors and how well they feel they fit into academic engineering (Gardner, 2008). U.S. and international graduate women carry past experiences into their graduate engineering programs, using those past experiences to understand and assess the culture of the graduate program. Some participants came from backgrounds that fostered positive development. For example, participants with backgrounds that emphasize gender equality recognize gender bias and less frequently let it influence their confidence or identity. Other participants had backgrounds that included previous educational or professional experiences that hindered their development. Participants use the culture at previous places of employment or education as a gauge for interpreting culture in their current engineering departments. Although women differ in background and how they interpret the culture of their current engineering department, several commonalities in how culture influences female graduate students emerged from this study.

**Influence of Graduate Engineering Culture**

How does culture influence the development and career decisions of graduate engineering women? The culture cultivated by graduate engineering programs has particular
influence on graduate women’s development in the areas of confidence, comfort with commitment, and identity. In addition to influence on development, culture affects how women make decisions and think about a career in academia.

Development

Intimacy and Isolation

In Erikson’s theory of psychosocial development (1963), the sixth stage involves development toward either intimacy or isolation. A movement toward isolation may result in a difficulty committing to “concrete affiliations and partnerships” for fear that these commitments may threaten their identity (Erikson, 1963, p.263). Conversely, women who resolve toward intimacy are more willing to commit to “concrete affiliations and partnerships” and to remain committed regardless of sacrifices and hardships (Erikson, 1963, p.263). Success as a graduate student is dependent on commitment to several affiliations and partnerships, including the commitment to a particular vein of research, affiliation with an advisor and research group, and commitment to the graduate program itself (Tinto, 1993). Aspects of a culture of engineering that influence a woman toward psychosocial isolation may also decrease that woman’s likelihood of success in a graduate engineering program.

Interview participant comments indicate that cultural aspects that influence a movement toward isolation include competition and a lack of collaboration, as in the cases of Carmen, Kelly and Malaya. Additionally, a culture that makes female graduate students feel unwelcome or like they do not belong leads to a sense of isolation within engineering. Finally, distance or satellite campus students, such as Shirley, may have more psychosocial isolation, depending on the structure or circumstances of their engineering program. Women who had extensive background hardships, like Emily, perceive that their background is not shared with their
colleagues and protect their identity with isolation. Most interview participants indicating loneliness or a lack of belonging in engineering had survey scores indicating psychosocial isolation. Sema, who had been in two departments at the same university, indicated that although she felt connected with her current research group, she felt very isolated in her previous graduate program, and her low development survey scores may indicate that she is still recovering from that experience. Other women, like Kelly from Public University, had chosen to develop their social life outside of their engineering program, and had survey scores indicating psychosocial intimacy, rather than isolation.

Conversely, collaborative departments where women feel connected and welcomed to the group as equals encourage development toward intimacy. Chelsey, Erin, and Inna all described their department and college cultures at Flagship as collaborative and welcoming and had survey scores indicating psychosocial intimacy, or willingness to commit to concrete affiliations. Similarly, Diane, who had a high intimacy score, described her satellite campus experience as collaborative and team-like. Average scores by university show a similar connection between welcoming, collaborative cultures and psychosocial development score. Flagship University students had the highest average intimacy versus isolation score, and Flagship students were the most likely to describe their department culture as welcoming and positive. Collaborative, welcoming cultures also affect other areas of female students’ development, including their confidence.

Confidence

Confidence gives women the ability and motivation to tackle challenges and see them to their completion, which is clearly necessary for success in engineering (Erikson, 1963). Graduate engineering cultures that are collaborative and welcoming, connect students, encourage team-
mentality and include supportive advisors and faculty, encourage confidence and positive self-concept in female graduate students. Diane and Sema’s stories provide an example of how supportive cultures can build confidence.

On the other hand, cultures that emphasize individuality and competition, while limiting collaboration, permit or encourage sexism, and do not provide support through advisors and faculty tend to decrease female graduate student’s confidence. Graduate women in these departments may “despair of their own skills and abilities” feeling “incapable, mediocre, and estranged” (Hawley, 1988, p.9). For students like Carmen and Betsy, a competitive culture permissive of sexism may result in women doubting their competency or place in engineering.

Identity

Cultural aspects also influence the development of identity versus role confusion, which is the fifth stage of psychosocial development. In identity development, women consider various life roles and form one consistent and integrated identity (Hawley, 1988). Development of a central identity allows them to feel “at home” in all areas of life and appreciate their individual value. A movement toward identity or role confusion, on the other hand, indicated a difficulty in identifying a central identity. Women with role confusion may feel their identity changes for different life roles.

