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THE POWER OF NUMBERS: GRADES AND FEMALE DENSITY IN INFLUENCING THE PERSISTENCE OF WOMEN IN ENGINEERING MAJORS

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Michelle Stine

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The dissertation of Michelle L. Stine was reviewed and approved* by the following:

Patrick T. Terenzini
Distinguished Professor of Education
Dissertation Advisor
Chair of Committee

Michael J. Dooris
Affiliate Associate Professor of Education

David M. Post
Professor of Education

Jennifer Van Hook
Associate Professor of Sociology and Demography

Dorothy H. Evenson
Professor and Senior Research Scientist
Professor-In-Charge, Higher Education Program

* Signatures are on file in the Graduate School

Abstract

Female participation in engineering has never topped 20% nationally for the proportion of bachelor's degrees earned by women. Research on this topic, as well as related self-esteem literature, suggest that women may be more likely than men to leave engineering if they have unmet grade expectations. Additionally, the presence of more women in engineering courses may positively influence women's persistence through peer reinforcement and the mitigation of possible social identity threat. This study explored differing degree outcomes for four cohorts of baccalaureate men and women (N=3,087) in a selective undergraduate engineering program by examining persistence at three levels: within the institution, within engineering, and within the originally intended engineering major, using three nested logistic regressions with increasingly restrictive criteria. The study hypothesized positive relationships between women and grades, between women and the proportion of other women in engineering-related courses (female density), and a conditional relationship among being female, grades, and female density. Women with high grades and a higher female density in courses should be more likely to persist in their originally chosen major or within engineering than men in the same situation.

The findings did not support these hypotheses. Grades influenced men and women equally at the institution and major levels. At the engineering level, however, men were more grade sensitive than women when earning equal GPAs after the first year in college. In terms of female density, the study found negative main effects at all three levels. Moreover, the negative interaction between being female and female density approached significance at the engineering level. A different statistical method is needed, however, before any conclusions can be reached.

The study also finds a flow of students between engineering fields as well as out of engineering, with aspiration to some majors facilitating the former or the latter. The significant majors change with the level of analysis. Finally, if historically underrepresented students graduate within six years, they are more likely than majority peers to graduate in their originally intended major.

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Chapter One

Introduction

1.1 Introduction

Women now outnumber men in the United States in earning associate's, bachelor's, and master's degrees, and they earn nearly half the conferred first professional and doctoral degrees (National Center for Education Statistics, 2008a). Moving beyond an era in which their work choices were severely limited, women have expanded their range of occupational possibilities to become senators, business leaders, doctors, lawyers, and astronauts. The percentage of women earning first professional degrees in medicine jumped from 6% of the total degrees awarded in 1960 to 49% in 2007. Likewise, the percentage of women earning degrees in law jumped from 2% in 1960 to 48% in 2007 (National Center for Education Statistics, 2009b). Evolving public attitudes, employment laws, and a shifting work environment are redefining what women can do in the workforce. Much change has occurred over the last five decades.

Unfortunately, the infusion of women into more prestigious occupations can obscure the fact that men and women still tend to cluster within certain other areas. Many of the traditionally "female" occupations (such as nursing, primary education, social, and clerical work) pay lower wages than typical "male" occupations (such as the trades, engineering, or construction). We are now only beginning to understand the scope and ubiquity of "horizontal segregation," where men and women tend to be employed within different kinds of work (Charles & Bradley, 2009; Charles & Grusky, 2004; Grusky & Charles, 2001). While women may have more occupational choices today, studies show that disproportionately more women are still choosing to enter and remain in female-typed occupations. In all three of these studies the authors suggest horizontal segregation is harder to eradicate because it occurs through the individual choices of women and men who are reacting (often unknowingly) to beliefs and assumptions regarding appropriate gender roles and behavior.

This segregation is reflected in high school seniors' choices of intended college major. Cooperative Institutional Research Program data indicate that men and women tend to cluster within certain majors even as they enter college (Pryor, Hurtado, Saenz, Santos, & Korn, 2007). In 2006, 13% percent of the females and 6% of the males surveyed planned to major in education, and 16% of the females and 5% of the males expected to major in the health professions, including medicine. Conversely, only 2% of the females versus 15% of the males said they were going to major in engineering. Although anywhere from a third to nearly two thirds of students change majors at least once during college (Adelman, 1998; J. A. Jacobs, 1986, 1995; Micceri, 2001), the proportion of men and women in each major remains relatively stable. Women dominate the humanities, education, and health professions while men dominate certain physical sciences, computer science, and engineering (Charles & Bradley, 2009; Goyette & Mullen, 2006; Serex & Townsend, 1999; Sonnert, Fox, & Adkins, 2007; Turner & Bowen, 1999).

The gendered choices of major have remained somewhat stable over time. In 1960, women were numerous in fields such as English and education, where they received the majority of degrees awarded each year. Even as the pool of choices has widened, women still maintain the majority in these fields and have even increased it. Figure 1 shows women's stability and gradual proportional growth in English and education while also documenting their increased participation in psychology, communications, and business. More degrees are now awarded to women than men in psychology and communications/journalism in addition to the traditional

English and education. Women earned 50% of the degrees in business in 2005. Engineering and computer science, however, have remained male-dominated, even through 2005.

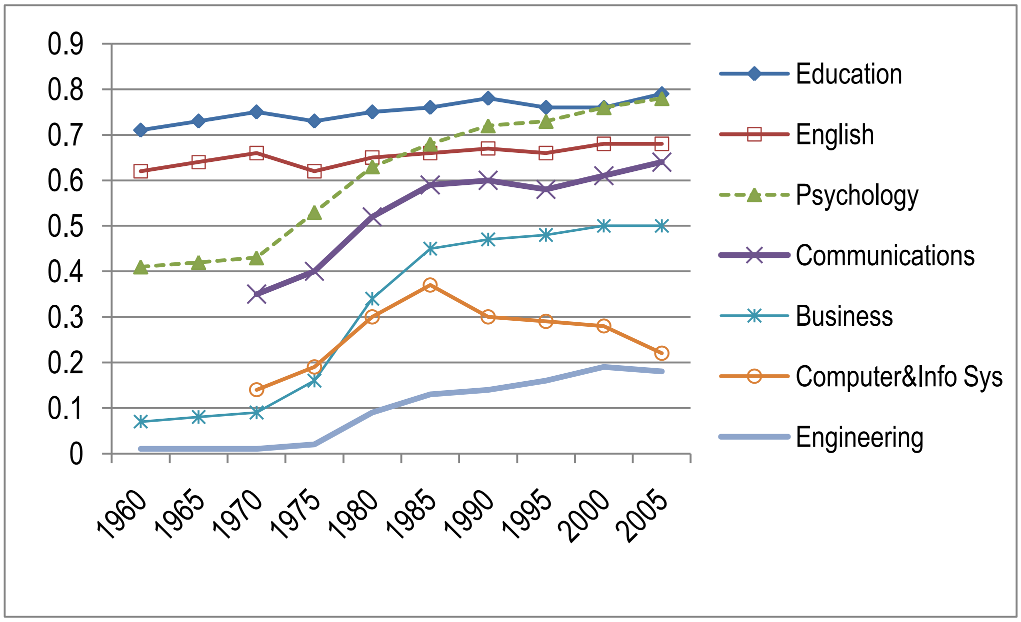

Figure 1: Proportion of women earning bachelor's degrees in selected fields: 1960 to 2005. Adapted from the National Center for Education Statistics (2009c, 2009d, 2009e, 2009f, 2009g, 2009h, 2009i)

The choice of major influences (and sometimes limits) the choice of occupation. Students selecting majors within the social sciences and humanities often choose from a subset of occupations after graduation that do not require a specific skill set at the entry level. These occupations include sales, management, service, or clerical positions. Although major is not necessarily connected to occupation in this scenario, women disproportionately enter clerical positions even if the gender proportions within their major may have been relatively equal (Joy, 2006). Other majors, such as education, architecture, and engineering, are pre-professional.

These majors represent a significant career gateway to the related professional field (Robst, 2007), and major is highly connected to specific occupations (Joy, 2006). Thus, the imbalanced gender distribution within majors contributes to the imbalanced gender distribution within occupations. Xie and Shauman (2005) identify college major and a four-year degree as a critical point for entry into science/engineering fields. While academically prepared students can enter the science/engineering path by choosing a science/engineering major, those graduating in fields outside these majors will find it difficult to move into many science/engineering occupations. Moreover, engineering has the lowest in-migration rates when students change majors. Thus, if students do not start out in engineering in college, they are likely to never enter (Ohland, et al., 2008).

This gendered pattern of major and occupational choices leads to real differences in economic outcomes. According to the National Association of Colleges and Employers (2007), majors and occupations chosen most often by women lead to lower- or middle-ranges of possible starting salaries (generally, between $25,000 and $40,000). These majors include English, psychology, teaching, and health-related fields. Men and women participate more equally in the business-related majors, which tend to start at $35,000 to $50,000. More men than women participate in those majors connected to occupations with the highest starting salaries, many of which are in technical, computer, or engineering fields. These salaries start around $50,000. Choice of major and occupation will influence lifetime earnings, social status, future career options, and job environment. Because men tend to choose occupations leading to higher earnings and women occupations leading to lower earnings, horizontal segregation is perpetuated and gender inequity persists.

Horizontal segregation has opportunity costs that extend beyond the individual level, however. Without a mixture of perspectives in all occupations, the probability that important ideas may be missed increases. This loss may occur as much in elementary education or nursing as it may in engineering or construction. When only one side of a population participates in a field, the ideas, solutions, and innovations generated may have a narrower scope or may be reached more slowly than if a larger variety of minds were part of the process.

1.2 Purpose

This study focused on one aspect of occupational segregation by examining persistence among male and female college students in engineering, a major leading to an occupation with historically low female participation, but which is now in apparent transition. Although women received only 18% of all baccalaureate degrees awarded in engineering in 2007 (National Center for Education Statistics, 2008b), this statistic hides a considerable amount of variation across different engineering subfields. Women actually received 38% of the degrees conferred in biomedical engineering, 36% of the degrees in chemical engineering, 32% of the degrees in industrial engineering, and 21% of the degrees in civil engineering (National Center for Education Statistics, 2009a). In contrast, however, this same report shows that women received only 12% of conferred degrees in electrical, electronics, and communications engineering, 9% of the degrees in general computer engineering, and 12% of the degrees in mechanical engineering. Today, the question may not be about "women in engineering" as much as it might be about "women in certain engineering fields."

Interestingly enough, the uneven female participation rates also appear in the sciences, where, in 2007, women earned 49% of the degrees conferred in general chemistry, 62% of the degrees in general biology, but only 21% of the degrees in general physics (National Center for Education Statistics, 2009a). Looking at all of engineering today, let alone science and engineering together when considering women in these fields, could lead to erroneous conclusions (Adelman, 1998). Women appear to be doing quite well in biology and chemistry. They appear to be making significant inroads in biological and chemical engineering. We still do not fully understand, however, why the growth in female participation has been lower in some fields, such as physics, computer science, mechanical engineering, and electrical engineering, than others. Do women encounter barriers or problems that may not be present (or as present) in other majors, either before or during college? Two possible barriers in college include the adjustment to college grading practices and the proportion of female students in their women's major-specific classes.

When women and men make the transition to college, they often experience difficulty adjusting to new academic standards (Grove & Wasserman, 2004; Loftus, 2005), especially if they are used to being good students in high school. One young woman described her shock as a first year engineering student: "I had to struggle that first semester at college to catch up with everybody else. I just always wanted to be the best in the class. And when I was in grammar school I was at the top. When I was in high school it was a little bit tougher. And when I got to college, forget it. I was in the middle of the pack. Which was the hardest thing about the first semester in college. It was a rude awakening" (Farmer, 1997, p. 12). Although both men and women can experience this set back, other research has shown that lower-than-expected grades have especially negative influences on women (Crocker, Karpinski, Quinn, & Chase, 2003; Crocker & Luhtanen, 2003; Holland & Eisenhart, 1990).

Likewise female students may have trouble adapting to the lower proportion of women in their major classes. While some women may enjoy being the only female in a class (Farmer, 1997) others find this imbalance less desirable (Gaskell, 1985; Valli, 1986) or even subconsciously threatening (Murphy, Steele, & Gross, 2007; Steele, Spencer, & Aronson, 2002).

Given the evidence suggested by the literature, the purpose of this study was to find a connection among grades, female density, and persistence for women in engineering.

1.3 Justification

Women in engineering have become a particular research interest among scholars of gender, education, and careers (Sonnert, et al., 2007). The slowness of gender integration in fields such as engineering, physics, and computer science remains a multifaceted puzzle that stands in contrast to the more balanced representation of men and women within fields such as chemistry, law, and medicine, and the numerical advantage held by women in biology. The results of this study have implications for theory and practice at the individual and societal levels as well as practice and policy implications for engineering education and the engineering profession.

In terms of the individual, the engineering occupations allow greater flexibility in hours, control of work, and less supervision (Glass, 1990), as well as greater income potential (National Association of Colleges and Employers, 2007). Because many of the higher-paying occupations like engineering require specific technical knowledge, women leaving these majors or avoiding male-dominated majors in college unknowingly foreclose pathways that are likely to lead them to greater economic benefits (National Association of Colleges and Employers) and status, as well as to more autonomy and control over their work life (Glass, 1990). Understanding more about what influences women's persistence in a male-dominated field can contribute to our understanding of the dynamics underlying occupational segregation, which plays a role in the continued economic inequality between men and women in the United States (Charles & Bradley, 2009; Charles & Grusky, 2004; Joy, 2006; Shu & Mooney Marini, 1998).

At the societal level, science and engineering provide the foundations for our modern, technology-dependent civilization. These areas are engines of U.S. economic growth and national security, lower female participation in science and engineering limits women's involvement in the number and variety of ideas generated, the fields that are studied, the grants that are awarded, and what, ultimately gets invented and developed. Lower participation in science and engineering translates to lower participation in the fields that shape the way we live.

At the practical level, science and engineering sustain and advance the nation's economy and our quality of life. They affect areas as broad as health and healthcare, communication, consumer goods, transportation, irrigation, and energy (Sonnert, et al., 2007). A demographically balanced workforce has economic utility (Adelman, 1998). As collaboration expands across countries and cultures, engineering teams can span continents. A demographically balanced team can facilitate the creation of new markets and better communicate with non-engineering stakeholders (Sheppard, Macatangay, & Sullivan, 2009). A gender imbalance, on the other hand, increases the likelihood of more homogeneous ideas in these critical industries and restricts a company's, industry's, or nation's ability to innovate, make products that meet the needs of its citizens, and remain globally competitive. "For any human service economy to work efficiently, the specialization of labor should be based not only on learned skills, acquired knowledge, and developed talent, but ability to communicate effectively with a demographically diverse group of clients" (Adelman, 1998, p. 4). Research indicates that women follow different moral (Gilligan, 1993) and epistemological (Baxter Magolda, 1992) development patterns and have different socialization experiences than do men (Valian, 1999). They bring different experiences, opinions, and points of view that can challenge dominant assumptions and ways of thinking. For example, would the Internet or the automobile look and function differently if more women had been involved in their designs? Would the original uses of these tools have emphasized other possibilities?

Increasing the number of women (and minorities) in white, male-dominated fields such as engineering has another social benefit. Modern society has become so intertwined with technology that the engineering profession must look beyond its niche as a source of technical expertise and problem-solving to understand how technology and future engineers fit into a larger societal role, which includes public service, vision, and leadership (National Academy of Engineering, 2004). Relying primarily on males, the profession is currently drawing on only half of the intellectual and creative power that it could be using.

Aside from issues of balance, the proportion of foreign-born science and engineering workers in the U.S. has been growing, and concern exists that we may experience a "brain drain" in the future if global competition for science and engineering skills increases (National Science Board, 2003). This same report predicts that the number of native born workers is likely to decline. According to longitudinal NCES data, engineering has slowly been losing market share to other majors in terms of degrees conferred, even though numbers have so far remained steady (NCES, 2006). Today, only six percent of college-bound students intend to major in engineering, as opposed to 12% in European countries, 20% in Singapore, and almost 40% in China (Committee on Prospering in the Global Economy of the 21st Century & Committee on Science, 2007). The engineering community recognizes that U.S. economic and technological dominance is in danger (National Academy of Engineering, 2004). Collectively, this community spends nearly $400 million per year to promote the engineering field (Baranowski & Delorey, 2007). With less than a 19% share of all engineering degrees awarded annually (NCES, 2007), women represent a workforce pool that has largely gone untapped.

Although women are entering some engineering fields in greater numbers than other fields, this growth in numbers has not been enough to address the issues above. As a nation, we must do more to encourage young women (and men) to enter and stay in engineering if we are to maintain our way of life and economic dominance, and solve the problems of the twenty first century. This study contributes to research and practice by examining female and male persistence decisions in engineering relating to grades and the proportion of women in engineering classes (female density). Chapter two contains the theoretical foundations for why grades and female density could influence persistence decisions. Chapter three outlines the methods and the variables used within the study. Chapter four walks through the analysis of student persistence outcomes. Chapter five provides a summary of findings in addition to conclusions and implications for practice, theory, and future research.

Chapter Two

Literature Review

2.1 Background

Even though more women are entering some science and engineering fields than in any previous time in U.S. history, a substantial body of work indicates that this participation has been a recent development. Berryman's (1983) initial characterization of the science pipeline, which became the dominant metaphor through the end of the century, described a conduit stretching from elementary school through college and graduate school. Students were considered part of the pipeline either through interest or academic ability. Berryman found that the number of students in the pipeline crested at the end of twelfth grade and shrank thereafter as students left the pipeline for various reasons. Berryman's report defined and quantified the problem and offered a conceptual framework (the pipeline) by which to engage and evaluate potential solutions.

Historically, more men than women have entered and persisted through the science, technology, engineering, and mathematics (STEM) pipeline, resulting in more men remaining at the end to enter science and engineering careers. Fewer women have entered and more have "leaked" out at various points, such as in the transition from high school to college, during college, at graduation, in going to graduate school, or in entering the science/engineering workforce. The smaller initial pool and greater leakage accounted for the lower proportion of women within science and engineering occupations. The pipeline metaphor allowed early researchers to focus attention on the leakage points and increase the pool of potential women at the beginning of the pipe, both in terms of interest and in terms of academic readiness.

The pipeline had its conceptual blind spots, however. As early as 1988, Ethington and Wolfle began to find complexities within the pipeline construct, such as the interaction between gender and socioeconomic status (SES). Higher SES women were less likely to indicate an interest in science or engineering. Other studies (Correll, 2001; Maple & Stage, 1991) replicated Ethington and Wolfle. Critiques of the pipeline construct have surfaced in the intervening years. Adelman (1998) suggested the use of "pathways" rather than a "pipeline" metaphor to conceptualize student movement and interests. According to Adelman, "What students do, after all, cannot be described very well by 'pipelines' with 'leaks.' The metaphors are children of policy needs, not helpful descriptors" (p. 10). "Leaking" students with individual goals probably have little consideration for a national science pipeline. As a result, factors affecting female choice were often explored outside the pipeline construct. For example, studies found that women and men hold different life and occupational goals and values (Beutel & Marini, 1995; Eccles, 1994; Leslie, et al, 1998), fulfill different gender roles (Hawks & Spade, 1998; Holland & Eisenhart, 1990; J. A. Jacobs, 1995; Valian, 1999), and have different ways of defining themselves (Crocker, Karpinski, et al., 2003; Holland & Eisenhart, 1990; Lee, 1998, 2002). Male and female students have differing levels of academic self-confidence and self-efficacy in science and mathematics (Brainard & Carlin, 1998; Catsambis, 1994; Felder, Felder, Mauney, Hamrin, & Dietz, 1995; Hawks & Spade, 1998; Sax, 2008). Social and cultural forces can serve to repel many women and disadvantage or discourage those who enter. Because men are often believed to be naturally better in mathematics, women may opt out of engineering or other math-intensive fields even if their test scores are the same or higher than those of their male counterparts deciding to pursue engineering (Correll, 2001, 2004). Likewise, engineering, as a masculine field with a masculine culture, appeals less to women even if they have the requisite math and science skills (Frehill, 1997, 2004; Leslie, McClure, & Oaxaca, 1998; Leslie & Oaxaca, 1998; McIlwee & Robinson, 1992; Tonso, 1996). Moreover, women may also anticipate conflicts between work and future family responsibilities and opt for a major they believe will lead to more flexible working hours or where there may be more women in the same situation (Hawks & Spade, 1998; Xie & Shauman, 2005). Women are more "other-oriented" and more drawn to "people fields" where they can either work with people or serve mankind (Baranowski & Delorey, 2007; Gilligan, 1993), and messages emphasizing the individual benefits of engineering, such as good pay or a stable job, do not reach them as readily as those emphasizing how engineering will help others (Baranowski & Delorey, 2007). Moreover, curricular practices, such as grading on a curve or using "weed-out" courses, can affect persistence of both men and women in science and engineering (Adelman, 1998; Seymour & Hewitt, 1997; Tobias, 1994). These interconnected issues have been found in the research surrounding women in science and in engineering literature. The fact that the latter continues to grow testifies to the increasing concern regarding female participation in engineering and the lack of an easy solution.

While not everyone can or should be an engineer, it remains puzzling why engineering as a field has attracted so few women when other math and science fields have become more gender-balanced. As little as a decade ago, unequal high school participation and lower test scores in math and science could explain a large portion of the gender disparity (American Association of University Women, 1999; Berryman, 1983). Not enough academically qualified women existed in the science and engineering pool to enter any of these disciplines at the same rate as men. More recent figures, however, suggest that the math and science achievement scores of males and females are now virtually equal (Freeman, 2004; Vogt, Hocevar, & Hagedorn, 2007; Xie & Shauman, 2005). Since chemistry and biology draw from the same academically qualified talent pool as does engineering, the reason for continued gender disparity cannot be a shortage of qualified female candidates. The natural experiment of expanding and equalizing the pool did not result in gender integration within engineering, which leads to the conclusion that not all the disparities have been pipeline-related. The literature, in addition to national trends, suggests at least two areas of possible interest that have not yet been explored in tandem: The difference between actual and expected grades and the female density within particular engineering majors.

2.2 Grades

The literature on college students has identified the general importance of grades, both in high school as a predictor of future success in college, and within college as a measure of academic success. Grades represent a reward for academic effort (Kuh & Hu, 1999; Leonard & Jiang, 1996) and have been viewed as the academic equivalent of a salary or wages in their importance to students (Bean, 1983; Becker, Geer, & Hughes, 1995). The structure of college provides the incentive to achieve good grades just as the structure of society provides incentives to achieve high salaries (Becker, et al., 1995). Grades determine whether students can remain in college, maintain any scholarships, and often whether students are able to go on to graduate school. Lack of adequate grades forecloses these options, just as lack of money limits an individual's participation in a capitalistic society.

Today's students inherit a culture that understands academic achievement represents a significant path of social mobility (Horowitz, 1987). Horowitz's "new outsiders" of the 1980s "grinded" for good grades in order to maximize their chances for law school. Before the Vietnam war, grade-conscious students did the same to increase their upward mobility (Becker, et al., 1995; Horowitz). "…Many undergraduates in the 1950s came to college to rise in the world or to sustain, by entering the professions, the class position that parents had gained through business. Their ambitions required them to work hard in college and to try to do well academically. The result was that, especially at large state universities that did not have competitive admissions, an intense grade consciousness was emerging. To certain observers it seemed all-pervasive" (Horowitz, p. 191). In this pre-Vietnam world of social ambition, good grades determined what Greek organization one could join, where one lived on campus, and even maturity (marked by good grades) or immaturity (marked by bad grades) (Becker, et al., 1995). Today, grades still play a role in the organization of academic life, from honors residences, professional societies, distribution of merit-based scholarships, and academic cut-off points for enrollment within some majors and within the institution.

Grades provide performance feedback to students and parents and indicate how well a student is doing, both individually and compared to peers. Thus, grades are also a source of psychological importance because people gain self-esteem when they compare themselves favorably to others (Leary & Baumeister, 2000). For example, the value of an A- may be measured in absolute terms (high academic achievement) as well as relative to the achievement of peers (outperforming peers who got Bs or Cs). The A- will hold a different meaning if peers receive mostly As. Despite its meaning in terms of academic achievement, an A- in this case indicates that one has achieved less than one's peers. Self-esteem may even suffer a dip, depending on the circumstances. A cumulative GPA reflects the average of students' grades across individual courses and can operate in the same relative or absolute manners, except that the stakes of social comparison may be higher.

Even students who do not rely on grades for self-esteem find it difficult to escape the negative effects of lower grades because grades also influence how others regard them, which in turn affects their self-esteem (Steele, et al., 2002). For example, underperforming students may be viewed by teachers as less able (G. L. Cohen & Garcia, 2008).

Given the commonality and centrality of grades during elementary and secondary school, by the time students reach college most are likely to have accepted grades' absolute and relative meanings as a fact of life. Some students may have become so used to receiving good grades that good grades for their own sake are a major source of self-esteem (Crocker, Karpinski, et al., 2003; Crocker, Luhtanen, Cooper, & Bouvrette, 2003; Horowitz, 1987) or the foundation of an identity (Holland & Eisenhart, 1990). Horowitz (1987) describes how one "articulate young man knew his GPA to the thousandth decimal place. He was self-admittedly obsessed with academic achievement and derived from it his 'whole self-esteem'" (p. 285). By maintaining good grades, students are able to maintain a positive view of themselves.

Psychological literature suggests individuals desire to succeed in domains in which they are highly identified, or in which they place their self worth (Crocker, Karpinski, et al., 2003; Crocker & Luhtanen, 2003; Crocker, Sommers, & Luhtanen, 2002; Pronin, Steele, & Ross, 2004; Steele, 1997; Steele, et al., 2002). Examples include being an athlete, making lots of money, or being a good student. Success in a domain brings feelings of self-worth and can even influence motivation for improvement. Bandura and Jourden (1991) report that MBA students playing in a simulated management game actually began setting higher goals and making better decisions after receiving feedback that they were mastering the game and outperforming their peers. If students find they can achieve good grades relatively easily in primary and secondary school, they can come to rely on grades as a ready source of self-esteem. Good students get good grades, and good grades reconfirm the identity of a good student.

On the other hand, failure, or less-than-expected performance, in a domain where self-worth is located can cause various degrees of discouragement, feelings of worthlessness, or disengagement from the activity in order to protect self-esteem (Crocker & Park, 2004; Dweck, 2000). Crocker, et al. (2003) found that psychology and engineering students whose self-esteem was contingent upon academic achievement were more influenced by low test scores than students whose self-esteem was not. After experiencing low scores, the former reported lower feelings of self-worth and greater disassociation from their major than did the latter. Women's self-esteem was more likely than men's to be contingent upon academic achievement, but female engineering majors reported being affected more strongly than their female psychology counterparts or male engineering peers. The authors suggest that, "Women in engineering who receive unexpectedly bad grades may conclude that they lack ability; for those whose self-worth is staked on their academic performance, this may lead to sharp drops in self-esteem and to doubts about belonging and disidentification with the engineering major" (Crocker, Karpinski, et al., 2003, pp. 507-508). The authors note that women in this condition may also be particularly focused on avoiding failure. Students who fear possible failure may opt for a major where they are more certain of high grades (Elliot & Church, 1997).

Other literature confirms that although women tend to get higher grades in high school and in college (Adelman, 1998; Kuh & Hu, 1999; Pryor, et al., 2007), women appear to be more grade-sensitive than men and more likely to change majors if they fail a course (Felder, et al., 1995), or to not enroll in further classes within a subject if they do poorly in a course (Rask & Tiefenthaler; Sabot & Wakeman-Linn; Seymour & Hewitt, 1997). If good grades become a goal independent of other goals, a focus on academic performance without a concurrent focus on learning may not lead to higher grades over the long term. Students focusing on performance are likely to forget material after the course is finished (Becker, et al, 1995) and may run into difficulty in advanced courses when they are expected to synthesize knowledge and make their own connections (Horowitz, 1987).

Why might women's self-esteem rest upon grades more often than men's? One possible explanation suggests that young women have been socialized to please others (Valian, 1999), and good grades generally make parents and teachers happy. Dweck (2000) suggests that bright girls are especially vulnerable to an epistemology where intelligence is fixed and where good grades make one appear smart and therefore a "good" person. Holland and Eisenhart (1990) theorize that many women enter college with the self-definition of a good student and suffer identity loss if they cannot maintain good grades. These women often find a new identity through romantic relationships.

Another explanation specifically regarding male-dominated fields suggests women rely on performance feedback, such as test scores or teachers, more so than their male peers in the same major because culture does not tell them they are naturally good in these areas (Correll, 2001). Moreover, cues such as role model encouragement, implicit support from family and friends, and assumed societal approval of major choice may also not be available to women in male-dominated majors (Felder, et al., 1995). Without these cultural indicators, women may give more weight to grades than they might in other majors, interpreting a semester or two of lower-than-expected grades as a signal to reassess major choice and life direction.

If students use grades to measure achievement and to define themselves, a national trend in rising high school grades and college grade expectations should attract attention within the higher education community, especially since many students go directly from high school to college. In *The Nation's Report Card: America's High School Graduates* (Shettle, et al., 2007), Class of 2005 graduates earned a grade-point average (GPA) that was roughly a third of a letter grade higher than that of their counterparts in 1990. Pryor, Hurtado, Saenz, Santos, and Korn (2007) document a 40-year trend in rising student-reported high school GPAs. They also report that the number of students expecting to make at least a B average in college rose from 42% in 1987 to 61% in 2006. This same study, however, also reports that the average number of hours spent studying during the senior year of high school fell from 47% to 33%.

Higher grade expectations and an history of relatively easy academic success (or at least fewer study hours) could have potentially negative consequences for students who expect to continue receiving good grades while expending the same level of effort as they did in high school. This possibility may especially be true for students coming from high schools in which they were big fish in relatively small ponds, since their frame of reference was limited (Drew & Astin, 1972). Since students from these situations may have positively biased assessments of their ability (Marsh & Parker, 1984), they are especially at risk for disappointment. Throughout high school, many of these students did better than the majority of their classmates. In college, however, their reference population shifts from high school classmates who may or may not intend to enroll in college to a group of classmates reflecting the best and brightest students that the postsecondary institution could attract. In order for half the students to be in the top 50% of the class, the other half must be in the bottom 50%. This transition may be hard for some students to make if they have been in the top 25%, top 10%, or top 5% of their classes all the previous years of their lives. Just as positive social comparison provides a boost to self-esteem, negative social comparison can do the opposite. In contrast to the MBA students in the 1991 Bandura and Jourden study who began setting higher goals and making better decisions when they were told they were mastering the game and outperforming peers, those told that their performance was lower than their peers grew discouraged and began making more erratic decisions.

One of the best predictors of persistence in engineering appears to be first-year GPA (Jackson, Gardner, & Sullivan, 1993; Robst, Keil, & Russo, 1998). Loftus (2005) identifies the transition between the first and second years as critical to student persistence in engineering. Many students accustomed to receiving good grades in high school without working too hard receive the first C or D of their lives during their first year. Such a grade could discourage most students, but especially those who rely on good grades as a source of pride and self-definition.

2.3 Female Density

Gender is generally obvious to the observer and, as Deaux and Major (1987) suggest, may have more commonly shared beliefs, such as the distinction between male instrumentality and female expressiveness, than many other social categories. The proportion of other women (female density) in a class or major may also play a role in female persistence in engineering. Negative female stereotypes in quantitative areas have some scientific legitimacy (Benbow & Stanley, 1983), but they are dispersed more widely in children's toys such as Barbie, who, in the 1990s said, "Math is hard!" (Ben-Zeev, et al., 2005) and by mothers and fathers who hold different expectations regarding math achievement for their sons and daughters (Eccles & Jacobs, 1986; J. E. Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; J. E. Jacobs, Finken, Lindsley Griffin, & Wright, 1998). These stereotypes are reinforced by beliefs that women in engineering fields are less feminine (Hartman & Hartman, 2008; Rotter, 1982). Gender essentialism plays a large role in occupational segregation (Charles & Bradley, 2009; Charles & Grusky, 2004; Grusky & Charles, 2001) as well as in the imbalanced distribution of domestic chores and child-rearing responsibilities (England & Farkas, 1986; Kanter, 1993; Valian, 1999). For these reasons and others, women in highly male-dominated majors may simply feel more comfortable in classes where there are more women.

The empirical basis for the gender "comfort in proportional numbers" construct rests upon two related literatures: The developing research on social identity threat and research specifically regarding female students in science and engineering classes and majors. For the purposes of this study, female density refers to the proportion of students who are female within a specific engineering field or sequence of courses. Although other measures exist, such as sex ratio, a proportion can be more intuitive to understand and is easily compared to the gender percentages in reports such as Pryor, et al (2007).

2.3.1 Social Identity Threat

Social identity threat (Steele, et al., 2002) evolved from stereotype threat (Steele, 1997; Steele & Aronson, 1995), which has made major contributions to understanding gender and racial disparities in science and engineering disciplines, and has been implicated as a major cause for gender and minority test disparities (Schmader, 2002). Described as a "threat in the air" by Steele (1997), stereotype threat can cause performance anxiety when a situation arises in which individuals feel a negative stereotype about their group is being applied and that they are in danger of conforming to the negative stereotype. For example, African American participants performed worse on a test of verbal skills when they believed the test was diagnostic of their abilities or when they were primed to think about racial stereotypes before taking the test (Steele & Aronson, 1995). Women underperformed on quantitative tests when they believed the tests were diagnostic and likely to confirm the stereotype that women are not as good in math (Johns, Schmader, & Martens, 2005; Martens, Johns, Greenberg, & Schimel, 2006; Schmader, 2002; Shih, Pittinsky, & Ambady, 1999). Asian women underperformed on a quantitative test when primed to think about their female identity but not when primed to think about their Asian identity, which held a positive stereotype for mathematics skill (Shih, et al., 1999). Even White men who scored over a 610 on the SAT-M underperformed when they believed their abilities were being compared to those of Asian students, who were represented as having a math advantage (Aronson, Lustina, Good, & Keough, 1999).

Similar to stereotype threat, social identity threat operates to trigger underperformance and psychological discomfort. However, unlike stereotype threat, social identity threat does not need to be overt. Steele, Spencer, and Aronson (2002) write:

> As noted, all people have multiple social identities: Their sex, age, race, ethnicity, social class, religion, professional identity, etc. In particular settings or domains of activity, a person can come to realize that they could be devalued, marginalized, or discriminated against, based on one of these identities...This realization could derive from a person's general cultural knowledge of how people with given social identities are regarded in given settings and domains of activity (cf. Goffman, 1963). Or it could be prompted by a cue in the setting that raises the possibility of such a devaluation. Once the realization happens, however, we assume that the person becomes vigilant to the possibility of

identity threat in the setting (as a default reaction) until it proves no longer necessary....But what brings the hypothesis into being and essentially forces it into the concerns of all potential targets, is the assumptive knowledge, shared by virtually all members of the culture, of how different groups of people are perceived and valued in the various settings of society (Goffman, 1963). It is this knowledge that makes the hypothesis, for all relevant parties, essentially unavoidable (p. 417).

Subsequent research suggests that numerical minority influences how women feel about science/engineering-related activities. Murphy, Steele, and Gross (2007) performed an experiment in which upper-division science, mathematics, and engineering (SME) students watched one of two promotional videos for a SME conference. Female students felt more desire to participate, and anticipated a greater sense of belonging, if they were part of the group watching the gender-balanced video. Those watching the same video in which only 25% of the participants were women felt less desire to participate and anticipated a lower sense of belonging. Although the situation was neutral and non-threatening, the subtle situational cue within the unbalanced video also triggered more physiological and cognitive uneasiness for women. Their heart rates and skin conductance were higher and they recalled more details about the video and the room because they were less relaxed.

But how many women are enough to alleviate the threat? In the neutral setting provided by Murphy, Steele, and Gross (2007), it appears to be somewhere between 25% and 50%. In a non-test situation where participants watched a sexist ad, it only took the presence of one male for the women in the room to feel uncomfortable (Abrams, Thomas, & Hogg, 1990). In a neutral quantitative test situation, female students' performance decreased with each additional male in the room taking the test at the same time (Inzlicht & Ben-Zeev, 2000). When female engineering students had a conversation with a male confederate and then took an engineering test represented as being diagnostic of skill, they performed worse if the male confederate exhibited sexual interest and dominant body language (sitting closer, shoulders back with legs wide apart) than when the confederate exhibited more tentative body language (sitting further away, leaning forward with knees together) (Logel, Walton, Spencer, Iserman, & von Hippel, 2009). Moreover, when taking a similar test in English, a subject where women typically score higher than men, the women interacting with the "sexist" males outperformed their female peers. The necessary number of women before a comfort level is reached appears to depend on the nature and context of the threat.

In an example of another group attuned to cues for potential devaluation, Purdie-Vaughns, Steele, Davies, Ditlmann, and Randall Crosby (2008) demonstrate that lack of numerical representation in corporate recruitment brochures made African American professionals at a networking event less trusting of a fictitious company's management than if the brochure photographs contained a higher ratio of diverse workers. This effect was moderated by a corporate statement of diversity. A company with low diverse representation and a color-blind diversity statement elicited the lowest amount of trust, but a strong statement for diversity counteracted the perceived threat in the non-diverse literature. The authors concluded that both the representation and the recruitment literature acted as cues for potential devaluation, but that they were taken in context with each other.

Perceived minority status in a situation can also influence feelings of belonging within an academic department (computer science) for Black and White Students (Walton & Cohen, 2007). The authors recruited students in a computer science class to list two or eight friends whom they believed might fit into the department and afterwards rate their own chances of success in computer science. The numbers were designed to make the task easy (everyone can think of two friends) or difficult (students would likely be hard-pressed to know eight people who would be a match). The authors hypothesized that Black students, as minorities, would be more susceptible to belonging uncertainty, a "global uncertainty about the quality of one's social bonds in academic and professional domains" (p. 94). The pressure to generate eight friends should trigger this uncertainty, which it did. Although both sets of students had trouble with the eight friend question, Black students' self-perceived potential to succeed in computer science was lower when asked to list eight friends. Moreover, in a hypothetical advising situation in which a same-race peer was considering entering the major, Black students asked to list eight friends were more likely to steer these peers away. The authors concluded that belonging uncertainty can occur in the absence of prejudice, tests, or other factors that had previously been shown to induce stereotype threat. Rather, "Subtle events that confirm a lack of social connectedness have disproportionately large impacts" (p. 86), that are in many ways similar to those of the Murphy, Steele, and Gross (2007) study mentioned previously. Thus, lack of women in a male-dominated field may set off a conscious or unconscious reaction to threat, acting to exacerbate an already unequal situation.

2.3.2 Women in Engineering

These social identity threat studies are consistent with findings from the sociological and women-in-science/engineering literatures, which stress the significance of peers. Peers are an important influence on college students (Astin, 1993; Leslie, et al., 1998; Pascarella & Terenzini, 2005). Defined as "any group of individuals in which the members identify, affiliate with, and seek acceptance and approval from each other" (Astin, p. 401), peers represent “the single most potent source of influence on growth and development during the undergraduate years” (p. 398). Patterns of peer influence on academic or occupational choices exist before college. Students select peers with similar aspirations (J. Cohen, 1983), and the peer group affects the scope and variety of student occupational decisions while still in high school (Bidwell, Plank, & Muller, 2000). For women, the choice to enroll in higher mathematics courses in high school is associated with the achievement of close friends and, to a lesser extent, course mates (Crosnoe, Riegle-Crumb, Frank, Field, & Muller, 2008). For girls, especially, having same-sex friends who excel academically is positively related to subsequent advanced math and science course taking (Riegel-Crumb, Farkas, & Muller, 2006).

Friends also influence future occupational aspirations. Peer support for science and opportunities to share science with friends is positively related to the preference of a science career for 9th and 12th grade girls (J. E. Jacobs, et al., 1998). In another study, Lee (2002) concludes that if high school girls cannot find and sustain emotionally satisfying relationships where scientific, mathematic, or engineering concepts are part of routine interaction, they are disadvantaged in their achievement in science.

At the college level, peers influence student persistence in engineering, business, social science, and other fields simply through the power of numbers (Astin, 1993). For example, the author found that the likelihood of students persisting in engineering increases as the proportion of engineering majors in an institution increases. Women may be more likely to persist, even in the face of difficulties such as lower-than-expected grades, if there are more women around them.

Peer influence can also work against persistence in engineering. Seventy three percent of the first-year students in the Hartman and Hartman study (2008) believed the perception that women in science or technical fields are unfeminine was at least a minor problem. Although only 28% of these same students felt the same way in their fourth year, those whom the belief might have affected the most could already have left the major. “Many white females abandon, reduce aspirations toward, or never enter science and engineering” due to peer influence (Leslie & Oaxaca, 1998, p. 328), while women valuing popularity and attractiveness to males are less likely to enter a STEM discipline in college than those without these values (Leslie, et al., 1998). Moreover, women starting in female-typed majors are much more likely to graduate in them if they attend a coeducational institution than if they attend a women’s college (Solnick, 1995). Holland and Eisenhart (1990) document how peers can have a negative influence on academic pursuits by rerouting failed “good students” through a peer system emphasizing female attractiveness and romantic relationships with males.

One by-product of a female-scarce environment appears to be an overly male-influenced culture. "When a girl or young woman is one of the few of her gender in a science or math classroom, study group, or program, it creates a ripe atmosphere for a hypercompetitive, ‘individualist’ male culture to dominate—one in which gender stereotypes thrive and perceptions of female isolation and lack of fit reverberate" (Riegel-Crumb, et al., p. 209). The old system of grading on a curve and “weed-out” courses encourages this competitive culture (Seymour & Hewitt, 1997). In a work environment study, female engineers at a start-up firm complained that male colleagues attempted to out-do each other technically in what the authors termed a “technical locker room” (McIlwee & Robinson, 1992). Women felt more comfortable in a formal, bureaucratic environment but less comfortable in informal situations where male culture was more prevalent (Kanter, 1993; McIlwee & Robinson, 1992).

Some disagreement with the gender density proposition does exist. Although many aspects of Kanter's (1993) tokenism theory support gender density, some do not. Kanter followed the difficulties of the first women to enter professional and managerial jobs at a large, bureaucratic multinational corporation. This entrance caused friction between the entrenched and organizationally powerful male majority and the female newcomers. Although the company's motives were well-meaning, female turnover, or "failure rate" (p. 207) was known to be much higher than that of men in the same positions. Kanter believed that women's rarity and scarcity, rather than their femaleness, shaped their environment and dubbed the results of this rarity "tokenism."

Components of tokenism included several dilemmas and contradictions. Women served as representatives of their gender when they fumbled and as unusual exceptions when they succeeded. They were made aware of their differences by their male coworkers but had to pretend these differences did not exist or were not important. Moreover, they were some of the most visible organizational players but often existed for show and were not included when real decisions were made. Kanter reasoned that as long as women existed in such low proportions, they would remain tokens within the organization. More women visibly acting as contributing organizational members would eventually distract from their novelty and allow them to be considered as equals.

Kanter (1993) suggested that the road to equal partnership and balance might be rocky. In Chapter Eight, she presented a continuum going from total majority (a 100:0 ratio) to skewed ratio (around 85:15) to tilted group (around 65:35) to balanced group (starting around 60:40).

Tokenism occurred within proportions similar to the skewed ratio of 85:15. The minority was visible but not enough members existed to make an impact. Even when a group had more than one minority member, the balance of power usually prevented minority members from becoming allies. When the minority reached a ratio of around 65:35 members began to gain power. At this point the women in Kanter's study were not just a threat to the male culture but real competition for jobs and favorable attention from bosses above. Some of the men actively tried to exclude the women or make them socially uncomfortable by telling sexist jokes or holding secret meetings. Kanter hypothesized that this conflict would ease as the ratio of women grew to be more balanced, but this would take time. In the interim between total majority and balanced group, the backlash against a growing minority may outweigh the psychological benefits of having more comfort in numbers.

Rogers and Menaghan (1991) found evidence of a backlash in their research. Their study contained a mixture of male-dominated majors in business and science/engineering. As the proportion of women increased in these traditionally male-dominated fields, tensions between genders also increased and brought differences to the forefront. Women, in the minority throughout, reported more feelings of performance pressure and lower likelihood that they would persist in their major as the proportion of their minority grew.

Sax (1996) did not find evidence to support or disprove a gender density argument, but rather that student outcomes in college were generally unaffected by the gender composition of a field after student characteristics, institutional characteristics, and major were controlled. For example, the men appeared to have lower math self-concepts when majoring in fields with more women, but this was because women tended to major in fields where math was not promoted.

However, Sax did not specifically focus on male-dominated disciplines but instead controlled for them via major.

Despite the danger of increased tensions and competition making the environment less hospitable for women, the current study hypothesized that women are more likely to persist in engineering majors where there are more women, for all of the psychological reasons discussed above. As an academic institution, college students should be relatively insulated from competition for jobs, promotions, and office politics, and thus may not experience as much backlash to their numbers as might non-students in an employment setting. Additionally, much of the balance has already occurred in other fields since the time of Kanter's study (first published in 1977), and even that of Rogers and Menaghan (1991). Society has had a number of years to adjust to the idea that women can work in once all-male fields. The women of the current study grew up as the change was occurring. Thus, the psychological gains in increased numbers for college women in engineering should outweigh the competitive forces these increased numbers may spark.

CHAPTER 3

Methods

3.1 Research Questions

The national trends of rising high school GPAs and fewer study hours, coupled with the psychological importance that many students place on grades, could be a concern for students, parents, faculty members, researchers, and administrators at the high school and collegiate levels. Those focusing attention on women in engineering may have even more cause for worry, since women's self-esteem and academic confidence tend to be more negatively affected when receiving bad grades (Crocker, Karpinski, et al., 2003; Crocker & Luhtanen, 2003). Additionally, the overall low percentages of women choosing to enter and stay in engineering presents a puzzle when compared to the participation rates of women in some sciences, such as biology and chemistry. Women's participation in engineering is not low across the board, however. Some fields, like bioengineering or chemical engineering, have percentages of women over 30 percent. As women make inroads into some of the engineering fields, psychological, sociological, and women-in-engineering literatures suggest that the presence of more women in these fields will facilitate greater female entrance and persistence. If this idea is correct, the first step to countering the imbalance in highly male-dominated fields such as electrical or computer engineering may be to increase the critical mass of women in these disciplines.