Cultural aspects that may lead to identity confusion include perpetuation of stereotypes, sexism, a lack of welcome, judging women based on gender rather than performance, and unsupportive faculty. Additionally, female graduate students who are first generation students and international students may face identity confusion as they attempt to integrate their home identity with their school identity. Interview participants with the lowest scores, indicating
identity confusion, tended to have an extra step in socialization, including adapting to American
culture, understanding college as a first-generational student, or being an ethnic minority.

Participants also described a culture that helped them develop a solid integrated identity.
Cultures that value diversity and confronted inappropriate stereotypes and sexism, while
encouraging connections between students, assisted students in developing identities that
incorporated all of their life roles. Consequently, these women felt more comfortable in deciding
their future career plans.

Career Choices

In addition to how culture affects female graduate students via their development, it also
can directly impact career choice. Study findings indicate that where participants reported the
highest level of positive graduate experiences, they also had the highest level of contentment
with their decision to study engineering and the highest likelihood of pursuing a faculty career.
For example, doctoral students at Flagship indicated the highest level of satisfaction with their
decision to study engineering of the three universities, and their satisfaction with engineering
related to intent to pursue a faculty career, $\chi^2(3) = 6.86, p = .077, \phi = .14$. This finding suggests a
direct relationship between a supportive graduate engineering culture and choosing an academic
career. Graduate engineering culture directly influences whether women will pursue a faculty
career, because women choose their career path in part based on the anticipated culture of that
future work place, and women develop their perception of what a career in academia might look
like based on what they see while in their graduate programs.

When asked about factors they consider when making decisions about their career over
half of the participants’ interviews indicated that the culture of a workplace was a major
consideration. Much like the characteristics that make a supportive department for graduate
students, women look for particular characteristics in their future workplace including connection, collaboration, and assessment based on merit rather than gender. Participants also expressed a desire for a work-family balance in future employment. Kate’s faculty role models demonstrate to her the feasibility of finding a balanced life as a faculty member. She says about the faculty life-style, “It gives you a great work-life balance, especially as a woman. You can have kids and go into the lab when they are asleep or whatever else, which is something that I really want.” Because Kate sees faculty in her department at Flagship successfully balancing family and work commitments, she believes she can as well and is highly motivated to pursue a faculty career. However, Kate’s experience and perception of faculty life was rare among narratives of participants. More frequently, graduate students in the current study and others (e.g. Austin, 2002) perceive difficulties inherent in finding balance between work and family as a faculty member. Tabitha from Public University explains why she has excluded a tenure-track faculty position as a career option: “That one's pretty much out for me, because I would like to at least entertain the thought of having kids and a family. And tenure and kids seems two mutually exclusive pursuits.” Directly contrary from Kate’s perception that faculty-life offers great work-life potential, Tabitha’s observations of faculty members in her department gave her the impression that she has to choose between a faculty career and children. Depending on what students observe as the faculty lifestyle and the possibility of finding work-family balance, prioritization of family may result in graduate women pursuing a faculty career or looking for a career outside of academia (Austin, 2002; Gardner, 2005).

As women move through graduate programs, they develop their perception of what they might expect from and what might be expected from them in a faculty career (Gardner, 2005). The socialization process is integral to their persistence in academia (Turner & Thompson, 1993).
Women from supportive cultures anticipate that they will be similarly supported in a faculty career, and consequently, they are more likely to pursue faculty careers. Conversely, graduate students in competitive engineering cultures, where collaboration is seen as weakness and women sense judgment based on their appearance and gender more than on their performance, believe that all graduate engineering programs are similarly unsupportive of women faculty.

“That's going to have everything to do with how supportive the department would appear to be,” Kelly from Public says about her decision to pursue or not pursue a career as a faculty member. “It's just not worth the rest of my life, because I've already given so much of my life to academics, to keep bleeding for nothing.” Women, like Kelly, who experience unsupportive graduate culture are less likely to want to continue and pursue a career in academia.