Based upon the two influences of grades and gender density, this study asked the following questions regarding women in engineering:

1) Does a higher GPA at the end of the first year in college positively influence female persistence in the originally chosen engineering major or within engineering more than it influences male persistence?

2) Does a relatively high percentage of female students in engineering courses (higher female density) positively influence female persistence in originally chosen engineering major or within engineering more than it influences male persistence?

3) Is there a conditional relationship (interaction) between grades and female density for women? For example, would women earning a high GPA but who are in courses with a lower female density be less likely to stay within engineering or their engineering major than male counterparts earning the same GPA?

3.2 Conceptual Framework

The hypothesized relationship among grades, gender density, and persistence within original intended field is summarized in Figure 2.

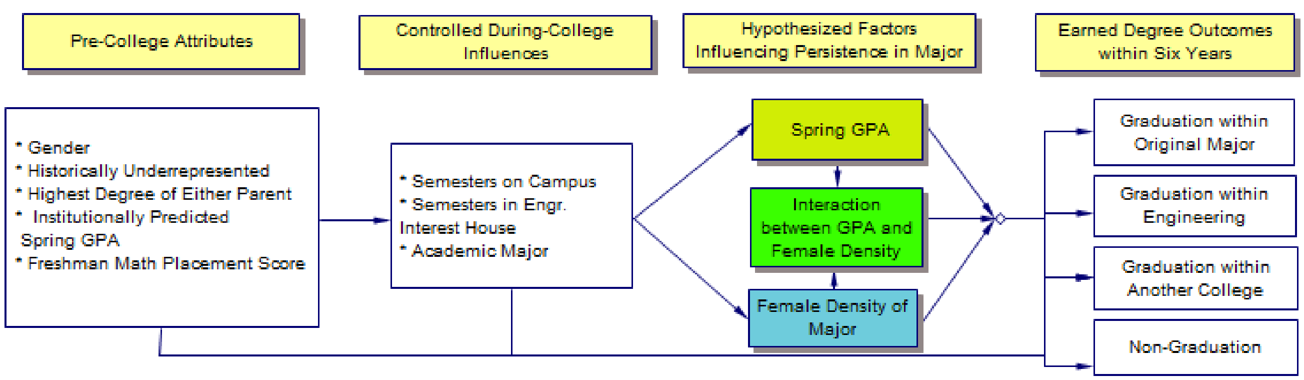

Figure 2: Conceptual framework explaining the effects of grades and female density on female persistence in an undergraduate engineering major

The figure suggests that students enter college with certain attributes, such as race/ethnicity and parental education, as well as different levels of pre-college achievement (summarized by the institutionally predicted GPA that is derived from high school grades and SAT/ACT scores). These pre-enrollment characteristics were controlled before considering the variables related to the study.

During college, students take courses that fulfill general education requirements or which are pertinent to their intended major and interests, and for which they receive grades. Engineering students earning a high grade-point average (GPA) might reasonably be expected to remain in their initial field. Although a cumulative GPA could include performance in classes outside the intended major, such as general education courses, the recommended course schedules for each of the engineering majors within the study assures that a majority of the first-year credits are taken in foundational courses in mathematics, engineering, or science.

Students with higher GPAs at the conclusion of the first spring were hypothesized to be more likely to persist in their originally intended engineering field than those with lower GPAs. However, since women are more accustomed to receiving higher grades in high school and college than men, and because those receiving good grades are more likely to regard themselves as good students than those not receiving good grades, women were hypothesized to be more likely than men to leave if they received a lower-than-expected or lower-than-average GPA (Rask & Tiefenthaler, 2008; Sabot & Wakeman-Linn, 1991; Seymour & Hewitt, 1997).

Likewise, because women may find comfort in numbers in a field where they have been negatively stereotyped (Abrams, et al., 1990; M. C. Murphy, et al., 2007; Steele, et al., 2002), and because positive female relationships within a field reinforce further interest and activity in that field (Crosnoe, et al., 2008; Lee, 2002; Riegel-Crumb, et al., 2006), women with an academic environment having a higher female density should be more likely to remain in that environment than those having an environment with lower female density. The presence of more women in a major was hypothesized to facilitate more mutually encouraging female friendships and lead to greater female persistence (J. E. Jacobs, et al., 1998; Lee, 2002).

Finally, the study also examined a possible interaction between grades and female density for women. Good grades may moderate the negative effect of a low female density for women while a high female density may dampen the negative effect of lower grades. For instance, a greater proportion of women in a female student's classes may positively influence her decision to stay despite lower grades. On the other hand, a higher grade may positively influence a woman's decision to stay despite a lower proportion of other women. Female students with both a high GPA and a high proportion of female classmates would have an overall greater likelihood of remaining in engineering than those with low GPAs and a lower proportion of female classmates.

The study differentiated among four outcomes for both men and women: Graduation in original engineering major, graduation in a different engineering major, graduation outside of engineering, and no graduation within six years. The three hypotheses surrounding grades, female density, and possible interactions between the two were tested at each of three levels (major, engineering, and institution).

3.3 Design and Population

The study adopted an *ex post facto* design undertaking secondary data analyses of institutional records from students enrolled in a large, nationally known college of engineering at the main campus of a public, land-grant, research university. The study represented a census of all first-time, first-year, full-time, male and female baccalaureate students starting in the summer or fall semesters of 2000 through 2003 who, upon taking a pre-enrollment advising survey, indicated an intention to major in architectural, aerospace, bioengineering, chemical, civil, computer, electrical, industrial, or mechanical engineering (n=3,249). The entering cohorts of 2000-2003 were chosen to avoid coincidental dips or spikes in enrollment as well as to provide enough cases to support meaningful analyses of the choices women make in pursuing a highly male-dominated engineering major such as electrical engineering or computer engineering. Bioengineering, a new major introduced in 2002, was included due to the relatively high proportions of women in its first two cohorts.

The intent to major in specific fields was used as a selection criteria because this university, for the most part, enrolls first-year students within a college rather than an individual major (e.g., "engineering" as opposed to a specific subfield within engineering). After earning a certain number of credits and completing a set of prerequisite courses, students may declare a specific academic major, usually at the start of the third year, although students are encouraged (or required) to take courses within the major before declaring. Students are free to leave their initial college or change their minds about their initially intended major at any time. After their formal declaration, they are also free to switch colleges and majors provided they complete any unmet requirements.

The target population did not contain part-time students or those beginning at any of the university's branch campuses because such students constitute a different population (higher median age and/or lower test scores) from those beginning study as full-time, first-year students at the main campus. Of the 3,249 initial students, 40 international students were also dropped due to probable differences in life experiences, attitudes towards engineering, and greater prevalence of missing information. Of the remaining 3,209 students, two students had missing course information and 120 failed to take a pre-enrollment advising survey providing necessary information for the study. These 122 students were dropped because they represented less than 4% of the study pool. Imputation details for partially missing course information are discussed later. The remaining 3,087 students constituted the final dataset.

To test the assumption that dropping the 120 non-survey takers does not make a difference for study outcomes, Chi-square tests of graduation outcomes (graduation in major, engineering, institution, or no graduation in six years) were performed for the population included in the study and those who were dropped due to missing information. The overall distributions were not significantly different. However, in comparing those who graduated with those who did not, the difference between the included and excluded students approached significance ($p=.092$). The non-survey takers were more likely to leave the institution without graduating than those who took the survey and remained in the study. This discrepancy makes sense, given that the non-survey takers would have missed their initial advising opportunity and the first contact with offices and resources that could have helped them. Chi-square tests were then performed on all the variables in the study for those taking the survey and those who did not. The distributions were not significantly different from one another. Since the non survey-takers had similar distributions on all outcomes and variables except graduation from the institution within six years, the decision to drop cases and not impute missing values was affirmed.

3.4 Data Collection

Individual student records containing selected attributes, such as gender, ethnicity, and responses to a pre-enrollment survey, were downloaded from institutional databases maintained by the central university computing office. The survey captures students' self- reports of parental education, intended major, and expected GPA after the conclusion of their first year in college. These data were combined with student records from the registrar's office, including cumulative GPA, course transcript, graduation, date of graduation, and any changes in major.

3.5 Variables

The variables of the study can be categorized as dependent, control, and independent variables. A theoretical basis is discussed for each, followed by a table of operational definitions and the coding schemes.

3.5.1 Dependent Variables

The dependent variables in this study include four outcomes for both men and women: Graduation from original engineering major, graduation from a different engineering major, graduation outside of engineering, and no graduation within six years. Graduation within six years is defined by receipt of a baccalaureate degree in or before the sixth spring semester, regardless of whether students entered college in the summer or fall term. Because the study adheres to the common standard of six years for graduation, students graduating after year six were combined with those who did not graduate. Only two students took longer than six years to graduate. Double and triple majors were assessed by allowing the initial engineering major to take priority over other majors and an engineering major to take priority over a non-engineering major. The four outcomes were tested at the institution level, the engineering level, and the major level.

3.5.2 Control Variables

Female

The female variable is necessary for answering the three research questions in the study. Women comprise nearly 20% of the dataset.

Historically Underrepresented

This study considers African American, Hispanic, or American Indian students to be historically underrepresented, and Whites and Asians to be majority students. Asians, although technically a minority, are counted with Whites because they perform similar to (or better than) White students in test scores and precollege achievement testing (Elliott, Strenta, Adair, Matier, & Scott, 1996; Hathaway, Sharp, & Davis, 2001). Other minority groups tend to do worse than Whites (Leslie & Oaxaca, 1998; Muller, Stage, & Kinzie, 2001; Steele & Aronson, 1995). This testing differential for under-represented students could lead to increased likelihood of switching majors, as was found in Moller-Wong and Eide (1997) for African American students. Only 366 out of the 3087 students in the study were under-represented, so the study did not differentiate among various underrepresented groups.

Parental Education

Parental education, net of other factors, positively influences student persistence in college (Pascarella & Terenzini, 2005) and can also influence student choice of major, especially within engineering and the sciences (Goyette & Mullen, 2006; Leslie & Oaxaca, 1998; Shu & Mooney Marini, 1998; Simpson, 2001).

Predicted GPA

The institution uses the predicted GPA as an estimate of each student's likely cumulative GPA after the first year of college. It derives this score from SAT or ACT scores, standardized high school GPA, and class rank. While these other measures provide separate indicators of academic strength, the institution has found that combining them provides a convenient bar for admissions that can also be re-calibrated from year to year as needed. The predicted GPA was hypothesized to be a significant factor in determining institution-level outcomes but to be less of a factor in determining engineering or major-level outcomes.

Math Placement

All incoming first-year students take a battery of placement tests before enrolling in classes. The math placement score indicates relative readiness to take Calculus I and II, both core courses requiring at least a C from all engineering majors. Researchers have found that the SAT-Math score is a better predictor for engineering student success than overall SAT score (Ohland, et al., 2008; Veenstra, Dey, & Herrin, 2008). The math placement score was chosen over SAT-M (or ACT equivalent) due to institutional integration of placement scores and Mathematics course curricula.

Semesters-on-Campus

The number of semesters spent in on-campus housing has been found to be a significant predictor for institutional retention (Pascarella & Terenzini, 2005). All first-year students at the institution are required to spend their first year living in on-campus housing unless they live locally and commute from home. In their second and subsequent years, students have the option of living on- or off-campus.

Semesters-in-Interest House

If the number of semesters spent in on-campus housing is a significant predictor of institutional retention (Pascarella & Terenzini, 2005), the number of semesters spent in a science and/or engineering interest house is likely a predictor of retention in engineering based on the idea that like-minded students in nearby housing may also provide positive reinforcement (Loftus, 2005; Seymour & Hewitt, 1997).

Controlled Major

This dichotomous variable indicates whether a cap exists on a student's anticipated engineering major. Capped majors typically take all students with a GPA above a certain threshold and any number of students just below the threshold necessary to achieve their desired enrollment number. Students with weaker GPAs may decide to switch majors within engineering or leave it altogether if they do not feel they are able to get into their initial major choice. Controlled majors in this study include aerospace, architectural, computer, and bioengineering.

Major

Since the study includes students from nine engineering fields, controlling for major ensures that relatively greater or lower persistence due to the effects of a specific department are not confounded with the effects of gender density or grade. The majors include aerospace, architectural, bioengineering, chemical, civil, computer, electrical, industrial, and mechanical engineering. The reference category is mechanical engineering, the largest major in total numbers of students (male and female). Eight dichotomous variables represent the remaining majors.

Because major is controlled, the study does not control for cohort. More variance is present among the departments than among years. Additionally, the numbers of women remaining in each major were low in many cohort years. For example, one major/cohort combination had zero women remaining and three others had one woman remaining each year.

3.5.3 Independent Variables

Spring GPA

Spring GPA is the cumulative GPA for all courses taken at the institution after completion of the first spring semester. Based upon each major's course schedule recommendations, the first year would include primarily engineering-related courses. As an overall indicator of academic progress, the institution's cumulative GPA also includes all other courses a student might take. However, the average would be weighted towards the engineering-related courses due to the number of these courses students are urged to take and a greater number of credit hours per course (often four as opposed to three). While students may do better in the non-engineering courses, these courses do not appear to exercise too much influence on the cumulative spring GPA. Less than 27% of the entire group, or 822 students, had some kind of "A" (A or A-) after their first year in school. [1]

Female Density

Female density is conceived as the proportion of women in each student's engineering environment. While environment could include academic, co-curricular, or purely social circumstances, this study uses an average of female density within each student's engineering-

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[1] Initially a GPA difference variable tracked the gap between actual and expected GPA. Since most students in the dataset expected to receive some kind of A, a higher GPA brought about by non-engineering courses would have

related courses to get as close an approximation of students' day-to-day experiences as possible using institutional data. To get this average, the recommended course schedules for each major were examined. These schedules listed required courses and the sequence in which they should be taken. The courses fell into three categories: core engineering courses, engineering courses, and required non-engineering courses. "Core" courses constitute the five foundational courses required of all engineering majors. Students must get a C or higher in each course in order to be eligible to declare an engineering major. Students usually take these courses during their first few semesters. "Engineering" courses include all courses, required or not, offered through the college of engineering. "Required" courses include any non-engineering course that is required by an engineering major, such as biology for bioengineering, architecture design for architectural engineering, and programming, advanced mathematics, or statistics courses. The gender proportions in each course were averaged to get three female density numbers for core, engineering, and required, non-engineering courses. Table 1 lists the subject areas covered in each of these categories.

Table 1: Courses Included in Each Female Density Category

Core Courses	Engineering Courses	Required Courses
Calculus I	Agricultural	Architecture (Design)
Calculus II	Architectural	Biology
Chemistry I	Bioengineering	Chemistry
Physics I	Chemical	Computer Science
Physics II	Civil	Advanced Mathematics
	Computer	Advanced Physics
	Electrical	Statistics
	Engineering Design and Graphics	
	Engineering Mechanics	
	Industrial	
	Materials Science	
	Mechanical	

3.5.4 Operational Definitions

Table 2 provides the operational definitions for all variables in the study.

Table 2: Variable Operational Definitions

Dependent Variables	
Outcome	This group of dichotomous variables is coded in the following manner based on student outcomes: • Institution = 1 if the student graduated from the institution within six years and 0 if the student did not graduate • Engineering = 1 if the student graduated from engineering within six years and 0 if the student graduated from a different college within the institution • Major = 1 if the student graduated from their original engineering major and 0 if the student switched engineering majors
Control Variables	
Female	Dichotomous, coded 1 if female and 0 if male.
Historically Under-	Dichotomous, coded 0 if either White or Asian, 1 if African American, Hispanic,

represented	or American Indian.
Parental Education (Highest degree of either parent)	This continuous variable is coded as follows: • 0: Less than high school • 1: High school diploma • 2: Some college • 3: Associate's degree • 4: Bachelor's degree • 5: Bachelor's degree plus some graduate coursework • 6: Graduate degree
Predicted GPA	Continuous between 2.0 and 3.66.
Freshman Math Placement Score	Continuous between 0 and 34
Semesters-on-Campus	Continuous between 0 through 14
Semesters-in-Engineering-Interest House	Continuous between 0 and 10
Controlled Major	Dichotomous, coded 1 if an enrollment cap exists on a student's intended engineering major (for example, if the major admits only 100 students per year) and 0 if the major has no cap.
Major	A set of dummy variables representing whether a student's originally intended major was in aerospace, architectural, bioengineering, chemical, civil, computer, electrical, industrial, or mechanical engineering. The value is 1 if yes and 0 if no. The reference category is mechanical engineering, the largest major in total numbers of students (male and female).
Independent Variables	
Spring GPA	Continuous from 0 to 4.0.
Average Female Density in Core Courses	Continuous from 6% to 61%.

Average Female Density in Engineering Courses	Continuous from 0% to 100%.
Average Female Density in Required Courses	Continuous from 0% to 86%.

3.5.5 Dataset Construction

Most variables came from the institutional databases with minimal transformation, such as the creation of dummy variables, a counting of semesters indicating when students had an on-campus address, or a recoding of survey responses. The core, engineering, and required variables were derived from student transcript data. A list of all courses taken by students during the time they were enrolled within engineering was compiled, including semesters, years, and sections. Introductory courses and those not within the core, engineering, or required categories were discarded, leaving a total of 1,962 unique core courses, 3,310 unique engineering courses, and 1,956 unique required courses. This course list was then merged with the institution's transcript and student databases to get the gender of all students enrolled in each particular semester-course-section combination. The number of females was divided by the total course enrollment to get the percentage of females per course section. All of a student's course/sections were averaged together within each of the three categories to get the average female density for each category. Thus, an electrical engineering student might have an average female density 35% in core courses, 12% in engineering courses, and 27% in required courses. In contrast, a chemical engineering student might have an average female density of 33% in core courses, 28% in engineering courses, and 40% in required courses. Even students in the same major and in the same cohort might have different percentages based on which course sections they took. Lab sections that required a separate enrollment and which awarded a separate grade were counted as individual courses. Thus, the percentage of women in students' introductory physics lectures and their physics labs both counted in their overall average for the percent female within the core courses. Labs and lectures were weighted equally in this study because although lectures may carry a more credits, labs have more peer interaction.

All but two students took at least one course that counted towards either core, engineering, or required courses. As mentioned earlier, these two students were dropped from the study because they left engineering before they took any of the necessary courses. However, any missing course data for the remaining students was calculated based on the average female percent for the appropriate category (core, engineering, or required), a student's major, and their cohort year. Table 3 provides the values used for replacing missing information. For example, a chemical engineering student entering in 2001 who left before taking any engineering courses would have a 28.1% assigned for their engineering courses variable. In contrast, the same student would have a 28.5% assigned to their engineering courses variable if they entered in 2002.

Table 3: Average Female Density by Major and Cohort Year for Core, Engineering, and Required Courses

	2000			2001			2002			2003		
	Core	Engr	Req	Core	Engr	Req	Core	Engr	Req	Core	Engr	Req
Arch	35.4%	0.3%	28.1%	32.9%	22.8%	26.1%	33.0%	23.3%	26.0%	32.2%	23.5%	23.5%
Aero	32.9%	19.3%	25.9%	29.8%	19.3%	24.8%	28.7%	17.1%	23.7%	29.8%	17.1%	23.5%
Bio E							31.8%	28.0%	39.8%	32.2%	29.5%	38.2%
Civil	36.7%	22.4%	28.6%	33.8%	21.3%	25.8%	32.8%	19.5%	25.1%	31.6%	18.8%	23.5%
Chemical	34.6%	26.1%	34.8%	32.2%	28.1%	35.0%	32.0%	28.5%	35.1%	31.7%	25.4%	35.1%
Computer	32.6%	15.0%	23.3%	29.3%	14.2%	23.3%	30.4%	14.6%	23.0%	30.2%	11.4%	22.4%
Electrical	31.7%	16.4%	24.9%	30.5%	14.7%	24.9%	29.4%	14.3%	21.5%	30.5%	14.3%	20.7%
Industrial	34.0%	25.3%	25.3%	31.4%	24.1%	27.4%	33.2%	24.5%	24.4%	33.9%	23.0%	27.2%
Mechanical	34.4%	18.7%	28.1%	31.9%	16.2%	26.1%	30.8%	16.9%	27.6%	30.1%	16.7%	27.3%

Of the 3,087 students in the study, 52 (1.9%) have substituted values for their core average, 108 (3.5%) have substituted values for their engineering average, and 393 (12.7%) have substituted values for their required courses. Using averages of cohort and major offered some advantages over other methods for dealing with missing data, such as multiple imputation, because student course-taking in the early semesters is most likely dependent upon such things as schedule conflicts and preferred time of day and not other potentially confounding variables. With these externally-driven factors, using major and cohort is likely to be a more effective method than attempting to impute missing data based on student attributes.

3.6 Analytical Procedures

This study uses institutional data for the entering summer and fall cohorts of 2000 through 2003 in nine engineering majors. The outcomes include graduation within originally intended engineering major, graduation from a different engineering major, graduation from a different college, and no graduation within six years. The four outcomes were independent of one another and mutually exclusive, two requirements for a competing-risks methodology, which allows multiple discrete outcomes (Allison, 1995). These outcomes can be calculated simultaneously or by using a series of dichotomous logistic regression models. Although a multinomial logistic regression may be more efficient, results are easier to interpret using the dichotomous models (Allison, 1995). The four outcomes can be nested from least restrictive to most restrictive (Unrau & Coleman, 1998). In this case, the least restrictive comparison is graduation with a degree versus no graduation. A more restrictive comparison is graduation in the engineering college versus graduation in a different college. Finally, the most restrictive comparison is graduation from the original engineering major versus graduation from a different engineering major. Figure 3 illustrates the nested levels as well as the order in which the regression blocks at each level are calculated.

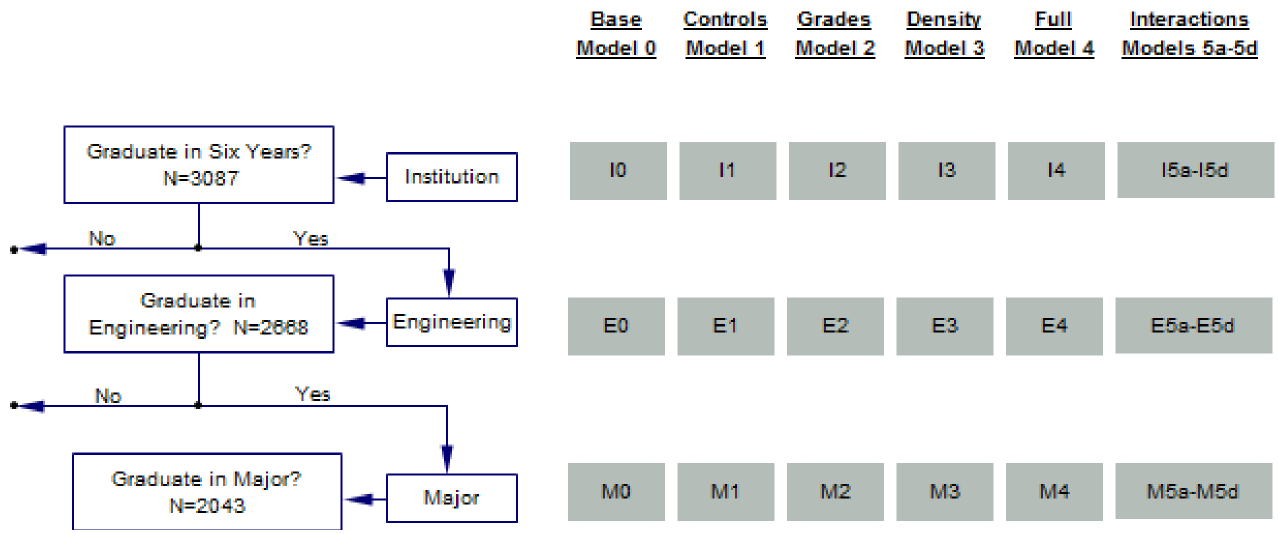

Figure 3: Modeling the four study outcomes

Each comparison is undertaken using cases that meet the previous, less restrictive criterion. The engineering-levels model draw from the pool of students who graduated within six years. The major-level models draw from the pool of students who graduated from engineering.

Comparison at each level happens through blocks of nested models formed from the research questions. Model 0 (shown below) represents the base model, containing only pre-college control characteristics, or the effect of these variables were the student able to graduate immediately upon entering college, and before having additional college experiences. Subsequent models build upon it from least complex to most complex.

$$\log \left(p \frac{p}{1-p}\right) = \alpha + \beta_{iFemale} + \beta_{iUnderrepresented} + \beta i_{Parental\ Ed} + \beta i_{Predicted\ GPA} + \beta i_{Math\ Placement}$$

where p = the probability of the outcome at the institution, engineering, or major level, α = the intercept, and $\beta_{iFemale}$ = the coefficient for the variable female, $\beta_{iUnderrepresented}$ = the coefficient for the variable underrepresented, and so on. The variables are entered in blocks. Model 1 includes Model 0 in addition to the "during-college" control variables. Model 2 includes Model 1 plus spring GPA. Model 3 includes Model 1 plus the female density variables. Finally, Model 4 includes Model 1 plus the grade and female density variables. Models 5a through 5d include various interactions related to the study hypotheses.

Since each comparison level has its own set of models, the coefficients allow the comparison between models (Model 1 versus Model 4) as well as among levels (e.g., the effect of being female on persistence at the institution level versus the same effects at the engineering level).

3.7 Limitations

This study, like all others, is limited in several ways. First, although the study examines the influence of grade expectations and gender density on the persistence of women in their initial engineering major, most switches between engineering majors, as well as moves out of engineering, are likely to be multi-dimensional. For example, while lower-than-expected grades may have some influence, perhaps chemistry may be more interesting to a student than chemical engineering. On top of the complexity of factors and underlying dynamics involved in student persistence decisions (Pascarella & Terenzini, 1991, 2005), students (especially women) often also contend with issues salient in science and engineering. For example, like the students in the studies of Seymour and Hewitt (1997) or Tobias (1994), students may run into competitive grading practices and instructors who think their role is to "weed-out" students in their courses. Likewise, self-efficacy (Bandura, 1994, 1997), or an individual's beliefs in their abilities for specific tasks or domains of knowledge, has proven to be a fruitful area of research in female persistence in science and engineering (Betz & Hackett, 1981; Hackett, Betz, O'Halloran, & Romac, 1990; Leslie, et al., 1998; Leslie & Oaxaca, 1998; Luzzo, Hasper, Albert, Bibby, & Martinelli Jr., 1999; Vogt, et al., 2007), but measurements of self-efficacy are not contained within the institutional databases available for this study. Finally, although ideas about gender and gender roles influence students' decisions to pursue a particular major (Charles & Bradley, 2009; Correll, 2004), this study does not examine the possible connection between gendered beliefs and gender density.

Second, the study does not account for external events or influences, such as occupational demand or national events. For example, the study overlaps with the dot-com bust in 2001, and some students may have switched majors due to perceived lackluster job prospects rather than because of factors hypothesized in this study. Similarly, internal, personal factors, such as student motivations, interest, and certainty, can vary over time. The institution of study does not capture this information beyond the initial pre-enrollment survey. Moreover, although capturing major intent at time of enrollment allows tracking of persistence within individual engineering major, students may not really understand the details or nuances of their field when they indicate their intent upon entrance. Thus, students may switch simply because they find something that more closely matches their interests or because the major is not what they had originally thought it to be. Likewise, although students can change their mind several times before deciding to stay or leave a field or major (Seymour & Hewitt, 1997), the institutional data used within this study capture only official student actions.

Third, although the study attempts to account for out-of-classroom experiences, semesters spent in on-campus housing and in engineering or science interest housing were the only two measures available with any consistency within the institutional databases. Membership in academic clubs, conversations with faculty members, relationships with peers, the number of friends in the same major, and other important information were not available in institutional databases created to record administrative transactions.

Fourth, the use of institutional data provides complete academic records for each student. Nonetheless, the findings may not be generalizable to other institutions if the students or the institution in this study vary from the broader collection of institutions and engineering students. The study population was defined to include only those students at the main campus, a population that is primarily traditional-aged, White, and of high academic ability. The study does not include part-time students or those who started at any of the university's branch campuses. These students may respond differently to lower grades or different gender densities, especially since they had, on average, lower SAT scores and a higher median age. Although the study sheds light on how grades and gender may influence majority and historically underrepresented groups within the context of persisting within engineering and within engineering major, it does not make distinctions among these underrepresented groups.

Finally, while the study follows patterns of student major choice, measures of student gender beliefs or what students may be thinking or feeling before they make their decisions are not captured in the institutions databases. Subsequent research could include either additional surveys or a qualitative component in addition to other institutions.

Chapter 4

Analysis

The first part of this chapter describes the dataset in greater detail and provides some cross-tabulations and other statistics that will set the stage for the multivariate analyses. In the second half of the chapter, a series of logistic regression models is run to evaluate the research questions.

4.1 Univariate Analyses

The dataset contains four cohorts of engineering students: 2,474 men and 613 women, or a total of 3,087. They come from nine engineering majors. Table 4 shows the numbers of students in each intended major, by cohort and the percentage of women entering in that particular year. Variations exist among majors, numbers, and percentages. Although industrial engineering had a larger proportion of women than mechanical engineering, it was a smaller program (only 30 total women in the four years of the study). Chemical engineering consistently drew the greatest number of women over the entire time of the study and also in each study year (no less than 33% each year). The patterns of gender enrollment follow national patterns. Although women are minorities in both electrical and chemical engineering nationally, proportionally more chose to enter the latter rather than the former (Pryor, et al., 2007). Moreover, a greater proportion of women graduated from chemical, biological, architectural, and industrial engineering, both from this institution and nationally (National Center for Education Statistics, 2007).

Table 4: Engineering Majors and Proportion of Women per Year

	Major									
Cohort Year	Aero.	Arch.	Bio.	Chem.	Civil	Comp.	Elec.	Ind.	Mech.	Year Total
2003	117	104	50	83	78	75	103	24	198	832
Males (n)	93	78	30	56	63	71	90	14	181	676
Females (n)	24	26	20	27	15	4	13	10	17	156
% female	21%	25%	40%	33%	19%	5%	13%	42%	9%	19%
2002	89	71	48	82	73	94	82	25	198	762
Males (n)	78	46	30	49	53	84	77	14	180	611
Females (n)	11	25	18	33	20	10	5	11	18	151
%female	12%	35%	38%	40%	27%	11%	6%	44%	9%	20%
2001	95	92		94	76	149	92	13	153	764
Males (n)	70	67	-	62	57	134	83	10	138	621
Females (n)	25	25	-	32	19	15	9	3	15	143
% female	26%	27%	-	34%	25%	10%	10%	23%	10%	19%
2000	68	78		128	55	137	87	17	159	729
Males (n)	49	55	-	80	38	122	76	11	135	566
Females (n)	19	23	-	48	17	15	11	6	24	163
% female	28%	29%	-	38%	31%	11%	13%	35%	15%	22%
Total Males	290	246	60	247	211	411	326	49	634	2474
Total Females	79	99	38	140	71	44	38	30	74	613
Total	369	345	98	387	282	455	364	79	708	3087

Tables 5a and 5b show students' initial GPA expectations.

Table 5a: Male Students' Expected GPA After Their First Year at College

Expected Spring GPA	Major									
	Aero.	Arch.	Bio.	Chem.	Civil	Comp.	Elec.	Ind.	Mech.	Total
A	67	41	11	74	28	85	64	8	103	481
% A	23%	17%	18%	30%	13%	21%	20%	16%	16%	19%
A-	142	103	31	111	81	187	142	24	299	1120
% A-	49%	42%	52%	45%	38%	45%	44%	49%	47%	45%
B+	59	64	16	46	76	96	88	15	173	633
% B+	20%	26%	27%	19%	36%	23%	27%	31%	27%	26%
B	21	36	2	15	25	39	28	2	57	225
% B	7%	15%	3%	6%	12%	9%	9%	4%	9%	9%
B- or lower	1	2	0	1	1	4	4	0	2	15
% B- or lower	0%	1%	0%	0%	0%	1%	1%	0%	0%	1%
Total	290	246	60	247	211	411	326	49	634	2474
Percent	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Over 60% of the students within this study expected to have at least an A- GPA at the end of their first year in college. Ninety nine percent expected at least a B, a percentage much higher than the national average of 61% (Pryor, et al., 2007). The greater percentage is likely attributable to the high academic ability of the students enrolled at the main campus of this institution and the competitiveness of the engineering program. A Chi-square test of male and female expectations shows no significant difference between the two distributions. Males and females both had high expectations for themselves.

Table 5b: Female Students' Expected GPA After Their First Year at College

	Major									
Expected Spring GPA	Aero.	Arch.	Bio.	Chem.	Civil	Comp.	Elec.	Ind.	Mech.	Total
A	12	19	5	32	7	9	6	7	17	114
% A	15%	19%	13%	23%	10%	20%	16%	23%	23%	19%
A-	45	49	22	58	36	23	12	10	32	287
% A-	57%	49%	58%	41%	51%	52%	32%	33%	43%	47%
B+	15	21	7	39	20	6	12	11	20	151
% B+	19%	21%	18%	28%	28%	14%	32%	37%	27%	25%
B	7	9	4	9	7	5	8	2	5	56
% B	9%	9%	11%	6%	10%	11%	21%	7%	7%	9%
B- or lower	0	1	0	2	1	1	0	0	0	5
% B- or lower	0%	1%	0%	1%	1%	2%	0%	0%	0%	1%
Total	79	99	38	140	71	44	38	30	74	613
Percent	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

As Tables 6a and 6b (below) indicate, however, a majority of these students (both male and female) failed to meet their expectations. In fact, only 6% of males and 7% of females received a GPA that could be considered an A, although roughly a third (27% for both males and females) received an A or A-. Forty two percent of males and 48% of females received either a B+ or a B their first year. A greater percentage of males received a B- or lower than did females (32% versus 25%, respectively). A Chi-square test between the male and female distributions equaled 18.66 with 4 degrees of freedom and was significant at .001.

Table 6a: Male Spring GPA Distributions

Actual Spring GPA	Major									
	Aero.	Arch.	Bio.	Chem.	Civil	Comp.	Elec.	Ind.	Mech.	Total
A	19	10	6	16	8	19	23	2	34	137
% A	7%	4%	10%	6%	4%	5%	7%	4%	5%	6%
A-	56	50	18	56	42	83	73	8	132	518
% A-	19%	20%	30%	23%	20%	20%	22%	16%	21%	21%
B+	62	54	11	58	42	100	63	8	166	564
% B+	21%	22%	18%	23%	20%	24%	19%	16%	26%	23%
B	51	54	9	46	40	71	72	12	111	466
% B	18%	22%	15%	19%	19%	17%	22%	24%	18%	19%
B- or lower	102	78	16	71	79	138	95	19	191	789
% B- or lower	35%	32%	27%	29%	37%	34%	29%	39%	30%	32%
Total	290	246	60	247	211	411	326	49	634	2474
% Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

The grade percentages varied across majors and between genders. Males did the best in bioengineering, where 10% received As and 30% received A minuses. Males did the worst in industrial engineering, where only 20% received any kind of A. Females did the most poorly in computer engineering, where only 9% received some kind of A. However, 9% represents only 4 women, so one additional woman would add a number of percentage points to this amount. Interestingly, the three majors in which females did most poorly (receiving a B or lower) were electrical, computer, and aerospace engineering (52%, 50%, and 49%, respectively). These three majors are heavily male-dominated. The three majors in which males did most poorly had greater female proportions, including industrial (63% Bs or lower), civil (56%), and architectural

(54%). Lest a pattern be suggested, however, the greatest proportion of women receiving an A or A- occurred in mechanical engineering (also male-dominated), where 15% received an A and 23% received an A-. The greatest proportion of males receiving an A or A- (40%) was in bioengineering, which has a high proportion of females.

Table 6b: Female Spring GPA Distributions

Actual Spring GPA	Major									
	Aero.	Arch.	Bio.	Chem.	Civil	Comp.	Elec.	Ind.	Mech.	Total
A	5	7	3	9	4	1	2	3	11	45
% A	6%	7%	8%	6%	6%	2%	5%	10%	15%	7%
A-	13	24	7	27	18	3	7	6	17	122
% A-	16%	24%	18%	19%	25%	7%	18%	20%	23%	20%
B+	22	22	16	45	18	18	9	9	22	181
% B+	28%	22%	42%	32%	25%	41%	24%	30%	30%	30%
B	16	19	6	23	19	9	5	3	11	111
% B	20%	19%	16%	16%	27%	20%	13%	10%	15%	18%
B- or lower	23	27	6	36	12	13	15	9	13	154
% B- or lower	29%	27%	16%	26%	17%	30%	39%	30%	18%	25%
Total	79	99	38	140	71	44	38	30	74	613
% Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

The letter grades in Tables 6a and 6b were determined by whether each students' GPA was at or above the midway point between the nearest two number grades. For example, if someone had a 3.84 or above, they are shown as having received an A. However, if they had a 3.83, they are shown as having received an A-. Variations among departments may simply be differences in teaching and grading methods. However, differences across grades and gender indicate that other forces may be at work.

Finally, this study examines how grades and gender density influence one of four mutually exclusive outcomes: Graduation within six years in original engineering major chosen at time of enrollment, graduation within six years from any engineering major, graduation within six years in a non-engineering major, and non-graduation.

Table 7a: Six-Year Graduation Outcomes, Males

Major	Competing Six-Year Graduation Outcomes										% of Males Initially Enrolled
	Graduate in Major		Graduate in Engineering		Graduate in Non-Engineering		Do not Graduate		Total		
	n	%	n	%	n	%	n	%	n	%	%
Aerospace*	109	38%	75	26%	59	20%	47	16%	290	100%	12%
Architectural*	123	50%	45	18%	46	19%	32	13%	246	100%	10%
Bioengineering*	12	20%	19	32%	19	32%	10	17%	60	100%	2%
Chemical	122	49%	55	22%	50	20%	20	8%	247	100%	10%
Civil	92	44%	34	16%	56	27%	29	14%	211	100%	8%
Computer*	124	30%	127	31%	93	23%	67	16%	411	100%	17%
Electrical	144	44%	77	24%	56	17%	49	15%	326	100%	13%
Industrial	34	69%	5	10%	4	8%	6	12%	49	100%	2%
Mechanical	305	48%	137	22%	101	16%	91	14%	634	100%	26%
Grand Total	1065	43%	574	23%	484	20%	351	14%	2474	100%	100%

* Major has an enrollment limit

As can be seen in Tables 7a and 7b, of the 2,474 men and 613 women in the study, roughly the same percentages of males and females overall chose to graduate in their major (43%/42%), graduate in engineering (23%/24%), leave engineering (20%/23%), or leave the institution (14%/11%). These percentages vary within major, however. Although the rates of graduation are similar for aerospace, architectural, chemical, and mechanical engineering, proportionally more men starting out in civil, computer, and electrical engineering graduated in those majors than did women. Proportionally more women who started in bioengineering graduated from that major than men, even though 40% of the men received some kind of "A" as opposed to only 26% of the women. These outcomes seem to indicate that despite many students failing to meet their initial grade expectations, a good number persevered in their initial major.

Table 7b: Six-Year Graduation Outcomes, Females

Major	Competing Six-Year Graduation Outcomes										% of Females Initially Enrolled
	Graduate in Major		Graduate in Engineering		Graduate in Non-Engineering		Do not Graduate		Total		
	n	%	n	%	n	%	n	%	n	%	%
Aerospace*	31	39%	20	25%	16	20%	12	15%	79	100%	13%
Architectural*	46	46%	23	23%	19	19%	11	11%	99	100%	16%
Biological*	10	26%	11	29%	12	32%	5	13%	38	100%	6%
Chemical	67	48%	29	21%	33	24%	11	8%	140	100%	23%
Civil	26	37%	22	31%	15	21%	8	11%	71	100%	12%
Computer*	7	16%	14	32%	17	39%	6	14%	44	100%	7%
Electrical	14	37%	8	21%	10	26%	6	16%	38	100%	6%
Industrial	19	63%	3	10%	3	10%	5	17%	30	100%	5%
Mechanical	37	50%	17	23%	16	22%	4	5%	74	100%	12%
Grand Total	257	42%	147	24%	141	23%	68	11%	613	100%	100%

* Major has an enrollment limit

The story becomes more nuanced when looking at what happened to students leaving their original major. Disciplinary and gender patterns emerge as to whether students stay in engineering, leave engineering, or fail to graduate in six years. For example, 44% of the men and 37% of the women stayed in civil engineering, but of those who left their initial major, 16% of the men versus 31% of the women stayed and graduated in another engineering field. The women who left civil engineering did not necessarily give up on engineering altogether. The same cannot be said for women leaving computer engineering, however. Of the students exiting this major, proportionally more women than men leave engineering altogether. Thirty-nine percent of the women as opposed to 23% of the men graduate in a different college if they leave computer engineering. While none of the Chi-square distributions for overall outcome were statistically different between males and females, the distributions approached significance at $p=.07$ for computer engineering and $p=.052$ for civil engineering. The patterns suggest that at this institution, at least, an opportunity exists for other engineering majors to more formally recruit women (and men) who leave their original major rather than see them leave engineering all together.

The final column in Tables 7a and 7b contain the same information that appears in Tables 6a and 6b, but which is provided again to show the overall market share of each major by gender and by persistence rate. Higher initial market share does not necessarily equate to higher persistence rates. Chemical engineering was the only major that appeared in the top three choices for female students and which also had one of the top three persistence rates. No such example exists for male students, although a large percentage (17%) desired to enter computer engineering, which had one of the lowest persistence rates for both males and females. Many of the low-persistence majors such as computer engineering, however, have enrollment caps, so some attrition is to be expected.

A description and theoretical justification was given for each of the variables in Chapter 3. Table 8 provides the study's variable measurement and metrics. These variables are listed in the order in which they are added to the models. Following the table are descriptions of the distributions for the continuous variables.

Table 8: Summary of Measurements and Metrics

	Continuous					Dichotomous	
Variable (N=3087)	Mean	Std. Dev.	Min	Max	Median	1	%
Female						613	19.9
Historically Underrepresented						366	11.9
Highest Parental Education	4.54	1.38	1	6	4		
Predicted GPA	3.04	0.21	2	3.66	3.03		
Freshman Math Placement	23.87	6.59	2	34	25		
Controlled Major						1411	45.7
Semesters-on-Campus	3.76	1.99	0	14	4		
Semesters-in-Interest House	0.96	1.71	0	10	0		
Aerospace						369	12
Architecture						345	11.2
Bioengineering						98	3.2
Chemical						387	12.5
Civil						282	9.1
Computer						455	14.7
Electrical						364	11.8
Industrial						79	2.6
Mechanical (reference group)						708	22.9
Spring GPA	2.97	0.70	0	4	3.07		
Female Density in Core Courses	31.73	6.35	6	61	31.75		
Female Density in Engr Courses	19.30	8.99	0	100	17.25		
Female Density in Req'd Courses	26.69	9.34	0	86	24.6		

The continuous variables reveal some important insights about the dataset. Within parental education, a 4.5 mean and a 4 median for highest parental education indicate that the students at this institution are coming from well-educated households. For over half the students, at least one parent has attained a Bachelor's degree. Additionally, the predicted GPA mean of 3.04 and median of 3.03 indicate that the students are fairly well-prepared. The institution predicts that nearly 50% will receive a 3.0 or higher after their first year in college, a prediction that is largely borne out, as shown in Tables 6a and 6b. The relatively high mean of 23.87 and median of 25 indicate that students are generally well-prepared to enter Calculus I. A 2 on this test would require students to take remedial math, while a 34 indicates mastery of the material for Calculus I.

The semesters-on-campus variable reflects the institutional policy that requires students who are not living at home and commuting to spend their first year in on-campus housing. The mean is 3.8 and the median is 2.0, indicating that at least half the students leave the on-campus housing after their first year, but of those who stay, most stay for a few years. The 0 reflects the at-home situation while the 14 reflects a student who spent some summers on campus and who has taken more than four years to graduate (3 semesters multiplied by 4 years is 12).

The semesters-in-interest house mean of .96 and the median of 1.7 indicate that students spent less time in science or engineering-themed residence housing than in regular residence housing, although whether this shorter period is due to choice or lack of accommodations is unclear. However, the maximum of 10 semesters indicates that at least one student spent most, if not all, of his/her academic career within the themed living option.

A spring GPA of 0 is not common but can happen if students do not attend class and fail to withdraw. While the mean spring GPA is 2.97, the median is 3.07. The 0 GPAs bring down the average while the 3.07 indicates that nearly half of the students received at least a B their first year, a statistic also corroborated by Tables 6a and 6b.

A look at all three of the course variables shows that the gender balance is skewed towards the males. When all of students' core, engineering, and required courses are averaged together, most contain more men than women.

Average female density in core courses is the least unbalanced. Many of these core courses are also required for science majors. Some of these majors, such as biology and chemistry, have more balanced gender proportions. The mean for this variable is 31.73 with a standard deviation of 6.35. The median is also 31.75, indicating that the curve is relatively normal.

Average female density in engineering courses, on the other hand, has the lowest mean (19.3), and its median of 17.25 indicates the distribution curve is positively skewed. A higher standard deviation of 8.99 indicates that more variance exists in this variable than within the core variable. Some students, male or female, may have attended heavily male-dominated courses while others may have attended more gender-balanced courses, depending, most likely, on their major. The low of 0 and the high of 100 come from students who did not remain in engineering. Some classes did not have any female students while others were 100% female because they were specifically offered to women in engineering. Students with a 0% or 100% left engineering before they took further courses that would alter this average.

Average female density in required courses has a mean of 26.69 and a median of 24.6, higher than the engineering courses but lower than the core courses. Since these courses included some having more gender balance, such as biology, chemistry, and architectural design courses, the higher average than engineering courses is not surprising. The standard deviation of 9.34 indicates that the variance is widest for this category because it encompasses such a variety of fields.