**Conclusions**

The cultures of graduate engineering programs influence career decisions indirectly, through development, and directly, by showing what a career in academia may be like. The attributes of a particular culture of engineering are not static, but changing as individuals in a department or college make choices about what type of culture they cultivate. Graduate engineering programs with cultures that 1) encourage collaboration and connection, 2) confront sexism in any form, 3) value diversity, 4) assess all students based on ability and performance rather than sex or gender, and 5) provide support and recognition of achievements for all students, encourage the positive development of their female graduate students. Women in these supportive graduate cultures are more likely to have integrity of identity, surety of direction and purpose, comfort in making commitments to partnerships, and the confidence needed to carry them through challenges. Women’s development in the areas of identity, confidence, purpose, and comfort in partnerships, as well as what they see while in the culture of the engineering
program, influence their career decisions, including whether they will pursue a faculty career.

The culture of graduate engineering programs not only influences the females currently in the graduate program, but also the character of academic engineering in the future.
CHAPTER VII: CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Despite decades of initiatives aimed at increasing numbers of women in engineering, underrepresentation of women continues in engineering programs across the U.S. (Burke, 2007). The numbers of women are particularly low among engineering faculty and academic leadership, and the percentage of female faculty remains near 10% in most engineering disciplines (NSF, 2011). The persistent underrepresentation of women in engineering is troubling because of the social influence of engineering and the need for diverse perspectives in engineering to address global concerns (NAS, 2006; Robinson & Dechant, 1997). Yet, recent research suggests that reaching equal representation of women in engineering disciplines may take 100 years at current rates of growth (Kaminski & Geisler, 2012), and these projections do not include corrective historical and systemic biases regarding women in engineering. Achieving gender equity in engineering will require a broader shift in academic engineering culture.

Women, Engineering, and Academia

In understanding the continued underrepresentation of women in engineering, researchers commonly use a pipeline to represent progression from early education through professorship (e.g. Mattis, 2007). In this representation, women “pour” into the beginning of the academic pipeline and a certain percentage “flow” out the other end, becoming engineering faculty and educational leaders. Women are said to “leak” from engineering at a higher rate than men, which explains their particularly low numbers in the upper ranks of academia (Mattis, 2007). As the current study indicates, one shortcoming of the pipeline analogy is the implication of linearity, that academic engineering has only one entry point and one ultimate exit point. In contrast, participants spoke of multiple entry points to academic engineering in the U.S. For example, international women often enter the U.S. academic engineering as graduate students, and some...
U.S. and international participants spoke of their re-entry into academia after a professional experience. Another weakness of the pipeline analogy is that only one liquid type, water, flows through the pipeline. The analogy promotes a narrow definition of women, which in turn leads to limited, one-size-fits-all approaches to increasing numbers of women in engineering. In contrast, women who participated in the current study had commonalities, but also varied substantially in development and perspective. In promoting women in engineering, the view of academic engineering must expand to include the diversity of women who enter engineering programs.

The pipeline analogy, despite its weaknesses, is instructive in understanding how to promote gender equity among engineering faculty. In the same way repair of a leaky pipe involves identifying and addressing the fault in the pipe, so addressing the loss of women from academic engineering requires attention to the “pipe” of engineering culture. Improving the representation of women in engineering requires attention to academic engineering culture and how that culture shapes the development and career decisions of women as they experience that culture.

Historical factors are important in understanding the culture of modern engineering programs. Western sciences originated in a time in which women were excluded from participation (Lucas, 2006; Rosser, 2008). Through the years, stereotypes developed that saw the normal scientist as white and male (Harding, 1991; Ward, 2008). Participants in the current study spoke to the persistence of the view that men are naturally better suited for scientific pursuit, such as engineering. The culture of some engineering programs continues to view women who do pursue careers in engineering as exceptions to the rule. Because of the power of science in determining what counts as “knowledge,” the exclusion of women from the sciences meant that women are not permitted to participate in knowledge construction. The perpetuation of these
stereotypes related to men and women in engineering occurs through the academic socialization process, in which students learn the cultural practices of the discipline. Socialization for the role of engineering faculty occurs primarily through graduate school. To understand why more graduate women do not pursue careers in academia, the current study focused on the experiences of women currently in the culture of graduate engineering programs and how their graduate experiences shape their views of self, others, and their future careers.

**Study Structure**

The current study asked “How does the culture of engineering influence the development and career intentions of female graduate students?” Psychosocial development, self-authorship development and post-colonial theories provide a framework for interpreting the structures of graduate engineering culture and how women change in response to that culture. Participants from graduate engineering programs at research-intensive universities responded to surveys and interviews. Analysis particularly considered the ways in which experiences in U.S. graduate engineering programs varies between international and U.S. participants. A combination of findings from quantitative and qualitative components of the study provides a full understanding of the experiences, development, and career motivations of study participants from multiple cultural backgrounds.