The variables listed in Table 8 are used to answer the first two research questions, 1) "Does a higher GPA at the end of the first year in college positively influence female persistence in the originally chosen engineering major or within engineering more than it influences male persistence?" and 2) "Does a relatively high percentage of female students in engineering courses (higher female density) positively influence female persistence in originally chosen engineering major or within engineering more than it influences male persistence?" Interactions among these variables are calculated to answer the third question, "Is there a conditional relationship (interaction) between grades and female density for women?" These interactions include the FemalexFemale Density variables, FemalexSpring GPA, and three-way interaction FemalexSpring GPAxFemale Density.

4.2 Multivariate Analyses

A series of nested models is analyzed at each of the study's three levels of analysis (institution, engineering, and major) with each level assuming success in the previous level. Graduation within six years versus non-graduation has 3,087 students in the dataset. Graduation within Engineering versus graduation in another field has 2,668 students. Graduation within initial engineering major versus graduation in a different engineering major has 2,043 students in the dataset.

Table 9 shows a list of variables and the models in which they are included. Model 0, the base model, contains only pre-college control variables. Model 1 adds the rest of the control variables, Model 2 adds spring GPA, Model 3 adds the course variables, and Model 4 represents the full main effects model.

Table 9: Variables within Each Model

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Female	x	x	x	x	x	x	x	x	x
Historically Under-represented	x	x	x	x	x	x	x	x	x
Highest Parental Education	x	x	x	x	x	x	x	x	x
Predicted GPA	x	x	x	x	x	x	x	x	x
Freshman Math Placement	x	x	x	x	x	x	x	x	x
Controlled Major		x	x	x	x	x	x	x	x
Semesters-On-Campus		x	x	x	x	x	x	x	x
Semesters-in-Interest House		x	x	x	x	x	x	x	x
Aerospace		x	x	x	x	x	x	x	x
Architectural		x	x	x	x	x	x	x	x
Bioengineering		x	x	x	x	x	x	x	x
Chemical		x	x	x	x	x	x	x	x
Civil		x	x	x	x	x	x	x	x
Computer		x	x	x	x	x	x	x	x
Electrical		x	x	x	x	x	x	x	x
Industrial		x	x	x	x	x	x	x	x
Spring GPA			x		x	x	x	x	x
Female Density in Engr Courses				x	x	x	x	x	x
Female Density in Req'd Courses				x	x	x	x	x	x
FemxSpring GPA						x		x	x
FemxFemale Density							x	x	x
Spring GPAxFemale Density									x
FemxSpring GPAxFemale Density									x

The second series of models, 5a-5d, explores the hypothesized relationships in the research questions. Model 5a includes an interaction term to test the relationship between the joint effect of grades and being female and answers Question 1 for each outcome level (institution, engineering, and major). Model 5b tests the relationship between the joint effect of female density and being female and answers Question 2 for each level. Model 5c tests both interactions at the same time. Finally, Model 5d adds a three-way interaction among grades, female density, and being female to answer Question 3.[2]

The nine models are run at the institution level (denoted with an "I"), the engineering level (denoted with an "E"), and the major level (denoted with an "M"). Thus, Model E-4 indicates that Model 4 (the full effects, non-interaction model) was run at the engineering level.

4.2.1 Institution-Level Main Effects

Table 10 shows the results for Models I-0 through I-4. Model I-0 contains only precollege student attributes. For this model, with no variables reflecting the intervening years between start and end of college career, inputs are strongly correlated with outputs. The fit statistics are quite poor, however. The -2 Log Likelihood (-2LL) provides a relational measure of how much a model deviates from a hypothetical "full" or "saturated" model that fits the data perfectly. Higher values indicate a larger difference between the model and the saturated model, and thus a poorer fit. Although this measurement does not stand by itself, comparing the Chi-Square difference between the -2LL statistics of two models can indicate whether one model has a significantly better fit than the other. The -2LL of 2,360.61 is the highest for the institution-level models, and serves as the baseline for worst fit. The Likelihood Ratio Chi-Square (LR Chi-Square) returns the probability that the model is significantly different than the null hypothesis, that the model is no better than 0, or no model. The LR Chi-Square of 91.31 in Model I-0 is the

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[2] Two-way and three-way interactions were tested with the core and required variables, but none of these were significant and are not shown.

lowest LR Chi-Square of the institution-level models and also serves as a baseline for the least amount of difference from 0, a no-effects model.

In Model I-0, predicted GPA is significant and positive. The natural log of the predicted GPA coefficient is 4.54. In interpreting odds, 1.0 is the value at which the odds are balanced. A number above 1 indicates positive odds, and a number below 1 indicates negative odds. Since 1.0 is the base, it is ignored to calculate positive odds. Thus, an odds of 1.29 is seen as a 29% increase. A .83, on the other hand, is read as a 17% decrease, or 1.0-.83. In the case of predicted GPA, an odds of 4.54 means that for each whole point that the predicted GPA rises, a student's odds of graduating within six years rise by 354%, a very strong effect. Parental education is also positive, having an odds of 1.11. For each additional level of parental education, odds of graduating within six years increase by 11%. Being from an historically under-represented group, however, decreases the odds of graduating within six years by 34% (1.0-.66) in relation to majority students.

Table 10: Six-Year Graduation versus Non-Graduation: Models I-0 through I-4

	Model 0			Model 1			Model 2			Model 3			Model 4		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Intercept	-3.57***	(0.78)	0.03	-3.902***	(0.84)	0.02	-3.371***	(0.91)	0.03	-2.38*	(1.18)	0.09	-1.823	(1.28)	0.16
Female	0.263+	(0.14)	1.30	0.005	(0.15)	1.01	-0.079	(0.17)	0.92	0.216	(0.22)	1.24	0.107	(0.23)	1.11
Historically Underrepresented	-0.419**	(0.15)	0.66	-0.593***	(0.15)	0.55	-0.549**	(0.17)	0.58	-0.64**	(0.19)	0.53	-0.615**	(0.2)	0.54
Highest Parental Edu.	0.109**	(0.04)	1.11	0.105**	(0.04)	1.11	0.143**	(0.04)	1.15	0.124*	(0.05)	1.13	0.128*	(0.05)	1.14
Predicted GPA	1.513***	(0.28)	4.54	1.341***	(0.29)	3.82	-0.117	(0.32)	0.89	1.276***	(0.36)	3.58	-0.331	(0.4)	0.72
Freshman Math Placement	0.017+	(0.01)	1.02	0.011	(0.01)	1.01	-0.012	(0.01)	0.99	-0.008	(0.01)	0.99	-0.029*	(0.01)	0.97
Controlled Major				-0.172	(0.19)	0.84	-0.158	(0.21)	0.85	-0.033	(0.24)	0.97	-0.177	(0.25)	0.84
Semesters-on-Campus				0.355***	(0.04)	1.43	0.258***	(0.04)	1.29	0.241***	(0.04)	1.27	0.214***	(0.05)	1.24
Semesters-in-Interest House				0.077	(0.05)	1.08	0.063	(0.06)	1.07	0.06	(0.06)	1.06	0.035	(0.06)	1.04
Aerospace				-0.318	(0.2)	0.73	-0.091	(0.22)	0.91	-0.112	(0.26)	0.89	-0.033	(0.28)	0.97
Architectural				0.2	(0.22)	1.22	0.218	(0.24)	1.24	-0.037	(0.28)	0.96	0.072	(0.29)	1.08
Bioengineering				-0.308	(0.33)	0.74	-0.467	(0.36)	0.63	0.203	(0.43)	1.23	-0.026	(0.45)	0.97
Chemical				0.36	(0.25)	1.43	0.411	(0.27)	1.51	0.781*	(0.31)	2.18	0.759*	(0.33)	2.14
Civil				0.023	(0.24)	1.02	0.16	(0.27)	1.17	-0.086	(0.3)	0.92	-0.058	(0.31)	0.94
Computer				-0.16	(0.19)	0.85	-0.041	(0.22)	0.96	-0.462+	(0.24)	0.63	-0.254	(0.26)	0.78
Electrical				-0.264	(0.22)	0.77	-0.307	(0.24)	0.74	-0.456	(0.26)	0.63	-0.579*	(0.28)	0.56
Industrial				-0.208	(0.37)	0.81	0.087	(0.43)	1.09	0.227	(0.51)	1.25	0.278	(0.54)	1.32
Spring GPA							1.617***	(0.1)	5.04	0***			1.73***	(0.13)	5.64
Female Density in Core Courses										0.025*	(0.01)	1.02	0.015	(0.01)	1.02
Female Density in Engr Courses										-0.006	(0.01)	0.99	-0.004	(0.01)	1.00
Female Density in Req'd Courses										-0.041***	(0.01)	0.96	-0.031***	(0.01)	0.97
-2 Log Likelihood	2360.61			2208.64			1873.84			1591.78			1396.61		
Likelihood Ratio Chi Square	91.31			243.29			578.09			137.65			332.83		
df	5			16			17			19			20		
-2 LL Chi Square				0.000	(1 over 0)		0.000	(2 over 1)		0.000	(3 over 1)		0.000	(4 over 1)	

+p<=.075 *p<.05 **p<01; ***p<.001

The addition of the during-college control variables improves the fit of Model I-1 over Model I-0. This improvement is measured by the Chi-square of the Model I-0 -2LL minus the Model I-1 -2LL, or 2,360.61–2,208.64=151.97. With one degree of freedom, the difference between the -2LLs is highly significant. The probability that the two models are the same is less than .001. This improvement is driven by mostly by the number of semesters-on-campus, a strongly positive variable found by several researchers to increase the likelihood of timely graduation for traditional-aged students (Pascarella & Terenzini, 2005). For every semester spent in on-campus housing, the odds of graduating within six years increase by 43%.

The addition of spring GPA in Model I-2 again improves the fit. The -2LL drops by nearly 350 from Model I-1. Spring GPA is highly significant, and controlling for it causes the predicted GPA variable to lose its significance. Since predicted GPA only forecasts success after the first year, actual success is a better measure. A one point increase in spring GPA raises the odds of a six-year graduation by a powerful 404%. Controlling for spring GPA accounts for some of the predictive power previously attributed to spending semesters on campus. While still significant, the odds of graduating within six years fall slightly from Model I-1. For every semester spent on campus, the odds increase by 29% rather than 43%. While 29% does not seem close to the 404% increase provided by a whole grade-point in the spring GPA, students can increase their odds of graduating within six years substantially (132%) by staying on campus for only two years (29% * 2 years * 2 semesters per year).

In Model I-3 (Table 10), variables for core and required courses also produce improvements over Model I-1, larger than the improvements of Model I-2 over I-1. However, the LR Chi-Square is only 137.65, the lowest since Model I-0. While the fit in relation to the hypothetical saturated model may be improving, the probability that the model is better than nothing has fallen. This dynamic is repeated in the engineering-level models, even though in both cases, the LR Chi-Square rises again with Model 4. The drop appears to be connected with the inclusion of the female density variables without spring GPA and possibly the opposing signs of the variables. The effect of female density in students' core courses is small but positive. For every additional percentage point that the average density of women in students' core courses rose, the odds of graduating within six years increases by 2%. This effect is countered by the negative significance of female density in required courses. For each increase in percentage in point in female density in these courses, the odds of graduation in six years decreases by 4%. While this combination appears odd, the female density of core courses loses its predictive power when additional variables are added. Also of note, students in chemical engineering have an increase of 118% in their odds of graduating within six years over their peers in mechanical engineering, the reference category.

Finally, when all the factors are included, Model I-4 offers improvements over Model I-3 and Model I-2. The -2LL is 1,396.61, lower than all the previous models. This model offers the best fit so far, but the LR Chi-Square is 332.83, between those of Models I2 and I3. Again, this may have something to do with the conflicting signs of the density variables. With everything controlled, however, the female density for required courses alone is highly significant (and negative). For every percent increase in this density, the odds of graduating within six years decrease by 3%. In practical terms, the range for female density in required courses is between 20% and 30% (the 25th and 75th percentiles), so a student with a 30% would have 30% decreased odds, or 3% * 10, for graduation within six years. Although such a decrease is nothing to take lightly, the positive odds generated by getting even a .25 higher on one's spring GPA dwarfs the effects for female density. For each whole grade-point increase in the spring GPA, a student's odds of graduating increase by 464%.

In addition to the dependent variables, other variables are also worth noting. While the effects of being from an historically underrepresented group, parental education, living on campus, and desiring to enter the chemical engineering program remain similar to those in other models, the negative effects of wanting to enter electrical engineering and freshman math placement score become significant. In relation to the reference group, aspiring mechanical engineers, aspiring electrical engineers have a 44% lower likelihood of graduating within six years. The negative sign for math placement is counter-intuitive, but the outcome for this model is graduation within six years. The sign may be different at the engineering or major levels. Notably, being female is not significant in any of the main effects models in Table 10. Men and women starting with the intention of entering the engineering majors in this study have the same odds of graduating within six years.

4.2.2 Institution-Level Interactions

When the interaction between being female and spring GPA is entered in Model I-5a in Table 11, the size and direction of the majority of coefficients do not change from Model I-4, and the difference in fit between the I-5a and I-4 is not significant. The effect for the female variable becomes a lot stronger, but a larger standard error prevents the effect from being significant. The interaction itself is negative but also not significant, despite the strong statistical significance of spring GPA. At the institution level, Research Question 1 and the hypothesis regarding the relationship between grades and being female is not confirmed.

Table 11: Six-Year Graduation versus Non-Graduation: Models I-5a through I-5f

	Model 5a			Model 5b			Model 5c			Model 5d		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Intercept	-2.037	(1.29)	0.13	-1.812	(1.29)	0.16	-2.051	(1.3)	0.13	-0.106	(1.57)	0.90
Female	1.599	(1.03)	4.95	0.064	(0.52)	1.07	1.652	(1.19)	5.22	-4.27	(2.85)	0.01
Historically Underrepresented	-0.63**	(0.2)	0.53	-0.615**	(0.2)	0.54	-0.631**	(0.2)	0.53	-0.612**	(0.2)	0.54
Highest Parental Edu.	0.126*	(0.05)	1.13	0.129*	(0.05)	1.14	0.126*	(0.05)	1.13	0.13*	(0.05)	1.14
Predicted GPA	-0.328	(0.4)	0.72	-0.332	(0.4)	0.72	-0.327	(0.4)	0.72	-0.36	(0.4)	0.70
Freshman Math Placement	-0.028*	(0.01)	0.97	-0.029*	(0.01)	0.97	-0.028*	(0.01)	0.97	-0.028*	(0.01)	0.97
Controlled Major	-0.189	(0.26)	0.83	-0.177	(0.25)	0.84	-0.189	(0.26)	0.83	-0.174	(0.26)	0.84
Semesters-on-Campus	0.215***	(0.05)	1.24	0.214***	(0.05)	1.24	0.215***	(0.05)	1.24	0.213***	(0.05)	1.24
Semesters-in-Interest House	0.037	(0.06)	1.04	0.035	(0.06)	1.04	0.037	(0.06)	1.04	0.038	(0.06)	1.04
Aerospace	-0.035	(0.28)	0.97	-0.031	(0.28)	0.97	-0.037	(0.28)	0.96	-0.014	(0.28)	0.99
Architectural	0.083	(0.29)	1.09	0.075	(0.29)	1.08	0.081	(0.29)	1.08	0.049	(0.29)	1.05
Bioengineering	0.005	(0.45)	1.00	-0.027	(0.45)	0.97	0.006	(0.45)	1.01	-0.007	(0.46)	0.99
Chemical	0.732*	(0.33)	2.08	0.762*	(0.33)	2.14	0.73*	(0.33)	2.08	0.753*	(0.34)	2.12
Civil	-0.049	(0.31)	0.95	-0.057	(0.31)	0.94	-0.05	(0.31)	0.95	-0.028	(0.32)	0.97
Computer	-0.256	(0.26)	0.77	-0.256	(0.26)	0.77	-0.254	(0.26)	0.78	-0.237	(0.26)	0.79
Electrical	-0.608*	(0.28)	0.54	-0.581*	(0.28)	0.56	-0.607*	(0.28)	0.55	-0.573*	(0.28)	0.56
Industrial	0.272	(0.54)	1.31	0.281	(0.54)	1.32	0.27	(0.54)	1.31	0.287	(0.55)	1.33
Spring GPA	1.797***	(0.14)	6.03	1.731***	(0.13)	5.65	1.797***	(0.14)	6.03	1.089**	(0.34)	2.97
Female Density in Core Courses	0.015	(0.01)	1.02	0.015	(0.01)	1.02	0.015	(0.01)	1.02	0.015	(0.01)	1.02
Female Density in Engr Courses	-0.006	(0.01)	0.99	-0.005	(0.01)	1.00	-0.005	(0.01)	1.00	-0.116*	(0.05)	0.89
Female Density in Req'd Courses	- 0.031***	(0.01)	0.97	- 0.031***	(0.01)	0.97	- 0.031***	(0.01)	0.97	-0.031***	(0.01)	0.97
FemxSpring GPA	-0.528	(0.35)	0.59				-0.532	(0.36)	0.59	1.693	(1.01)	5.44
FemxFemale Density in Engr				0.002	(0.02)	1.00	-0.002	(0.02)	1.00	0.241*	(0.1)	1.27
Sp GPAxFemale Density in Engr										0.043*	(0.02)	1.04
FemxSp GPAx FemDensity in Engr										-0.092**	(0.03)	0.91
-2 Log Likelihood	1394.44			1396.60			1394.43			1386.02		
Likelihood Ratio Chi Square	334.99			332.83			335.00			343.41		
df	21			21			22			24		
-2 LL Chi Square	0.141	(5a over 4)		0.927	(5b over 4)		0.337	(5c over 4)		0.015	(5d over 5c)	

+p<=.075 *p<.05 **p<01; ***p<.001

Model I-5b, tests the interaction term for female density in engineering and being female. Here again, the fit is no better than with Model I-4. The interaction term is not significant while the individual dependent variable is similar to what it was in Model I-4. For each rise in percent of a student's average female density in engineering courses, the odds of graduation within six years fall by 3%. As in Model I-5a, the coefficients for the other variables also remain similar to those in Model I-4. Research Question 2 and the hypothesis regarding the relationship between being female and female density is also not confirmed.

Model I-5c includes both interaction terms, and neither one becomes significant. Model I-5d adds the interaction between spring GPA and female density as well as a three-way interaction among being female, spring GPA, and female density. It represents an improved fit over Model I-5c, because both of the new terms, as well as the interaction between being female and female density, are significant. However, the high standard error for the female variable in model I-5d raises questions about the model's stability. Given that the interactions were not significant in the simpler models, the significance in I-5d is likely not due to a true effect but rather the high standard error. Research Question 3 regarding the interactive effects among the three variables cannot be confirmed with this model.

While the institution models have some expected results, such as the negative influence of being a member of an historically underrepresented group, the positive influence of semesters spent on campus, or the strong positive influence of spring GPA, the findings fail to confirm the hypothesized directions for Question 1 (females and grades) and Question 2 (females and female density) and find no effect for Question 3 (a relationship among being female, grades, and female density). Net of other factors, it appears that female engineering students are not positively influenced by grades and by having more women in their classrooms in the manner hypothesized when considering graduation within six years.

4.2.3 Engineering Level-Main Effects

The "E" models tested whether the 2,668 students who graduated from the institution within six years did so within the college of engineering or from another college. Table 12 shows Models E-0 through E-4. Model E-0 is similar to the institutional-level Model I-0. Again, the base model has a poor fit with a -2LL of 2,696.82. However, the LR Chi-Square, measuring the difference between the model and the a null hypothesis of no model, is 207.94, as opposed to only 91.31 in Model I-0. The higher LR Chi-Square may be due to the model's more homogenous pool of students. Everyone in the pool graduated six years, unlike the students at the institution level.

Highest parental education and predicted GPA are both significant, although parental education is now negative. It will remain significant until more variables are controlled in models E-3 and E-4 although it will retain its negative sign. Parental education is not a positive factor in a student's likelihood of remaining in engineering. The effect of the freshman math placement score, smaller in the institution-level models, increases in magnitude. For every additional point students receive on this test, their odds of graduating from engineering increase by 8%. Finally, being from an historically underrepresented group loses its negative significance. Members of non-majority groups have similar odds for remaining in engineering, provided they graduate within six years from the institution.

Table 12: Staying within Engineering versus Leaving: Models E-0 through E-4

	Model 0			Model 1			Model 2			Model 3			Model 4		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Intercept	-4.31***	(0.77)	0.01	-4.042***	(0.81)	0.02	-4.274***	(0.85)	0.01	0.195	(1.16)	1.22	0.693	(1.25)	2.00
Female	-0.15	(0.12)	0.86	-0.147	(0.12)	0.86	-0.16	(0.13)	0.85	0.677**	(0.2)	1.97	0.819***	(0.21)	2.27
Historically Underrepresented	0.07	(0.15)	1.07	0.036	(0.15)	1.04	0.135	(0.16)	1.14	0.022	(0.21)	1.02	0.084	(0.22)	1.09
Highest Parental Edu.	-0.074*	(0.04)	0.93	-0.072*	(0.04)	0.93	-0.074+	(0.04)	0.93	-0.026	(0.05)	0.97	-0.033	(0.05)	0.97
Predicted GPA	1.341***	(0.27)	3.82	1.319***	(0.28)	3.74	-0.013	(0.3)	0.99	1.502***	(0.37)	4.49	-0.048	(0.41)	0.95
Freshman Math Placement	0.077***	(0.01)	1.08	0.08***	(0.01)	1.08	0.062***	(0.01)	1.06	0.036**	(0.01)	1.04	0.009	(0.01)	1.01
Controlled Major				-0.404*	(0.18)	0.67	-0.46*	(0.19)	0.63	-0.295	(0.24)	0.74	-0.465+	(0.25)	0.63
Semesters-on-Campus				0.056*	(0.03)	1.06	0.036	(0.03)	1.04	0.006	(0.03)	1.01	-0.013	(0.04)	0.99
Semesters-in-Interest House				0.005	(0.03)	1.01	-0.026	(0.04)	0.97	0.008	(0.04)	1.01	-0.027	(0.04)	0.97
Aerospace				-0.483**	(0.18)	0.62	-0.38*	(0.19)	0.68	-0.93***	(0.25)	0.39	-0.897**	(0.26)	0.41
Architectural				0.19	(0.2)	1.21	0.246	(0.21)	1.28	-0.282	(0.27)	0.75	-0.165	(0.29)	0.85
Bioengineering				-0.969***	(0.28)	0.38	-1.172***	(0.29)	0.31	-0.146	(0.37)	0.86	-0.307	(0.39)	0.74
Chemical				-0.601**	(0.2)	0.55	-0.655**	(0.21)	0.52	0.021	(0.27)	1.02	-0.056	(0.29)	0.95
Civil				-0.601**	(0.21)	0.55	-0.586**	(0.22)	0.56	-0.683*	(0.29)	0.51	-0.669*	(0.31)	0.51
Computer				-0.35*	(0.18)	0.70	-0.332	(0.19)	0.72	-0.795**	(0.25)	0.45	-0.7**	(0.26)	0.50
Electrical				-0.427*	(0.21)	0.65	-0.424+	(0.22)	0.65	-0.778**	(0.29)	0.46	-0.899**	(0.31)	0.41
Industrial				0.535	(0.44)	1.71	0.609	(0.45)	1.84	0.511	(0.64)	1.67	0.657	(0.65)	1.93
Spring GPA							1.611***	(0.11)	5.01				1.885***	(0.15)	6.59
Female Density in Core Courses										-0.014	(0.01)	0.99	-0.029*	(0.01)	0.97
Female Density in Engr Courses										-0.01	(0.01)	0.99	-0.016	(0.01)	0.98
Female Density in Req'd Courses										-0.096***	(0.01)	0.91	-0.097***	(0.01)	0.91
-2 Log Likelihood	2696.82			2517.92			2449.08			1630.68			1462.33		
Likelihood Ratio Chi Square	207.94			255.30			496.64			272.95			485.79		
df	5			16			17			19			20		
-2 LL Chi Square				0.000	(1 over 0)		0.000	(2 over 1)		0.000	(3 over 1)		0.000	(4 over 1)	

+p<=.075 *p<.05 **p<01; ***p<.001

When the during-college variables are added in Model E-1, the fit improves but is still poor (-2LL is 2,517.92). As in the Institutional-level Model I-1, semesters-on-campus is significant. For each semester spent in on-campus housing, the odds of graduation from engineering rise by 6%. Controlled major, not significant when looking at graduation within six years, becomes significant when looking at persistence within engineering. Intending to enroll in a controlled major decreases the odds of staying within engineering by 33%. Additionally, more department variables are significant at the engineering level than were significant at the institution level. Students intending to enter aerospace, bioengineering, chemical, computer, electrical, and industrial engineering have lower odds of staying within engineering than do their peers wishing to enter mechanical engineering—as low as 62% less for bioengineering-bound students.