**Culture and Development**

Study findings suggest a complex relationship between the graduate engineering cultures and female graduate students. The culture of graduate programs varies from supportive to detrimental for students’ development. Differences between programs indicate that engineering culture is not static and can be shaped to better support development. Culture has particular influence in the key areas of integrity of identity, comfort in partnerships, and confidence.
Graduate cultures that value diversity and confront inappropriate stereotypes and sexism, while encouraging connections between students, assist students in developing identities that incorporate all of their life roles. Where graduate culture fails to support the positive development, graduate women have fragmented views of self. Women from background cultures that conflict with aspects of science culture have particular difficulty in integrating the multiple layers of their identity. For example, international women must integrate their native cultural identity with their identities as woman, student, and engineer. Lack of solid central identity leads to uncertainty among graduate women, particularly related to their future career plans. Identity development is also closely tied to development of confidence and comfort with professional partnerships.

Graduate engineering cultures that emphasize collaboration rather than competition between immediate colleagues increase graduate women’s comfort in making commitments to partnerships and associations. In cultures that promote competition between students and emphasize negative feedback regarding research, women develop fear related to professional relationships, and may isolate themselves for protection. If graduate women isolate themselves, they fail to develop connections needed to excel in engineering.

Graduate engineering cultures that are collaborative and welcoming, connect students, encourage team-mentality and include supportive advisors and faculty encourage confidence in female graduate students. However, when engineering cultures fail to provide support for confidence development, graduate women doubt their competency and fit in engineering.

How women develop also shapes how they respond to their graduate engineering program. An unsupportive graduate program culture has diminished influence on self-authoring participants and participants with high confidence and identity. Since self-authoring women are
able to define their identity, sense of knowledge, and relation to others internally (Baxter Magolda, 2008), they often dismiss external voices that doubt their competency or their fit in engineering. Self-authoring women know and define their own identity, so they recognize sexist behavior from colleagues and are less likely to internalize biases expressed by colleagues. In contrast, women who base views of self and social relations on external voices are discouraged by others’ perceptions of their ability, even when others’ perceptions are inaccurate and conflict with the reality of their performance in research and engineering.

![Figure 7.1: Interplay between graduate engineering culture and affective development](image)

Figure 7.1: *Interplay between graduate engineering culture and affective development*

For all graduate women, but particularly those with external definitions of self and social relationships, culture influences development. When women know who they are and how they fit with engineering colleagues, they have a greater sense of belonging and confidence in innovation and research. As they develop confidence and solidify their identities, women also have greater surety of direction and purpose as they consider their future career path.

**Development and Career Decisions**

Another focal point of this study is to consider how the affective development of graduate engineering women influences their career decisions. Findings indicate that the culture influences aspects of development, and that several aspects of affective development influence
graduate women’s career decisions and projections. Overall, women who have strong identity formation, relational capacity, and confidence are more certain about their career direction and more likely to pursue careers they perceive as challenging.

As graduate women solidify and become more comfortable with their identity, they are more likely to know what they want from a career, and consequently indicate greater commitment to and satisfaction with their career plans. Satisfaction with career plans is particularly high among students who self-author their identity, or define their identity based on internal conviction rather than external authorities.

Development of confidence also influences graduate women’s career decisions. Graduate women that fail to develop confidence, fear disappointing others and are less willing to take on careers they view as challenging. Consequently, low confidence may result in graduate women taking positions for which they are over-qualified rather than pursuing faculty careers.

The fear associated with a lack of confidence coupled with a highly critical culture may result in graduate women withdrawing or hiding from colleagues to avoid attacks to their identity. Isolation from colleagues may reinforce images of women as outsiders in engineering. Without the networks and collaborations necessary for a successful academic career (Fox & Mohapatra, 2007), women may choose or be forced to pursue a career outside of academia.

As graduate women consider their possible career paths, development in the areas of identity, confidence and comfort with professional partnerships, shape their perceptions of the careers for which they are the best fit. Findings indicate that development also plays a role in shaping career motivations. In particular, development of generativity, or desire to leave a positive legacy, motivates women to pursue careers in which they can “make a difference.” Whether or not graduate women choose to pursue a faculty career hinges on their perceptions of
self and whether they will be able to make a positive difference through the faculty role (Figure 7.2).