When spring GPA is added in Model E-2, it is strongly significant and positive, and the magnitude of the effect is practically the same as in Model I-2 (1.611 versus 1.617). For each grade-point, odds of graduation from engineering increase by 401%. As in the institution models, spring GPA remains strongly significant in all the engineering level models. Finally, the major variables that were significant in Model E-1 remain significant in Model E-2.

Controlling for female densities in Model E-3 causes the sign for female to flip and become positive and significant. Women have 97% greater odds of graduation from engineering than do men, all other things being equal. The coefficient for female density in required courses is negative and significant, and the magnitude is greater than what it was in Model I-3. For every additional percentage point in the female density of students' required courses, the odds of graduating from engineering fall 9%.

Here again, as in Model I-3, the higher -2LL indicates that the fit for Model E-3 improves from Model E-2 while the LR Chi Square decreases from what it was in E-2. Since the female variable becomes significant when density variables are added, they could be canceling each other out. The variation is captured when looking at fit against the "full" model, but not for overall improvement over no model at all.

Model E-4, with all the independent variables, looks somewhat similar to Model E-3. The magnitude for being female has increased. Being female now improves the odds for graduation within engineering by 127%. The female density of required courses retains its negative significance and is joined by female density within core courses. For each increase in percentage point, the odds of graduating in engineering decrease by 3% for core courses and 9% in required courses. Additionally, at least one of the density variables was suppressing the effects of spring GPA. When all the variables are in the same model, the magnitude of spring GPA grows to enormous proportions. For every grade-point a student receives, the odds of graduating within engineering now increase by 559%. Spring GPA accounts for all the explanatory power of the math placement score, which falls to near zero in this model. Being enrolled in a controlled major, which has fluctuated in significance, now approaches significance and remains negative. Finally, most of the department variables remain at similar magnitudes and significance with small fluctuations.

4.2.4 Engineering-Level Interactions

Table 12 shows the results from Models E5a-E5d.

Table 13: Staying within Engineering versus Leaving: Models E-5a through E-5d

	Model 5a			Model 5b			Model 5c			Model 5d		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Intercept	0.281	(1.27)	1.32	0.542	(1.25)	1.72	0.18	(1.27)	1.20	0.806	(1.73)	2.24
Female	3.007**	(1.03)	20.22	1.826**	(0.61)	6.21	3.691**	(1.13)	40.08	6.605*	(3.27)	738.84
Historically Underrepresented	0.06	(0.22)	1.06	0.079	(0.22)	1.08	0.057	(0.22)	1.06	0.042	(0.22)	1.04
Highest Parental Edu.	-0.037	(0.05)	0.96	-0.034	(0.05)	0.97	-0.038	(0.05)	0.96	-0.043	(0.05)	0.96
Predicted GPA	-0.034	(0.41)	0.97	-0.056	(0.41)	0.95	-0.04	(0.41)	0.96	-0.049	(0.41)	0.95
Freshman Math Placement	0.01	(0.01)	1.01	0.01	(0.01)	1.01	0.011	(0.01)	1.01	0.011	(0.01)	1.01
Controlled Major	-0.487+	(0.25)	0.61	-0.462+	(0.25)	0.63	-0.481+	(0.25)	0.62	-0.474+	(0.25)	0.62
Semesters-on-Campus	-0.012	(0.04)	0.99	-0.013	(0.04)	0.99	-0.013	(0.04)	0.99	-0.012	(0.04)	0.99
Semesters-in-Interest House	-0.022	(0.04)	0.98	-0.026	(0.04)	0.97	-0.021	(0.04)	0.98	-0.027	(0.04)	0.97
Aerospace	-0.923***	(0.26)	0.40	-0.929***	(0.26)	0.39	-0.951***	(0.26)	0.39	-0.944***	(0.26)	0.39
Architectural	-0.17	(0.29)	0.84	-0.226	(0.29)	0.80	-0.225	(0.29)	0.80	-0.227	(0.29)	0.80
Bioengineering	-0.272	(0.39)	0.76	-0.306	(0.39)	0.74	-0.273	(0.39)	0.76	-0.331	(0.4)	0.72
Chemical	-0.067	(0.29)	0.94	-0.099	(0.29)	0.91	-0.102	(0.29)	0.90	-0.127	(0.29)	0.88
Civil	-0.663*	(0.31)	0.52	-0.689*	(0.31)	0.50	-0.681*	(0.31)	0.51	-0.69*	(0.31)	0.50
Computer	-0.706**	(0.26)	0.49	-0.667*	(0.26)	0.51	-0.677*	(0.26)	0.51	-0.673*	(0.26)	0.51
Electrical	-0.933**	(0.31)	0.39	-0.895**	(0.31)	0.41	-0.925**	(0.31)	0.40	-0.929**	(0.31)	0.40
Industrial	0.598	(0.65)	1.82	0.614	(0.65)	1.85	0.56	(0.65)	1.75	0.564	(0.65)	1.76
Spring GPA	2.02***	(0.17)	7.54	1.875***	(0.15)	6.52	1.996***	(0.17)	7.36	1.803***	(0.42)	6.07
Female Density in Core Courses	-0.029*	(0.01)	0.97	-0.029*	(0.01)	0.97	-0.028*	(0.01)	0.97	-0.029*	(0.01)	0.97
Female Density in Engr Courses	-0.017	(0.01)	0.98	-0.003	(0.01)	1.00	-0.005	(0.01)	0.99	-0.037	(0.07)	0.96
Female Density in Req'd Courses	-0.097***	(0.01)	0.91	-0.099***	(0.01)	0.91	-0.099***	(0.01)	0.91	-0.099***	(0.01)	0.91
FemxSpring GPA	-0.739*	(0.34)	0.48				-0.681*	(0.34)	0.51	-1.685	(1.1)	0.19
FemxFemale Density in Engr				-0.039+	(0.02)	0.96	-0.033	(0.02)	0.97	-0.118	(0.12)	0.89
Sp GPAxFemale Density in Engr										0.011	(0.02)	1.01
FemxSp GPAx FemDensity in Engr										0.029	(0.04)	1.03
-2 Log Likelihood	1457.70			1459.04			1455.23			1453.40		
Likelihood Ratio Chi Square	445.93			444.59			448.40			450.23		
df	21			21			22			24		
-2 LL Chi Square	0.031	(5b over 4)		0.070	(5d over 4)		0.029	(5c over 4)		0.063	(5d over 4)	

+p<=.075 *p<.05 **p<01; ***p<.001

The interaction term in Model E-5a, which reflects the joint effects of being female and spring GPA, is significant and negative. For every increase in grade-point, the odds a women will stay in engineering decrease by 52%. The effect is not as straightforward as it seems, however, due to the enormous and significant coefficients for being female and for spring GPA. Women see an odds increase of 1,922% for remaining in engineering, and spring GPA itself provides an odds increase of 654% for every whole grade-point increase. The strength of these coefficients is extraordinary, but the high magnitude for grades may be explained by the requirement that all students must pass five foundational courses before being allowed to declare an engineering major. Students who fail calculus, physics, or chemistry their first year may decide to leave engineering rather than retake the failed courses. According to Tables 6a and 6b, women also had higher grades than men at the end of their first spring, which may explain the strength of the female variable as well as collinearity between being female and the interaction (the standard error for the female variable rises as more female interactions are added). To put these odds into perspective when compared to those of males with a 3.0, Figure 4 plots what this increase would look like at each grade level. As can be seen, the interaction dampens the female advantage, but never to the point where the female odds fall below those of males. The difference in odds is the greatest between a 2.5 and a 3.5 GPA. As the spring GPA rises, the male and female regression lines start to converge. Notably, women have higher odds than men for remaining within engineering even at the lower grade ranges. When it comes to grade sensitivity, the women of this study are not leaving engineering more readily than men due to a lower spring GPA. Thus, Research Question 1, which hypothesizes a positive relationship between being female and spring GPA, is disconfirmed.

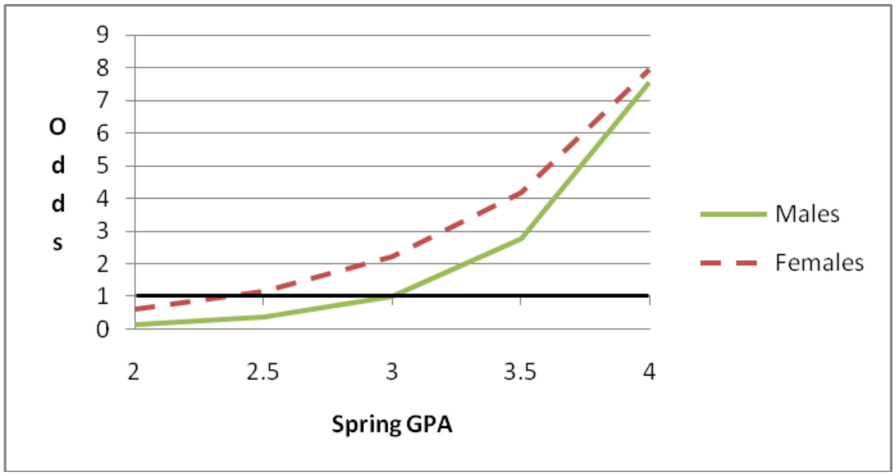

Figure 4: The interaction between spring GPA and being female in Model E-5a

The interaction term in Model E-5b, which measures the joint effects of being female and the female density in one's engineering classes, is negative and approaches significance, as does the improvement of fit between Model 4 and Model E-5b. The signs and magnitude of the other variables are similar to what they were in Model E-4. Notably, women have a 521% increase over men in their odds for graduating within engineering. In both Models E-5a and E-5b, the female coefficient increases in magnitude from its value in E-4, indicating that the interactions between being female and the variables of interest were suppressing the true effects of being female.

To assess whether the female density variables are affecting the large female effect in Model E-5a, a separate regression was run (not shown) that removed the density variables but which kept the interaction for female and spring GPA. Although the coefficient for the interaction term was slightly smaller, it was still significant and negative. The magnitude of the female coefficient dropped from 3.01 to 1.8, however, indicating a connection between being female and the average proportion of women in one's engineering-related courses. The disappearing 1.2 offset the negative odds associated with higher female density. Although these were the same for men and women, a look at the means for each density variable by gender reveals that the means for women are higher than those for men. On average, women have higher densities of other women in their engineering-related courses than do men, thus decreasing their odds of graduating within the college of engineering more than their male counterparts. The higher positive coefficient for being female compensates for this penalty since the negative effect is the same for men and women.

Table 14 shows the univariate statistics for the three density variables.

Table 14: Female Density by Gender for Core, Engineering, and Required Courses

	Core			Engineering			Required		
Variable	Males	Females	Total	Males	Females	Total	Males	Females	Total
Mean	30.75	35.70	31.73	17.15	28.14	19.30	25.58	31.78	26.69
Std. Dev	6.17	5.74	6.35	6.92	11.40	8.99	6.92	10.27	9.34
Min	6	17	6	0	8	0	0	12	0
Max	61	54.40	61	48	100	100	86	71	86
Median	30.67	35.50	31.75	15.67	26.14	17.25	23.71	28.53	24.6

Women have higher female density in their courses for all three course categories, and this difference is most pronounced in the engineering courses, where the female average is 28.14% compared to the 17.15% average for males. Women are more likely to be in courses where there are more women, either because of they took a seminar aimed at women in engineering or because they have chosen a major with relatively more women. The male maximum for engineering courses is 48% while the female maximum is 100%. The women with a 100%

average switched out of engineering upon completion of the women in engineering seminar and without taking other engineering courses that would have lowered their average.

Women likely had higher odds in E-5a to make up for their, on average, higher female densities. However, the almost-significant negative interaction between the engineering courses and being female suggests that despite the positive female main effect, women are still at a disadvantage in terms of enrolling in engineering courses with more women. This penalty could be related to the women in engineering seminar example above, where a few women had 100% for their female density within engineering courses. Women leaving early in their academic careers would not have taken enough upper level courses, where the female density is lower, to lower their density averages. Without a way to account for time elapsed, it cannot be determined whether the density effects are true effects or confounded by time.

The fit for Model E-5c, which contains both interaction terms, represents an improvement over Model 4 but not over Model E-5a (p=.12, not shown) and a barely significant improvement over Model E-5b (p=.051, not shown). This significance is likely due to the inclusion of the FemalexSpringGPA interaction. The interaction between being female and spring GPA is again significant in E-5c, but the standard error for the female coefficient is 1.13. Being female likely provides an increase in the likelihood of remaining in engineering, but 3,908% is quite large and probably due to the collinearity among the female variable and its interactions.

Finally, Model E-5d adds a three-way interaction among being female, spring GPA, and female density in engineering courses. However, the high standard error for female calls the model stability into question and the three-way interaction is not significant. Question 3, regarding a relationship between grades, female density, and being female, is, thus, not confirmed at the engineering level.

The engineering models find a negative relationship between grades and being female (Question 1), and a possible negative relationship between being female and female density (Question 2), but no relationship among between grades, female density, and being female (Question 3). The engineering models also differ from the institution models in other ways. The decreased odds associated with being from an historically underrepresented group disappear at the engineering level. Provided these students graduate, they have the same odds as majority students for remaining within engineering. Parental education is no longer significant after grades and female density are controlled. Intending to enter a controlled major approaches negative significance, which might be expected because these majors are more competitive. Only students having a certain GPA or above are guaranteed a space. While this cap may not have mattered at the institution level, if students cannot get into a desired major they may be more likely to leave engineering than to leave the institution.

Finally, the coefficients for engineering majors change at the engineering level. Aerospace, computer, electrical, and civil engineering are consistently negative. Students in these majors are less likely to remain in engineering than are their peers in mechanical engineering, the reference group. Additionally, chemical engineering, positive at the institution level, is not significant at the engineering level.

4.2.5 Major-Level Main Effects

Table 13 shows the major-level models run against the pool of the 2,043 students who stayed in engineering.

Table 15: Staying within Original Major versus Leaving: Models M-0 through M-4

	Model 0			Model 1			Model 2			Model 3			Model 4		
Major	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Intercept	-2.802***	(0.76)	0.06	-2.939***	(0.81)	0.05	-3.195***	(0.83)	0.04	-2.352**	(0.89)	0.10	-2.315*	(0.91)	0.10
Female	-0.082	(0.12)	0.92	-0.217	(0.13)	0.81	-0.172	(0.13)	0.84	0.134	(0.15)	1.14	0.257	(0.15)	1.29
Historically Underrepresented	0.341*	(0.16)	1.41	0.345*	(0.17)	1.41	0.406*	(0.17)	1.50	0.373*	(0.17)	1.45	0.453**	(0.17)	1.57
Highest Parental Edu.	-0.067+	(0.03)	0.93	-0.069+	(0.04)	0.93	-0.076*	(0.04)	0.93	-0.067+	(0.04)	0.94	-0.074*	(0.04)	0.93
Predicted GPA	0.989***	(0.27)	2.69	1.059***	(0.28)	2.88	0.257+	(0.3)	1.29	1.128***	(0.29)	3.09	0.276	(0.31)	1.32
Freshman Math Placement	0.027**	(0.01)	1.03	0.033***	(0.01)	1.03	0.02*	(0.01)	1.02	0.031**	(0.01)	1.03	0.015	(0.01)	1.01
Controlled Major				-0.349*	(0.17)	0.71	-0.385*	(0.17)	0.68	-0.41*	(0.17)	0.66	-0.463**	(0.17)	0.63
Semesters-on-Campus				0.051+	(0.03)	1.05	0.045+	(0.03)	1.05	0.054*	(0.03)	1.06	0.05+	(0.03)	1.05
Semesters-in-Interest House				-0.029	(0.03)	0.97	-0.046	(0.03)	0.95	-0.02	(0.03)	0.98	-0.035	(0.03)	0.97
Aerospace				-0.524**	(0.17)	0.59	-0.505**	(0.18)	0.60	-0.474**	(0.18)	0.62	-0.49**	(0.18)	0.61
Architectural				0.379*	(0.19)	1.46	0.389*	(0.2)	1.48	0.841***	(0.21)	2.32	0.866***	(0.21)	2.38
Bioengineering				-1.013**	(0.31)	0.36	-1.135***	(0.32)	0.32	-0.58	(0.33)	0.56	-0.627+	(0.33)	0.53
Chemical				-0.206	(0.19)	0.81	-0.283	(0.2)	0.75	0.239	(0.22)	1.27	0.235	(0.22)	1.27
Civil				-0.124	(0.21)	0.88	-0.131	(0.22)	0.88	0.049	(0.22)	1.05	0.035	(0.22)	1.04
Computer				-0.772***	(0.17)	0.46	-0.793***	(0.18)	0.45	-0.92***	(0.18)	0.40	-0.991***	(0.19)	0.37
Electrical				-0.4*	(0.19)	0.67	-0.432*	(0.2)	0.65	-0.513*	(0.2)	0.60	-0.603**	(0.21)	0.55
Industrial				0.976*	(0.41)	2.65	1.066*	(0.41)	2.90	1.366**	(0.42)	3.92	1.468***	(0.42)	4.34
Spring GPA							0.983***	(0.12)	2.67				1.086***	(0.13)	2.96
Female Density in Core Courses										-0.006	(0.01)	0.99	-0.012	(0.01)	0.99
Female Density in Engr Courses										-0.066***	(0.01)	0.94	-0.071***	(0.01)	0.93
Female Density in Req'd Courses										0.019+	(0.01)	1.02	0.015	(0.01)	1.01
-2 Log Likelihood	2607.52			2517.92			2449.08			2456.13			2377.20		
Likelihood Ratio Chi Square	45.23			134.84			169.86			169.86			248.79		
df	5			16			17			19			20		
-2 LL Chi Square				0.000	(1 over 0)		0.000	(2 over 1)		0.000	(3 over 1)		0.000	(4 over 1)	

+p<=.075 *p<.05 **p<01; ***p<.001

Just as Model E-0 was slightly different than Model I-0, M-0 is also slightly different than Model E-0. Model M-0 has the lowest LR Chi-Square of all the models in the study due to the increased homogeneity of the pool (all the students graduating from an engineering field) and the small number of variables. The model is better than no model, but not by much with an LR Chi-Square of 45.23 as opposed to the 91.31 of Model I-0 and the 207.94 of E-0. The -2LL fit of 2,607.52 is also poor, and the fit does not improve as much as in the other model levels when more variables are added.

Most notably in Model M-0, being from an historically underrepresented group has become significant at the .05 level and positive, an effect that stays relatively consistent throughout all the M models (as high as an increase of 45%). This effect is surprising given that underrepresented students have negative odds of graduating in six years. Those who graduate are more likely to stay in their initially chosen engineering major than are White or Asian students. Their higher odds may be due to the fact that to be included in this dataset they would have already overcome an initial disadvantage associated with graduating in six years. These historically underrepresented students may constitute a more determined group than peers who did not face such an initial disadvantage. Parental education is also significant but negative. For every level of education a parent has, the odds of remaining within the originally chosen engineering major decrease by 7%. This effect also remains stable throughout the major models. Although also surprising, the effect confirms literature suggesting that families with higher socioeconomic status may steer their children into the liberal arts or higher prestige occupations such as law or medicine (Goyette & Mullen, 2006). Otherwise, predicted GPA and math placement score both had positive coefficients. Being female had no effect in Model M-0 and continues to have no effect throughout the rest of the major-level models.

When the during-college variables are added to Model M-1, coefficients remain similar to those in M-0. Aspiring to a controlled major is associated with 29% lower odds of remaining in that major. Aerospace, bio, computer, and electrical engineering maintain their negative significance in the major models. Students intending to enter these majors are less likely to graduate in these fields than students entering mechanical engineering (41%, 64%, 54%, and 33%, respectively). However, students intending to enter architectural and industrial engineering have increased odds of staying in their original majors (46% and 165%, respectively).

In Model M-2, spring GPA is strongly positive and significant. For each increase in grade-point, students see a 167% increase in their odds of graduating within their originally intended major. When the female density variables are added in Model M-3, bioengineering loses its significance. The negative odds associated with this major were being conflated with the negative odds associated with higher female densities. For every percentage point that the female density in engineering courses rises, the odds of remaining within the original major decrease by 6%.

Model M-4 is much like Model M-3. Spring GPA is positive and highly significant, and the coefficient for female density in engineering courses is similar to that in Model M-3. Students intending to enter architectural engineering have a 138% increase and those intending to enter industrial engineering have a 334% increase in the likelihood of staying in their original major as compared to the reference group, mechanical engineers.

4.2.6 Major-Level Interactions

Table 13 shows the coefficients for the interaction models.