Figure 7.2: Influences of development in the areas of self-authorship, confidence, identity, and generativity on career decisions of female graduate students in engineering

**Culture and Career Decisions**

The study findings indicate that culture has a direct influence on the career decisions of graduate engineering women. Participants indicated that a major motivation in choosing a particular career path is their perceptions of the culture in that future workplace. Graduate women look for particular characteristics in their future workplace including connection, collaboration, lack of bias, and evaluation of value based on merit rather than gender.
In relation to careers in academia, graduate women develop perceptions of what a career in academia might look like based on what they see while in their graduate programs. While this socialization process is crucial for their persistence in academia (Gardner, 2005; Turner & Thompson, 1993), study findings indicate that graduate women’s perceptions of faculty life and academic culture are often limited to the setting of the graduate program. Since graduate programs in engineering are more commonly at research-intensive universities (including students in the present study), graduate women base their view of a faculty career on the research-intensive tenure-track faculty position. Additionally, the culture of a graduate program shapes graduate women’s view of academic culture in general. In other words, women from mostly supportive graduate engineering programs anticipate that they will experience a similarly supportive culture if they pursue a faculty career. They have more positive views of a potential faculty career, and are more likely to persist in academia. Conversely, graduate students in competitive engineering cultures, where collaboration is seen as weakness and women sense judgment based on their appearance and gender more than on their ability, see an unsupportive culture as normative for academic engineering and assume that faculty women experience a similar lack of support. Women who experience unsupportive graduate culture are less likely to want to continue and pursue a career in academia. Graduate engineering culture influences the career decisions of graduate women directly, by shaping students view of an academic career, and indirectly through its influence on affective development (Figure 7.3).
Figure 7.3: Basic relationships between graduate engineering culture, affective development and career decision among female engineering graduate students

Diversity of Backgrounds and Perspectives

Women come to graduate engineering programs from diverse cultural backgrounds, and their backgrounds shape their response to the culture of their graduate program. Although as a general rule, culture, development and career decisions interact as described in Figure 7.3, women’s previous experiences and cultural background can alter the influence of graduate engineering culture. Understanding the nuanced responses of women to their graduate engineering culture is crucial to providing support for all women in engineering.
The present research specifically explores how graduate engineering culture influences the development and career decisions of international women, particularly noting where international women and U.S. women differ. The intent is not to cast international women as abnormal and U.S. women as normal, but rather to consider the diverse ways women experience engineering. Understanding the experiences of international women is particularly relevant to increasing the representation of women in engineering since 46% of graduate women are foreign-born (NSF, 2011). While many of the relationships between culture, development and career decisions are the same for international students as they are for U.S. students, international women often have additional challenges during their graduate program, lack of development toward identity and confidence, and career constraints not faced by their U.S. counterparts.

Although international participants come from a variety of countries and cultures, they share some common experiences related to U.S. graduate engineering culture. For example, most international participants spoke of difficulties establishing meaningful connections with colleagues because of language differences. Another challenge for many international participants is learning how to relate in an individualistic culture. Many of the international participants came from countries where collectivism is the cultural norm. Collectivism, a social system in which individuals give central importance to the group(s) they are part of as opposed to the individuals themselves (Davidson & Foster-Johnson, 2001), contradicts normative U.S. culture and normative science culture, both of which take an individualist approach. Women from collectivist cultures have difficulties knowing how to establish friendships and identity in an individualistic culture (Pizzolato, Nguyen, Johnston & Wang, 2012; Tan & Goh, 2006). Lack of ability to establish meaningful relationships and connection with colleagues in their U.S.
engineering program decreases international graduate women’s sense of well-being, and influences their development.

Findings indicate that international women differ from their U.S. counterparts in several areas of development. In particular, international women had low scores related to confidence, identity, and integrity/despair. International women express low confidence in a variety of ways including avoidance of challenging tasks, procrastination, and passivity. In supportive, collaborative cultures, confidence improves with time in U.S. engineering programs. However, in highly individualistic and competitive cultures, confidence continues to decline as the student progresses through graduate school.

International participants also had low identity development scores. Identity confusion among international students may stem from their inability to identify their place in an individualistic culture or from difficulties in unifying their identities as women, natives of their home countries, and engineers in a new academic setting. International women who struggle with their identity may isolate themselves from the unfamiliar and have difficulties making concrete decisions about their career, because they remain uncertain about basic convictions. These career decisions are complicated for women with identities defined by external voices, since authorities from a home country, authorities in current engineering departments, and their own internal voice often conflict.