Table 16: Staying within Original Major versus Leaving: Models M-5a through M-5f

	Model 5a			Model 5b			Model 5c			Model 5d		
	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)	B	S.E.	Exp(B)
Intercept	-2.491**	(0.93)	0.08	-2.24*	(0.91)	0.11	-3.059***	(0.87)	0.05	-4.231**	(1.45)	0.01
Female	1.158	(0.86)	3.18	-0.247	(0.46)	0.78	0.78	(0.9)	2.18	6.302	(3.38)	545.43
Historically Underrepresented	0.447*	(0.17)	1.56	0.451*	(0.17)	1.57	0.443*	(0.17)	1.56	0.434*	(0.17)	1.54
Highest Parental Edu.	-0.076*	(0.04)	0.93	-0.074*	(0.04)	0.93	-0.076*	(0.04)	0.93	-0.077*	(0.04)	0.93
Predicted GPA	0.279	(0.31)	1.32	0.289	(0.31)	1.33	0.295	(0.31)	1.34	0.287	(0.31)	1.33
Freshman Math Placement	0.015	(0.01)	1.01	0.014	(0.01)	1.01	0.015	(0.01)	1.01	0.015+	(0.01)	1.02
Controlled Major	-0.472**	(0.17)	0.62	-0.465**	(0.17)	0.63	-0.477**	(0.17)	0.62	-0.482**	(0.17)	0.62
Semesters-on-Campus	0.05	(0.03)	1.05	0.05+	(0.03)	1.05	0.05+	(0.03)	1.05	0.051+	(0.03)	1.05
Semesters-in-Interest House	-0.034	(0.03)	0.97	-0.036	(0.03)	0.96	-0.035	(0.03)	0.97	-0.034+	(0.03)	0.97
Aerospace	-0.505**	(0.19)	0.60	-0.479*	(0.18)	0.62	-0.496**	(0.19)	0.61	-0.502**	(0.19)	0.61
Architectural	0.857***	(0.21)	2.36	0.893***	(0.22)	2.44	0.887***	(0.22)	2.43	0.884***	(0.22)	2.42
Bioengineering	-0.628+	(0.33)	0.53	-0.637+	(0.33)	0.53	-0.64+	(0.33)	0.53	-0.611+	(0.34)	0.54
Chemical	0.221	(0.22)	1.25	0.238	(0.22)	1.27	0.22	(0.22)	1.25	0.2	(0.22)	1.22
Civil	0.028	(0.22)	1.03	0.043	(0.22)	1.04	0.036	(0.22)	1.04	0.034+	(0.22)	1.03
Computer	-0.993***	(0.19)	0.37	-1.007***	(0.19)	0.37	-1.015***	(0.19)	0.36	-1.024***	(0.19)	0.36
Electrical	-0.617**	(0.21)	0.54	-0.613**	(0.21)	0.54	-0.633**	(0.21)	0.53	-0.636**	(0.21)	0.53
Industrial	1.442**	(0.42)	4.23	1.479***	(0.42)	4.39	1.449**	(0.42)	4.26	1.429**	(0.42)	4.17
Spring GPA	1.142***	(0.14)	3.13	1.08***	(0.13)	2.95	1.15***	(0.14)	3.16	1.689***	(0.36)	5.42
Female Density in Core Courses	-0.013	(0.01)	0.99	-0.012	(0.01)	0.99	-0.013	(0.01)	0.99	-0.013+	(0.01)	0.99
Female Density in Engr Courses	-0.07***	(0.01)	0.93	-0.077***	(0.01)	0.93	-0.077***	(0.01)	0.93	0.027+	(0.07)	1.03
Female Density in Req'd Courses	0.014	(0.01)	1.01	0.015	(0.01)	1.02	0.015	(0.01)	1.02	0.017+	(0.01)	1.02
FemxSpring GPA	-0.285	(0.27)	0.75				-0.361	(0.27)	0.70	-2.036*	(1.02)	0.13
FemxFemale Density in Engr				0.021	(0.02)	1.02	0.026	(0.02)	1.03	-0.225+	(0.14)	0.80
Sp GPAxFemale Density in Engr										-0.032+	(0.02)	0.97
FemxSp GPAx FemDensity in Engr										0.076	(0.04)	1.08
-2 Log Likelihood	2376.09			2375.88			2374.15			2370.03		
Likelihood Ratio Chi Square	249.90			250.11			251.83			255.96		
df	21			21			22			24		
-2 LL Chi Square	0.291	(5a over 4)		.250	(5b over 4)		0.218	(5c over 4)		0.127	(5d over 5c)	

+p<=.075 *p<.05 **p<01; ***p<.001

Models M-5a, M-5b, and M-5c follow the same significance patterns as M-4, with the coefficients changing very little and the differences between the models not significant. The standard errors in Models M-5b and M-5c are larger than the female coefficient, suggesting these models are untrustworthy. Model M-5d also has a high standard error for the female coefficient (3.38 while the coefficient itself is 6.320). The negative interaction between spring GPA and female density in engineering courses (approaching significance) does not include the female variable, but it did not retain its near significance when run in a separate model as the only interaction. Question 1, regarding a positive interaction between being female and spring GPA, is not confirmed. Neither Question 2, with female density and the female coefficient, nor Question 3, regarding the joint effects of grades, being female, and female density, can be answered.

Although no research questions are confirmed in the major models, other interesting findings come to light. Being female does not matter in most of the major models, but being from an historically underrepresented group increases odds (up to 45%) of staying within the initial engineering major through all models. Provided these students stay within the institution, they are more likely to stick to their initial major than are their majority counterparts.

Like the engineering models, the major models share the negative effects of intending to enter aerospace, computer, and electrical engineering. At this level, students planning for these majors are more likely to leave both their major and engineering altogether than those planning to enter mechanical engineering. Some major effects are positive, however. Architectural and industrial engineering-bound students both have higher odds of staying and graduating within their majors than their mechanical engineering counterparts. However, the lack of negative significance at the engineering level indicates that students who do switch out of these majors are just as likely to switch into another engineering major as they are to leave engineering.

Overall, the findings at each level differ from those at the previous levels. Moreover, the findings did not confirm the hypotheses associated with each research question. In some cases the findings were counter to what was expected. Chapter 5 explores some of the possible explanations and implications of these findings.

Chapter 5

Summary, Conclusions, and Implications

5.1 Summary

Since the 1970s, the U.S. has seen an influx of women in other previously male-dominated fields. Roughly fifty percent of new graduates in medicine and law are now female (National Center for Education Statistics, 2009b). Women now outnumber men in earning baccalaureate degrees in biology and represent half the baccalaureate recipients in chemistry (National Center for Education Statistics, 2009a). Engineering, in contrast, has remained relatively male-dominated despite subfields such as bioengineering or chemical engineering that have become slightly more gender-balanced over time (National Center for Education Statistics, 2009g). Given the rising female participation in other fields, the lower female participation rate in engineering continues to puzzle researchers, employers, educators, and policy-makers.

At the individual level, lower female participation affects women's career choices, lifetime earnings, job satisfaction, job freedom, and workplace power. In a larger sense, however, women's lower participation affects the nation. Only six percent of U.S. undergraduates major in engineering as compared to 12% in most of Europe, 20% in Singapore, and over 40% in China (Committee on Prospering in the Global Economy of the 21st Century & Committee on Science, 2007). Furthermore, the U.S. is trailing several other countries, including Australia, Poland, Italy, and the United Kingdom, in terms of baccalaureate degree attainment rates for traditional-aged students (Organisation for Economic Cooperation and Development, 2009). Taken together, these measures suggest that we have a lower proportion of college graduates to fuel our knowledge economy and a far lower proportion of new engineers to replace an aging workforce. If this trend continues, our capacity to compete with other countries through innovation, research, and technology may be crippled as we will have a comparatively smaller talent pool to tap. Recruiting and retaining more women in engineering will be critical as the nation continues to rely on engineering's products to sustain its way of life and its global leadership (Sonnert, et al., 2007).

Additionally, as the role of engineers changes from that of technical expert to guide and visionary leader (National Academy of Engineering, 2004), it becomes even more important to have both men and women helping us navigate and interpret our technology-filled future. Today's engineers must increasingly work with other technicians and managers who bring different viewpoints and sometimes different languages, cultures, and outlooks (Sheppard, et al., 2009). Women's current lower participation means a greater possibility of missed ideas, a narrower range of solutions, and the higher probability of overlooked opportunities to relate to the constituents that engineering serves.

This study explored the persistence of women (and men) within engineering, and specifically the influence of two factors the literature indicates may be problematic for women especially. While both men and women can come to see a high GPA as important to who they are and have a rough transition moving from high school to college (Farmer, 1997; Grove & Wasserman, 2004; Loftus, 2005) other research suggests that women experience greater emotional difficulties than men if they receive lower-than-expected grades (Crocker, Karpinski, et al., 2003; Crocker & Luhtanen, 2003; Holland & Eisenhart, 1990). Additionally, the presence of other women in a male-dominated field may provide friendship (Lee, 2002; Riegel-Crumb, et al., 2006) and a sense of belonging (M. C. Murphy, et al., 2007; Walton & Cohen, 2007) that encourages persistence during rough times.

Against that background, this study sought answers to the following three research questions:

1) Does a higher GPA at the end of the first year in college positively influence female persistence in the originally chosen engineering major or within engineering more than it influences male persistence?
2) Does a relatively high percentage of female students in engineering courses (higher female density) positively influence female persistence in originally chosen engineering major or within engineering more than it influences male persistence?
3) Is there a conditional relationship (interaction) between grades and female density for women? For example, would women earning a high GPA but who are in courses with a lower female density be less likely to stay within engineering or their engineering major than male counterparts earning the same GPA?

The questions were addressed at three levels of logistic regressions: the institution (graduation within six years versus non-graduation), engineering (graduation within engineering versus graduation in another area), and major (graduation within original engineering major versus graduation within another engineering major) levels. The outcomes were nested from least restrictive (graduation in six years versus no graduation) to most restrictive (graduation in six years and remaining within engineering versus graduating within six years, remaining within engineering, and remaining within the major) (Unrau & Coleman, 1998). The dataset consisted of 3,087 first-year, non-international, full-time, men and women in the 2000, 2001, 2002, and 2003 cohorts enrolled in the college of engineering at a large, public, land-grant, research university. This group represented a census of those students intending to major in aerospace, architectural, bio, chemical, civil, computer, electrical, industrial, and mechanical engineering.

Table 17 summarizes the study findings by level. In general, the findings either contradict or fail to confirm the hypotheses generated by the research questions. As will be seen, these findings are not straightforward.

Table 17: Summary of Question Findings by Level

	Level		
	Institution	Engineering	Major
Q 1: Relationship between grades and being female?	None	Negative	None
Q 2: Relationship between female density and being female?	None	Negative Approaching Significance	None
Q 3: Conditional relationship between female density and grades?	N/A	N/A	N/A

5.1.1 Research Question 1

Contrary to expectations, good grades appear not to provide a greater advantage to women than men in persisting at any level. Moreover, at the engineering level, the joint effects of spring grades and being female are negative, moderating the highly positive influence that grades confer on both genders. However, the interaction was weaker than the main effects of spring GPA and of being female, so it dampened, but did not cancel, these more powerful effects. Women still had a greater likelihood of remaining within engineering across all GPA levels, but men began to close the gap as the GPA approached a 4.0. Notably, the magnitude of the female coefficient rose when the FemalexSpring GPA interaction was controlled. The strength of the interaction was suppressing the positive effects of being female. Women are more likely than men to remain in engineering when the two sexes' grades are equal.

The results allow additional conclusions. In terms of remaining within engineering, not only are women more likely than men to stay at all levels of grades, women are just as resilient as men in the face of lower-than-expected grades. Tables 5a and 5b show that both genders had almost equal grade expectations before starting classes their first year. Sixty four percent of males and 66% of females expected to earn at least an A-. These numbers do not change when analyzing the dataset at the engineering level. Sixty-five percent of men and 66% of women expected either an A or an A-. Since only 27% of these men and 25% of these women received an A- or above, nearly equal proportions of men and women were disappointed. Despite this, women were more likely to remain, even when the spring GPA was below a 3.0. Men appear to be more grade sensitive than women. The research cannot tell, however, whether those students valuing high grades, men or women, were the ones who left engineering to graduate from another college at the institution.

The resiliency of women at the engineering level highlights another finding. If the retention rate within engineering is the same for both sexes (66%), and women have an increased likelihood of staying within engineering, why is their persistence rate the same as males? One possible explanation is that they are at a disadvantage in some other area. Female density in courses is a strong suspect.

5.1.2 Research Question 2

The study's findings did not support, at any level, Question 2, which hypothesized a positive relationship between a higher female density in engineering-related courses and female persistence within engineering or within major. Additionally, the interaction between the being female and female density in engineering courses approaches negative significance at the engineering level. The main effects of female density (for both men and women) in core, engineering, and required courses were significant and negative.

The most likely reason for this dynamic is that the female density variables collapse courses taken over several semesters into one average that does not reflect their time-varying nature. Men and women both start out in introductory seminars or foundation courses. Women, may also take an all female "women in engineering" or "women in technical fields" seminar, which increases their average female density because the course is 100% women. As students progress through their academic plans, they take more upper level courses. Some majors, such as electrical or computer engineering, have very low percentages of women in the upper level courses simply because not many women opt to pursue these fields. Students who leave the institution, engineering, or their major early in their academic careers are likely to have higher female densities simply for this reason. Without allowing the density to vary over time, the 100% of a woman who left engineering after this first seminar is considered the same as the 21% of a woman who graduated in aerospace engineering.

If the negative effect remains after the passage of time is taken into account, other reasons for this negative relationship could include competition or selection. According to Kanter's (1993) tokenism theory, as the proportion of minority individuals rises, it will grow large enough (between 15% and 35%) to become a threat to the majority. The means of the core, engineering, and required courses variables fall within this range. The higher proportions of women in some courses coupled with women's higher grades may lead to more competition and thus a higher withdrawal rate for women. This greater likelihood for withdrawal due to competition may balance out women's higher grades and greater resiliency in the face of lower grades. If women were leaving due to increased competition, the interaction between being female and female density would remain negative and significant after female density is allowed to vary over time.

As for selection, women who wish to enter a male-dominated field, say, computer engineering may be more dedicated to this goal than those entering a more gender-balanced field such as chemical engineering. It might require a greater conceptual leap, greater personal risk, and more determination to aspire to a field where one is an obvious minority. In the case of selection, the interaction between female and female density will also be negative and significant.

Selection could also work from the opposite direction. Women today have more career options than women had a few decades ago. Surrounded with so many possibilities, high-performing women may leave engineering because another major offers more career promise, is more interesting to them, or takes them in a preferred intellectual direction. Thus, women who remain in engineering could be doubly selected, being neither pushed out nor drawn out.

5.1.3 Research Question 3

Question 3 posited a conditional relationship between being female and grades and being female and female density. No effects were found at any level. The hypothesis of Question 3 is not confirmed.

5.2 Conclusions

The study does not support the hypotheses implied in the research questions and instead finds some effects that were contrary to expectations. The findings hold potential value for the education, engineering, and research communities. Net of other factors, the women at this institution do not leave engineering or their originally intended engineering majors at a higher rate than men. The actual outflow rates and likelihood to persist are similar in both sexes. This finding is consistent with Ohland, et al. (2008), who also fails to identify differential male and female persistence within engineering using a larger, multi-institution dataset.

Women are also no more grade-sensitive than men in this study. In fact, at the engineering level, women are *less* so. This finding contradicts Rask and Tiefenthaler (2008), who found that lower grades made women less likely to major in economics. The students of the two studies differed, however, in their level of commitment. The engineering students of the current study entered college with the intent of majoring in a particular engineering major. The students in the Rask and Tiefenthaler study were attending an economics class as part of a general education requirement and were not necessarily intending to major in the subject. Women may be more grade sensitive if they are still exploring their options, but gender differences in grade sensitivity may last only until an academic direction is chosen.

In failing to find greater female grade sensitivity, this study also contradicts the findings of Felder, et al. (1995), another single-institution study, and Seymour and Hewitt (1997). While the levels of student commitment across the studies are comparable, the passage of time between the studies or the characteristics of the students attending the institution(s) of study may have influenced the present study's students to be less grade-sensitive.

The study also raises some questions about the proportion of women in engineering-related courses and how to measure it. The effects of female density in core, engineering, and required courses were all negative and equally applicable to both male and female students. The interaction between being female and female density in engineering courses was almost significant at the engineering level, and negative. More work is needed in refining how this concept is measured and analyzed. The current study had no way to account for the time-varying nature of female density in courses, a possible factor in these variables' negative signs.

In addition to the findings related to the research questions, the study's use of three levels of analysis highlights differences that can occur within the same variables at different levels. Generally speaking, many of the institution-level findings are consistent with the research literature regarding persistence of students in college. For example, students spending more semesters in on-campus housing had higher odds of graduation, as did those who had a higher spring GPA. Students from underrepresented populations had lower odds, all things considered.

As the pool of students narrowed to include only those who graduated or only those who remained within engineering, however, other variables became significant. Women had greater odds than men of graduation in engineering, which helped to offset the negative effects associated with higher female densities in engineering-related courses. Although this study does not explore the nature of this female advantage, possibilities include friendship factors (J. E.

Jacobs, et al., 1998; Lee, 2002; Riegel-Crumb, et al., 2006), peer effects (Astin, 1993; Leslie, et al., 1998; Pascarella & Terenzini, 2005), selection into a male-dominated field, and formal support systems, such as women in engineering programs, which have promoted women's persistence despite other disadvantages women might face (Ohland, et al., 2008). Importantly, the positive effect for being female and the weaker negative female and spring GPA interaction did not disappear when the female density variables were removed, indicating that some additional unobserved variable(s) are influencing female persistence in engineering.

Furthermore, intending to enter certain majors reduced or increased the odds of graduating within engineering or the originally chosen major, but these odds changed depending upon the level at which the analysis was run. For example, students intending to enter electrical engineering were more likely to leave the institution before graduating than were those intending to enter mechanical engineering. Aerospace, computer, and civil engineering-bound students are more likely to leave the college of engineering and graduate from a different college than mechanical engineers. Finally, students planning to enter architectural or industrial engineering were more likely to stay in their major than mechanical engineers. However, if these students left their first department, they were just as likely to leave engineering as mechanical engineers. Given that departmental culture differs from institution to institution, similar, but not the same patterns of migration are likely to exist in other institutions.

Finally, if students from historically underrepresented groups graduated within six years, they were more likely to graduate from their originally chosen major than their peers. This finding comes as a surprise, as students from underrepresented groups were less likely to graduate within six years from this institution. Students from underrepresented groups who make it past the engineering gateway courses may be especially motivated to succeed, be beneficiaries of programs aimed to help minorities in engineering, or have formed social networks to help them succeed.

5.2.1 Implications for Theory and Research

The institution/engineering/major-level analytical framework facilitates discovery of differences that may occur at each level of analysis. The effects for historically underrepresented students provide an example. At the institution level, these students appear to be at a disadvantage with respect to graduation within six years. At a more specific level of analysis, however, they are more likely to stay in their originally chosen engineering major than their majority counterparts. Likewise, the combined effects of spring GPA and being female are negative at the engineering level, but do not exist at the institution and major levels. Thus, studies that do not differentiate between leaving at each level may run the risk of confounded results.

Second, the study supports the findings of Ohland, et al. (2008) in finding no differential persistence existed between males and females in engineering. The many past studies documenting women's lower persistence rates in engineering and the sciences suggest that differential persistence was a problem in the past. We may be witnessing a sociological phenomenon as women's participation increases in engineering progressively (if slowly) one field at a time, starting with chemical and biological engineering, rather than across the board. Apart from the obvious connections to related fields that have already become gender balanced (e.g., chemistry and biology), what differences exist between the highly male-dominated engineering fields and the more balanced fields? What similarities exist between highly male-dominated engineering fields and other highly male-dominated fields such as information technology or physics? Understanding these dynamic may give us further insight regarding occupational segregation.

The findings of this study and its location within a broader literature suggest that the process leading to more balanced gender proportions may consist of several stages: First, the persistence differences between males and females subside. At roughly the same time, more females (or males) enter a few particular disciplines while the field as a whole remains dominated by the majority. As the proportion of the minority grows in these fields, other minority members begin to enter the more unbalanced fields in greater numbers. Finally, the rates of entrance and persistence in all fields become generally more balanced. This outline could be compared against statistics over time regarding the influx of women into law, medicine, and the sciences. The pattern could then also be compared to what might be seen in traditionally female occupations that males may be starting to enter.

5.2.2 Implications for Institutional Practice

In terms of practice, the institution has made efforts over the past decade to revamp "weed-out" courses. The female advantage seen in Model E-5a, and likely the equal persistence rates between men and women, may be a result of these practices.

Additionally, migration patterns within engineering should be of interest to all engineering programs. At this institution, for example, students aspiring to enter architectural and industrial engineering had higher odds of graduation within these majors than did those aspiring to enter mechanical engineering. However, if these architectural or industrial engineering students left their original majors, their odds of choosing another major within engineering were the same as those of students deciding to leave mechanical engineering. Thus, some engineering majors may be able to recruit students from other majors who otherwise may have left engineering, a pattern discussed in T. J. Murphy, et al., (2007) and Walden and Foor (2008). These researchers found that effective recruiting, contact with dynamic program members, a welcoming climate for students migrating into the major, and a clear, relevant image of the discipline's identity help influence students to relocate within STEM rather than leave it for another, non-STEM major. Possible receiving fields are probably identifiable in each institution. Programs willing to accept in-migration from other majors should be supported in their efforts to recruit from those who may otherwise leave engineering. If enrollment caps exist on some engineering majors, departments could make sure that a clear path within engineering is defined for students who do not qualify for their first-choice major. Although engineering student persistence is higher than several other disciplines, any outward migration is too much as engineering has seen decreases over the last 20 years both in absolute numbers as well as overall market share of college degrees (Ohland, et al., 2008).

5.2.3 Implications for Policy

If persistence within undergraduate engineering has stabilized between men and women, we have reached a milestone. However, achieving equal departure rates does not mean that the "women in engineering" problem is fixed at the college level. Not only do women still enter engineering at much lower rates than do men, but the effort and focus the engineering community has given so far to retain engineering students is likely responsible for the equal rates as well as the high overall persistence rate (Ohland, et al., 2008). Investment in student programs should continue, lest the ground recently gained be lost.

Second, if women have no greater odds of leaving or succeeding, and engineering has the lowest in-migration rate of any college major, more diligent recruiting is needed at the primary and secondary school levels to increase the numbers of women and men willing and able to enter engineering fields at the college level. Pryor, et al., (2007) document this disparity. A decreasing percentage of high school students is indicating interest in pursuing an engineering major each year, and women lag behind men. This implication echoes that of other studies recommending recruitment be a larger focus (Baranowski & Delorey, 2007; Ohland, et al., 2008; Sonnert, et al., 2007). A limited amount can be accomplished at the college level to widen and deepen the pool. Although Kinzie (2007) and Xie and Shauman (2005) identified female in-migration as a source of female engineers, their numbers are not enough to make a significant difference. More can be done at the elementary and secondary levels before entrance to college. When in-migration is low, more students entering the pipeline will increase the number of students who may continue in engineering.

5.3 Directions for Future Research

As a single institution study, the obvious next step would be to expand it to include multiple institutions. However, before going to that level, more should be done to explore the construct of female density and its effects, if any, on degree completion and persistence within originally specified field. Although a negative effect only approached significance at the engineering level for the interaction between female and female density in engineering courses, the overall effects for the core, engineering, and required variables were negative. The current study did not take into account the fact that the proportion of women in engineering could vary over time. The study model treated the density variable of 100% for a woman taking one “women in engineering” orientation seminar the same as the density variable of 15% for a woman who successfully entered and graduated from computer engineering. The inclusion of a time-varying component in an event history model would separate which effects are real and which effects are simply due to early departure. If the negative effects for women remain after an event history analysis, the ideas of selection or competition could be further explored.