International women may feel their career path constrained by a number of factors that they do not share with the majority of their U.S. counterparts. Findings from this study indicate many international women in engineering do not make the initial choice to study engineering. Instead, a father or other family member made the initial decision for them to study engineering, and in many cases, the views of these family members remain a major consideration in career
decisions. International participants also indicated other ways in which they felt their career options were limited, including lack of engineering positions outside of academia that are open to non-U.S. citizens. While more international than U.S. graduate participants indicated a high likelihood to pursue a career in academia, many international women pursue faculty careers because they see no other option, not because they identify with the career option or feel confident in the faculty role.

While graduate engineering culture influences the development and career decisions of international women and U.S. women, international women also face unique challenges and restraints. As engineering faculty and program staff shape culture to better support graduate women, practice and policy should support the development of women from diverse cultural backgrounds.

**Recommendations for Policy and Practice**

The culture of graduate engineering programs influences the career decisions of graduate women both indirectly, through development, and directly, by giving a picture of what a career in academia may resemble. Consequently, interventions to increase the representation of women among engineering faculty and academic leadership must focus on cultural transformation. Because of the deeply entrenched nature of engineering culture, transforming graduate engineering programs to better support female students will not be an easy endeavor. However, findings indicate that some engineering programs have begun cultural transformation, and as a result, provide a culture in which graduate women can develop strong identity, purpose, comfort in collaboration, and confidence needed to tackle complex engineering challenges.

The cultural transformation needed in graduate engineering programs includes broadening definitions and expectations for “women.” Increasing the number of women in
Engineering is a worthwhile endeavor, because of the diverse perspectives women bring to engineering. Initiatives with narrow views of “women in engineering” promote continuance of colonial practices that label women as the deviant in need of assistance by the dominant group. Instead, effort should aim to transform culture to value diversity and eliminate gender bias.

Expanding the definition of women will certainly include bringing international women into discussions of policy and practice. International women represent a growing percentage of engineering graduate students, and consequently their experiences and challenges in U.S. engineering programs are relevant to understanding why female engineers with graduate degrees do not persist in academic careers.

Cultural transformation should target areas associated with women’s positive psychosocial and self-authorship development. Although the initiative for cultural transformation must come from academic leadership, cultural change will not come from policy changes alone. Specifically, individuals at every level of engineering programs should promote collaboration and a team-mentality among students and faculty. Equal treatment of women and men, emphasizing the need to assess capability by actual performance rather than making assumptions about an individual’s ability or interests based on their gender, needs to extend past policy to become expected practice. Finally, cultural transformation needs to include examination of the ways formal and informal conversations in engineering programs essentialize “women.” Engineering faculty, staff, and academic leadership must move from toleration of gender biases and from differential treatment of women to an inclusive model that values diversity and diverse viewpoints. Without cultural transformation, progress toward equal representation of women in engineering will remain slow, and highly trained women, like those in the present study, will be discouraged from pursuing careers as engineering faculty.
Recommendations for Research

The research reviewed here examined relationships between engineering culture and the development and career decisions of graduate engineering women at three public research-intensive universities, specifically comparing the experiences of international women with U.S. women. The present study builds on and expands research in the areas of graduate student development and socialization (e.g. Austin, 2002; Gardner, 2009), academic engineering culture (e.g. Kunda, 2006), post-colonialism in the context of academic science and engineering (e.g. Carter, 2004), experiences of female students in engineering (e.g. Seymour & Hewitt, 1997), and international student experience (e.g. Trice, 2007). Findings from this present study point to a need for graduate engineering practices and policies to take a holistic approach that considers the influence of culture and accounts for the diversity of students enrolled in the program.

More work remains to understand the experiences and development of the growing number of international students in graduate engineering programs. While this study included international women, comments from participants indicate that international men also face challenges in graduate engineering programs. Further research may uncover ways in which U.S. engineering culture influences international men and their potential success in academic engineering. Additionally, this present study considered all international students together, potentially missing unique experiences of international students from particular regions. Research in this area would reveal ways in which the culture of U.S. engineering programs conflict or correspond with students’ cultures of origin. Graduate engineering programs that take the unique challenges of international students into consideration are more likely to retain and produce diverse graduates with the capacity to be creative and innovative in the engineering.
The present study also limited focus to female graduate students at public, research-intensive universities in the U.S. Northwest. Further research could explore the themes of culture, development, and career decisions in the context of other types of engineering programs, including those in other regions and those with less research-intensive environments. Findings from this present study indicate that graduate engineering women have limited views of faculty-life and academic culture based on their socialization in their graduate program. Different academic contexts may alter relationships between culture, development, and career choice.

Research presented here also limited focus to female graduate students in engineering. Although the underrepresentation of women in the upper ranks of engineering is particularly high, other disciplines, such as those in mathematics and physical sciences, have similarly low numbers of faculty women. Future research could explore whether there are similar relationships between culture, development, and career decisions in these other disciplines.

Finally, while this study discusses findings related to how women from different cultures differ in how they experience and respond to graduate engineering programs, much work remains in exploring the role of culture in shaping the development and career choices of minorities in engineering. There is need for research that takes a holistic approach, considering neither development nor career choices without also accounting for the role of culture in relation to minorities in engineering.

Overall, research related to underrepresentation in engineering and other scientific fields must work towards understanding how cultural context influences career choices. Integral to this research is a developmental perspective that reflects appreciation of specific ways in which culture can shape how women view themselves and their place in engineering. Whether graduate
women leave academic engineering or stay to pursue careers as faculty depends largely on the experiences and development women have in their graduate engineering programs.
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## APPENDIX A

### Items in Modified “Career Decision Making Survey”

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Stage</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interpersonal</strong></td>
<td>External</td>
<td>For me, a crucial role of an advisor or a committee chair is to be an expert on a variety of career options.</td>
</tr>
<tr>
<td></td>
<td>Formulas</td>
<td>For me, a crucial role of an advisor or a committee chair is to provide guidance about a choice that is appropriate for me.</td>
</tr>
<tr>
<td></td>
<td>Crossroads</td>
<td>For me, a crucial role of an advisor or a committee chair is to help me think through multiple options.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If an advisor or someone I respect recommended a career in a field that I had never considered before, I would try to explain my point of view.</td>
</tr>
<tr>
<td><strong>Self-Authorship</strong></td>
<td></td>
<td>For me, a crucial role of an advisor or a committee chair is to direct me to information that will help me make a decision on my own.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If an advisor or someone I respect recommended a career in a field that I had never considered before, I would try to understand their point of view and figure out an option that would best fit my needs and interests.</td>
</tr>
<tr>
<td>Dimension</td>
<td>Stage</td>
<td>Item</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Epistemological</td>
<td>External Formulas</td>
<td>When making a decision about my career, I think that facts are the strongest basis for a good decision.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When making a decision about my career, I think that experts are in the best position to advise me about a good choice.</td>
</tr>
<tr>
<td></td>
<td>Crossroads</td>
<td>I think that making a good career choice is mostly a matter of personal opinion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When people have different interpretations of a book, I think that some books are just that way. It is possible for all interpretations to be correct.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I think that making a good career choice is not a matter of facts or expert judgment, but a match between my values, interests, and skills and those of the job.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When people have different interpretations of a book, I think that multiple interpretations are possible, but some are closer to the truth than others.</td>
</tr>
<tr>
<td></td>
<td>Self-authorship</td>
<td>Experts are divided on some scientific issues. In these situations, I would have to look at the evidence and come to my own conclusion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experts are divided on some scientific issues. In these situations, I think it is best to accept the uncertainty and try to understand the principal arguments behind different points of view.</td>
</tr>
<tr>
<td>Dimension</td>
<td>Stage</td>
<td>Item</td>
</tr>
<tr>
<td>------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Intrapersonal</td>
<td>External Formulas</td>
<td>In making a major life decisions, my primary method is to acquire as much information as possible.</td>
</tr>
<tr>
<td></td>
<td>Crossroads</td>
<td>In making major life decisions, my primary method is to reflect on my own views on the topic.</td>
</tr>
<tr>
<td></td>
<td>Self-authorship</td>
<td>In making major life decisions, my primary method is to make a decision after considering all the available information and my own views.</td>
</tr>
</tbody>
</table>
APPENDIX B

Example Calculations for Self-authorship Development from Student Response

The following represents example calculations for determining self-authoring capacity from student response and includes example profiles of women at each position of self-authorship. Abbreviations are as follows: ef = external formulas, c = crossroads, and s-a= self-authorship.
<table>
<thead>
<tr>
<th>Student Profile</th>
<th>Intrapersonal Average</th>
<th>Epistemological Average</th>
<th>Interpersonal Average</th>
<th>Overall Dimension Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>e.f.</td>
<td>c.</td>
<td>s.a.</td>
<td>e.f.</td>
</tr>
<tr>
<td>External formulas</td>
<td>5</td>
<td>3.5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Crossroads</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Transitioning</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Self-authorship</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Bimodal</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX C

Survey Section 3: Career Intentions and Satisfaction

Instructions

Below are four questions related to your intentions and your satisfaction with those intentions. Following each question, there are possible responses. Please circle the response that best describes your intentions or satisfaction.

1. How satisfied are you with your decision to study engineering?
   a. Very dissatisfied
   b. Somewhat dissatisfied
   c. Neither dissatisfied nor satisfied
   d. Somewhat satisfied
   e. Very satisfied

2. How likely are you to continue your education in engineering after completion of your current degree?
   a. Not at all likely
   b. Somewhat likely
   c. Moderately likely
   d. Very likely

3. How likely are you to pursue a career in academia as a faculty member?
   a. Not at all likely
   b. Somewhat likely
   c. Moderately likely
   d. Very likely
4. How satisfied are you with your career plans?

   a. Very dissatisfied
   b. Somewhat dissatisfied
   c. Neither dissatisfied nor satisfied
   d. Somewhat satisfied
   e. Very satisfied
**APPENDIX D**

**Interview Protocol**

**Notes:**

*Italicized portions are personal notes and reminders*

*Have participants read through and sign consent form prior to interview start.*

*Remind interviewee that their responses will be kept completely confidential and their responses will not be linked to them in any way.*

*Ask participant if you can record the interview.*

1. What is your major or area of study?

2. When you took the survey, what were some of your general responses to it?

3. Tell me about your experience in your department as a graduate student. How would you describe it overall?

4. How do you think your cultural background shaped your responses to the survey questions? Your view of your experience as a graduate student?

5. I see you said that you have are not at all/somewhat/moderately/very likely to pursue a career as a faculty member. Can you tell me a little bit more about your career plans in general?
   a. What motivates you to continue or discontinue pursuing a career in academic (as faculty) engineering?
   b. When you make life-decisions, such as those about your career, what would you say are your most important considerations or factors? *(related to self-authorship)*
6. I am going to show you a set of descriptions and ask you to tell me which one you feel better describes you. Why?

    (See supplemental sheet on page 187)

   a. MPD 4: Industry/inferiority
   b. MPD 5: Identity/identity confusion
   c. MPD 8: Ego integrity/despair

7. How do you feel you “fit” into your department here at [your university]? Into your discipline?

8. How would you describe the culture of your department? How do you think that culture influenced your choices on the survey?

9. Is there anything else you would like to add about your experience as a woman in engineering?
Follow-Up Interview Supplement

For each box, please choose the side that you think sounds the most like you and why, or explain what characteristics fit you from each option.

<table>
<thead>
<tr>
<th>Box 1</th>
<th>Box 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option 1</strong></td>
<td><strong>Option 1</strong></td>
</tr>
<tr>
<td>- Relish achievement for achievement sake</td>
<td>- Feel like there is a difference between who you are and who you want to be</td>
</tr>
<tr>
<td>- Like to tackle difficult tasks</td>
<td>- Who you are and who people see you as changes in different life roles</td>
</tr>
<tr>
<td>- Get absorbed in a task and want to see it to its completion</td>
<td>- Hesitate to make commitments and major decisions in part because you’re not sure if your beliefs/motivations may change</td>
</tr>
<tr>
<td>- Confident in your ability to complete challenges</td>
<td></td>
</tr>
<tr>
<td><strong>Option 2</strong></td>
<td><strong>Option 2</strong></td>
</tr>
<tr>
<td>- Frequently procrastinate</td>
<td>- Know who you are, where you’re going, and what your goals and values are</td>
</tr>
<tr>
<td>- Have difficulty concentrating</td>
<td>- Feel like you are basically the same person with the same values and attitudes in all of your life roles</td>
</tr>
<tr>
<td>- Sometimes doubt your competency</td>
<td>- Basically happy with who you are</td>
</tr>
<tr>
<td><strong>Box 3</strong></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Option 1</strong></td>
<td><strong>Option 2</strong></td>
</tr>
<tr>
<td>• Feel like your life has meaning and purpose</td>
<td>• You’ve missed a lot of opportunities and misdirected your energy</td>
</tr>
<tr>
<td>• Satisfied with what you’ve accomplished in your life thus far</td>
<td>• Feel like life in general is meaningless</td>
</tr>
</tbody>
</table>