Once the issues related to female density are resolved, the multi-level framework could be expanded to cover other male-dominated fields such as computer science and physics. If the findings are similar, work should also be done to understand the greater participation of women in biology and chemistry, fields that were once male-dominated but which have now become more gender balanced. Did more women initially enter some subfields more than others? For example, did women start to enter organic chemistry before they began to enter analytic chemistry? If so, why? Could women have perceived these fields as more relevant to helping others or making a societal difference? Did they feel the career options included more chances to work with other people or work in a more family-friendly environment? Were these fields perceived as less “not appropriately feminine?” Similarities and differences could then be drawn between the initial science subfields and the engineering subfields that women are now entering in higher proportions. A greater understanding of what draws women to some fields will facilitate understanding regarding what repels or fails to draw women to other fields.

Additionally, work could be done approaching from the female-dominated side. While occupations such as elementary education, child care, counseling, social work, and nursing generally garner less prestige and pay, they are also vital to the functioning of our society. Is the failure of these occupations to attract more male interest all about pay and prestige or is there something else at work, such as a perceived "femininity" associated with the work, the work environment, perceived (or real) reverse discrimination, or something else entirely?

In a more practical and administrative arena, the variance among the odds of persistence in different departments should be studied in order to refine policies and institutional practices. The current models used dummy variables with mechanical engineering as the reference group. Thus, all results were relative to students in mechanical engineering. The difference between students remaining within civil engineering and computer engineering, for example, is not as straightforward. Since department effects in this study were something to be controlled and not studied themselves, dummy variables with a reference category sufficed. However, a series of logistic regressions could be run to compare department to department if each regression contained the dummy variable for one department (Warcholak, 2010). This process would allow comparison of each department's significance to the others.

Someday, it may no longer be necessary to study women's lower participation rates in engineering because participation rates will be about the same. We see this possible future in bio- and chemical engineering nation-wide, followed by industrial and civil engineering. Perhaps we may also someday understand women's slow entrance into other male-dominated fields as well and be able to put programs and policies in place to facilitate horizontal integration, both from the male and female sides. With greater participation of minority groups in all these areas, our chances for fuller, more creative, and better solutions increase.

References

Abrams, D., Thomas, J., & Hogg, M. (1990). Numerical distinctiveness, social identity, and gender salience. *British Journal of Social Psychology, 29*, 87-92.

Adelman, C. (1998). *Women and men of the engineering path: A model for analyses of undergraduate careers*. Washington, DC: Office of Educational Research and Improvement, U.S. Department of Education.

Allison, P. D. (1995). *Survival analysis using SAS: A practical guide*. Cary, NC: SAS Institute, Inc.

American Association of University Women (1999). *Gender gaps: Where schools still fail our children*. NY: American Association of University Women Educational Foundation.

Aronson, J., Lustina, M. J., Good, C., & Keough, K. (1999). When white men can't do math: Necessary and sufficient factors in stereotype threat. *Journal of Experimental Social Psychology, 35*, 29-46.

Astin, A. (1993). *What matters in college? Four critical years revisited*. San Francisco, CA: Jossey-Bass.

Bandura, A. (Ed.) (1994) Encyclopedia of Human Behavior (Vols. 4). New York: Academic Press, Inc.

Bandura, A. (1997). *Self-efficacy: The exercise of control*.

Bandura, A., & Jourden, F. J. (1991). Self-regulatory mechanisms governing the impact of social comparison on complex decision making. *Journal of Personality and Social Psychology, 60*(6), 941-951.

Baranowski, M., & Delorey, J. (2007). *Because dreams need doing: New messages for enhancing public understanding of engineering*.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco: Jossey-Bass.

Bean, J. P. (1983). The application of a model of turnover in work organizations to the student attrition process. *The Review of Higher Education, 6*(2), 129-148.

Becker, H. S., Geer, B., & Hughes, E. C. (1995). *Making the grade: The academic side of college life*. New Brunswick, NJ: Transaction Publishers.

Ben-Zeev, T., Carrasquillo, C. M., Ching, A. M. L., Kliengklom, T. J., McDonald, K. L., Newhall, D. C., et al. (2005). "Math is hard!" (BarbieTM, 1994): Responses of threat vs. challenge-mediated arousal to stereotypes alleging intellectual inferiority. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach*. New York: Cambridge University Press.

Benbow, C. P., & Stanley, J. C. (1983). Sex differences in mathematical reasoning: More facts. *Science, 222*(4627), 1029-1031.

Berryman, S. E. (1983). *Who will do science? Trends, and their causes, in minority and female representation among holders of advanced degrees in science and mathematics*: The Rockefeller Foundation.

Betz, N. E., & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of Counseling Psychology, 28*(5), 399-410.

Bidwell, C. E., Plank, S., & Muller, C. (2000). Peer social networks and adolescent career development. In A. C. Kerckhoff (Ed.), *Generating social stratification*. Boulder, CO: Westview Press.

Brainard, S., & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education, 87*, 369-375.

Catsambis, S. (1994). The path to math: Gender and racial-ethnic differences in mathematics participation from middle school to high school. *Sociology of Education, 67*(3), 199-215.

Charles, M., & Bradley, K. (2009). Indulging Our Gendered Selves? Sex Segregation by Field of Study in 44 Countries. *American Journal of Sociology, 114*(4), 924-976.

Charles, M., & Grusky, D. B. (2004). *Occupational ghettos: The worldwide segregation of women and men*. Stanford, CA: Stanford University Press.

Cohen, G. L., & Garcia, J. (2008). Identity, Belonging, and Achievement: A Model, Interventions, Implications. *Current Directions in Psychological Science, 17*(6), 365-369.

Cohen, J. (1983). Peer influence on college aspirations with initial aspirations controlled. *American Sociological Review, 48*(5), 728-734.

Committee on Prospering in the Global Economy of the 21st Century, & Committee on Science, Engineering, and Public Policy (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, D.C.: National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies

Correll, S. J. (2001). Gender and the career choice process: The role of biased self-assessments. *The American Journal of Sociology, 106*(6), 1691-1730.

Correll, S. J. (2004). Constraints into Preferences: Gender, Status, and Emerging Career Aspirations. *American Sociological Review, 69*(1), 93-113.

Crocker, J., Karpinski, A., Quinn, D. M., & Chase, S. K. (2003). When grades determine self-worth: Consequences of contingent self-worth for male and female engineering and psychology majors. *Journal of Personality and Social Psychology, 85*(3), 507-516.

Crocker, J., & Luhtanen, R. K. (2003). Level of self-esteem and contingencies of self-worth: Unique effects on academic, social, and financial problems in college students. *Personality and Social Psychology Bulletin, 29*(6), 701-712.

Crocker, J., Luhtanen, R. K., Cooper, M. L., & Bouvrette, A. (2003). Contingencies of self-worth in college students: Theory and measurement. *Journal of Personality and Social Psychology, 85*(5), 894-908.

Crocker, J., & Park, L. E. (2004). The costly pursuit of self-esteem. *Psychological Bulletin, 130*(3), 392-414.

Crocker, J., Sommers, S. R., & Luhtanen, R. K. (2002). Hopes dashed and dreams fulfilled: Contingencies of self-worth and graduate school admissions. *Personality and Social Psychology Bulletin, 2002*(28), 1275-1286.

Crosnoe, R., Riegle-Crumb, C., Frank, K., Field, S., & Muller, C. (2008). Peer group contexts of girls' and boys' academic experiences. *Child Development, 79*(1), 139-155.

Deaux, K., & Major, B. (1987). Putting gender into context: An interactive model of gender-related behavior. *Psychological Review, 94*(3), 369-389.

Drew, D. E., & Astin, A. W. (1972). Undergraduate Aspirations: A Test of Several Theories. *The American Journal of Sociology, 77*(6), 1151-1164.

Dweck, C. S. (2000). *Self theories: Their role in motivation, personality, and development*. New York: Taylor & Francis Group.

Eccles, J. S., & Jacobs, J. E. (1986). Social forces shape math attitudes and performance. *Signs, 11*(2), 367-380.

Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72*(1), 218-232`.

Elliott, R. A., Strenta, C., Adair, R., Matier, M., & Scott, J. (1996). The role of ethnicity in choosing and leaving science in highly selective institutions. *Research in Higher Education, 37*(6), 681-709.

England, P., & Farkas, G. (1986). *Households, employment, and gender: A social, economic and demographic view*. Hawthorne, NY: Aldine De Gruyter.

Farmer, H. S. (1997). Theoretical overview: Longitudinal study. In H. S. Farmer & Associates (Eds.), *Diversity & women's career development: From adolescence to adulthood*. Thousand Oaks, CA: Sage Publications, Inc.

Felder, R. M., Felder, G. N., Mauney, M., Hamrin, J., Charles E., & Dietz, E. J. (1995). A longitudinal study of engineering student performance and retention: III. Gender differences in student performance and attitudes. *Journal of Engineering Education, 84*(2), 151-163.

Freeman, C. (2004). *Trends in educational equity of girls & women: 2004* (No. NCES 2005016). Washington, DC: National Center for Education Statistics.

Frehill, L. M. (1997). Education and Occupational Sex Segregation: The Decision to Major in Engineering. *The Sociological Quarterly, 38*(2), 225-249.

Frehill, L. M. (2004). The gendered construction of the engineering profession in the United States, 1893-1920. *Men and Masculinities, 6*(4), 383-403.

Gaskell, J. (1985). Course enrollment in the high school: The perspectives of working-class females. *Sociology of Education, 58*, 48-59.

Gilligan, C. (1993). *In a different voice: Psychological theory and women's development*. Cambridge, MA: Harvard University Press.

Glass, J. (1990). The Impact of Occupational Segregation on Working Conditions. *Social Forces, 68*(3), 779-796.

Goyette, K. A., & Mullen, A. L. (2006). Who studies the arts and sciences? Social background and the choice and consequences of undergraduate field of study. *The Journal of Higher Education, 77*(3), 497-538.

Grove, W. A., & Wasserman, T. (2004). The life-cycle pattern of collegiate GPA: Longitudinal cohort analysis and grade inflation. *Journal of Economic Education, 35*(2), 162-174.

Grusky, D. B., & Charles, M. (2001). Is there a worldwide sex segregation regime? In D. B. Grusky (Ed.), *Social stratification: Class, race, & gender in sociological perspective* (2nd ed., pp. 391-403). Boulder, CO: Westview Press.

Hackett, G., Betz, N. E., O'Halloran, M. S., & Romac, D. S. (1990). Effects of verbal and mathematics task performance on task and career self-efficacy and interest. *Journal of Counseling Psychology, 37*(2), 169-177.

Hartman, H., & Hartman, M. (2008). How undergraduate engineering students perceive women's (and men's) problems in science, math, and engineering. *Sex Roles, 58*, 251-265.

Hathaway, R. S., Sharp, S., & Davis, C.-S. (2001). Programmatic efforts affect retention of women in science and engineering. *Journal of Women and Minorities in Science and Engineering, 7*, 107-124.

Hawks, B., & Spade, J. (1998). Women and men engineering students: Anticipation of family and work roles. *Journal of Engineering Education, 87*, 249-256.

Holland, D. C., & Eisenhart, M. (1990). *Educated in romance: Women, achievement, and college culture*. Chicago: The University of Chicago Press.

Horowitz, H. L. (1987). *Campus life: Undergraduate cultures from the end of the eighteenth century to the present*. Chicago: The University of Chicago Press.

Inzlicht, M., & Ben-Zeev, T. (2000). A Threatening Intellectual Environment: Why Females Are Susceptible to Experiencing Problem-Solving Deficits in the Presence of Males. *Psychological Science, 11*(5), 365-371.

Jackson, L. A., Gardner, P. D., & Sullivan, L. A. (1993). Engineering persistence - Past, present, and future factors and gender differences. *Higher Education, 26*(2), 227-246.

Jacobs, J. A. (1986). The sex-segregation of fields of study: Trends during the college years. *The Journal of Higher Education, 57*(2), 134-154.

Jacobs, J. A. (1995). Gender and academic specialties: Trends among recipients of college degrees in the 1980s. *Sociology of Education, 68*(2), 81-98.

Jacobs, J. E., Davis-Kean, P., Bleeker, M., Eccles, J. S., & Malanchuk, O. (2005). "I can, but I don't want to": The impact of parents, interests, and activities on gender differences in math. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach*. New York: Cambridge University Press.

Jacobs, J. E., Finken, L. L., Lindsley Griffin, N., & Wright, J. D. (1998). The career plans of science-talented rural adolescent girls. *American Educational Research Journal, 35*(4), 681-704.

Johns, M., Schmader, T., & Martens, A. (2005). Knowing is half the battle: Teaching stereotype threat as a means of improving women's math performance. *Psychological Science, 16*(3), 175-179.

Joy, L. (2006). Occupational differences between recent male and female college graduates. *Economics of Education Review, 25*(2006), 221-231.

Kanter, R. M. (1993). *Men and women of the corporation*. NY: BasicBooks.

Kinzie, J. (2007). Women's paths in science: A critical feminist analysis. *New Directions in Institutional Research, 133*, 81-93.

Kuh, G., & Hu, S. (1999). Unraveling the complexity of the increase in college grades from mid-1980s to the mid-1990s. *Educational Evaluation and Policy Analysis, 21*(3), 297-320.

Leary, M. R., & Baumeister, R. F. (2000). The nature and function of self-esteem: Sociometer theory. *Advances in Experimental Social Psychology, 32*, 1-62.

Lee, J. D. (1998). Which kids can "become" scientists? Effects of gender, self-concepts, and perception of scientists. *Social Psychology Quarterly, 61*(3), 199-219.

Lee, J. D. (2002). More than ability: Gender and personal relationships influence science and technology involvement. *Sociology of Education, 75*(4), 349-373.

Leonard, D. K., & Jiang, J. (1996). Gender bias and the college predictions of the SATS: A cry of despair. *Research in Higher Education, 40*(4), 375-407.

Leslie, L. L., McClure, G. T., & Oaxaca, R. L. (1998). Women and minorities in science and engineering: A life sequence analysis. *The Journal of Higher Education, 69*(3), 239-276.

Leslie, L. L., & Oaxaca, R. L. (1998). Women and minorities in higher education. In J. C. Smart (Ed.), *Handbook of Higher Education* (Vol. 13, pp. 304-352). New York: Agathon Press.

Loftus, M. (2005). Lending a hand. *ASEE Prism, 14*(5), 26-29.

Logel, C., Walton, G. M., Spencer, S. J., Iserman, E. C., & von Hippel, W. (2009). Interacting with sexist men triggers social identity threat among female engineers. *Journal of Personality and Social Psychology, 96*(6), 1089-1103.

Luzzo, D. A., Hasper, P., Albert, K. A., Bibby, M. A., & Martinelli Jr., E. A. (1999). Effects of self-efficacy-enhancing interventions on the math/science self-efficacy and career

interests, goals, and actions of career undecided college students. *Journal of Counseling Psychology, 46*(2), 233-243.
Maple, S. A., & Stage, F. K. (1991). Influences on the choice of math/science major by gender and ethnicity. *American Educational Research Journal, 28*(1), 37-60.
Marsh, H. W., & Parker, J. W. (1984). Determinants of student self-concept: Is it better to be a relatively large fish in a small pond even if you don't learn to swim as well? *Journal of Personality and Social Psychology, 47*(1), 213-231.
Martens, A., Johns, M., Greenberg, J., & Schimel, J. (2006). Combating stereotype threat: The effect of self-affirmation on women's intellectual performance. *Journal of Experimental Social Psychology, 42*, 236-243.
McIlwee, J. S., & Robinson, J. G. (1992). *Women in engineering: Gender, power, and workplace culture*. Albany, NY: State University of New York Press.
Micceri, T. (2001). *Change your major and double your graduation chances.* Paper presented at the Annual Meeting of the Association for Institutional Research, Long Beach, CA.
Moller-Wong, C., & Eide, A. (1997). An engineering student retention study. *Journal of Engineering Education, 86*(1), 7-15.
Muller, P. A., Stage, F. K., & Kinzie, J. (2001). Science achievement growth trajectories: Understanding factors related to gender and racial-ethnic differences in precollege science achievement. *American Educational Research Journal, 38*(4), 981-1012.
Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18*(10), 879-885.
Murphy, T. J., Shehab, R. L., Reed-Rhoads, T., Foor, C. E., Harris, B. J., Trytten, D. A., et al. (2007). Achieving Parity of the Sexes at the Undergraduate Level: A Study of Success. *Journal of Engineering Education*(July, 2007), 241-252.
National Academy of Engineering (2004). *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: The National Academy of Engineering of the National Academies.
National Association of Colleges and Employers (2007). *2007 NACE salary survey*. Bethlehem, PA: National Association of Colleges and Employers.
National Center for Education Statistics (2007). Table 269: First professional degrees conferred by degree-granting institutions in dentistry, medicine, and law, by number of institutions conferring degrees and sex of student: Selected years, 1949-50 through 2005-06 Retrieved June 27, 2008, from http://nces.ed.gov/programs/digest/d07/tables/dt07_269.asp
National Center for Education Statistics (2008a). Table 268: Degrees conferred by degree-granting institutions, by level of degree and sex of student: Selected years, 1869–70 through 2017–18 Retrieved July 3, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_268.asp
National Center for Education Statistics (2008b). Table 285: Bachelor's degrees conferred by degree-granting institutions, by sex, race/ethnicity, and field of study: 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_285.asp
National Center for Education Statistics (2009a). Table 275: Bachelor's, master's, and doctor's degrees conferred by degree-granting institutions, by sex of student and discipline division: 2006–07 Retrieved July 3, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_275.asp

National Center for Education Statistics (2009b). Table 279: Number of institutions and first-professional degrees conferred by degree-granting institutions in dentistry, medicine, and law, by sex of student: Selected years, 1949–50 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_279.asp
National Center for Education Statistics (2009c). Table 300: Degrees in business conferred by degree-granting institutions, by level of degree and sex of student: Selected years, 1955–56 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_300.asp
National Center for Education Statistics (2009d). Table 301: Degrees in communication, journalism, and related programs and in communications technologies conferred by degree-granting institutions, by level of degree and sex of student: 1970–71 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_301.asp
National Center for Education Statistics (2009e). Table 302: Degrees in computer and information sciences conferred by degree-granting institutions, by level of degree and sex of student: 1970–71 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_302.asp
National Center for Education Statistics (2009f). Table 303: Degrees in education conferred by degree-granting institutions, by level of degree and sex of student: Selected years, 1949–50 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_303.asp
National Center for Education Statistics (2009g). Table 304: Degrees in engineering and engineering technologies conferred by degree-granting institutions, by level of degree and sex of student: Selected years, 1949–50 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_304.asp
National Center for Education Statistics (2009h). Table 306: Degrees in English language and literature/letters conferred by degree-granting institutions, by level of degree and sex of student: Selected years, 1949–50 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_306.asp
National Center for Education Statistics (2009i). Table 314: Degrees in psychology conferred by degree-granting institutions, by level of degree and sex of student: Selected years, 1949–50 through 2006–07 Retrieved July 2, 2009, from http://nces.ed.gov/programs/digest/d08/tables/dt08_314.asp
National Science Board (2003). *The science and engineering workforce: Realizing America's potential*. Washington, DC: National Science Foundation.
NCES (2006). Table 254: Bachelor's degrees conferred by degree-granting institutions, by discipline division: Selected years, 1970-71 through 2004-05 Retrieved January 2, 2008, from http://nces.ed.gov/programs/digest/d06/tables/dt06_254.asp
NCES (2007). Table 294: Degrees in engineering and engineering technologies conferred by degree-granting institutions, by level of degree and sex of student: Selected years, 1949-50 through 2005-06 Retrieved June 27, 2008, from http://nces.ed.gov/programs/digest/d07/tables/dt07_294.asp
Ohland, M. W., Sheppard, S. D., Lichtenstein, G., Eris, O., Chachra, D., & Layton, R. A. (2008). Persistence, engagement, and migration in engineering programs. *Journal of Engineering Education*.

Organisation for Economic Cooperation and Development (2009). *OECD Factbook 2009*. Paris, France.
Pascarella, E. T., & Terenzini, P. T. (1991). *How college affects students: Findings and insights from twenty years of research*. San Francisco, CA: Jossey-Bass Publishers.
Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research*. San Francisco, CA: Jossey-Bass.
Pronin, E., Steele, C. M., & Ross, L. (2004). Identity bifurcation in response to stereotype threat: Women and mathematics. *Journal of Experimental Social Psychology, 40*, 152-168.
Pryor, J. H., Hurtado, S., Saenz, V. B., Santos, J. L., & Korn, W. S. (2007). *The American freshman: Forty year trends, 1966-2006*. Los Angeles, CA: University of California, Los Angeles, Higher Education Research Institute.
Purdie-Vaughns, V., Steele, C. M., Davies, P. G., Ditlmann, R., & Randall Crosby, J. (2008). Social identity contingencies: How diversity cues signal threat or safety for African Americans in mainstream institutions. *Journal of Personality and Social Psychology, 94*(4), 615-630.
Rask, K., & Tiefenthaler, J. (2008). The role of grade sensitivity in explaining the gender imbalance in undergraduate economics. *Economics of Education Review, In press*.
Riegel-Crumb, C., Farkas, G., & Muller, C. (2006). The role of gender and friendship in advanced course taking. *Sociology of Education, 79*(July), 206-228.
Robst, J. (2007). Education and job match: The relatedness of college major and work. *Economics of Education Review, 26*, 397-407.
Robst, J., Keil, J., & Russo, D. (1998). The effect of gender composition of faculty on student retention. *Economics of Education Review, 17*(4), 429-439.
Rogers, S. J., & Menaghan, E. G. (1991). Women's persistence in undergraduate majors: The effects of gender-disproportionate representation. *Gender and Society, 5*(4), 549-564.
Rotter, N. G. (1982). Images of engineering and liberal arts majors. *Journal of Vocational Behavior, 20*, 193-202.
Sabot, R., & Wakeman-Linn, J. (1991). Grade inflation and course choice. *The Journal of Economic Perspectives, 5*(1), 159-170.
Sax, L. J. (1996). The dynamics of "tokenism": How college students are affected by the proportion of women in their major. *Research in Higher Education, 37*(4), 389-425.
Sax, L. J. (2008). *The gender gap in college: Maximizing the developmental potential of women and men*. San Francisco, CA: Jossey-Bass.
Schmader, T. (2002). Gender identification moderates stereotype threat effects on women's math performance. *Journal of Experimental Social Psychology, 38*, 194-201.
Serex, C. P., & Townsend, B. K. (1999). Student perceptions of chilling practices in sex-atypical majors. *Research in Higher Education, 40*(5), 527-538.
Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving*. Boulder, CO: Westview Press.
Sheppard, S. D., Macatangay, K. C., Anne, & Sullivan, W. M. (2009). *Educating engineers: Designing for the future of the field*. San Francisco, CA: Jossey-Bass.
Shettle, C., Roey, S., Mordica, J., Perkins, R., Nord, C., Teodorovic, J., et al. (2007). *The nation's report card: America's high school graduates* (No. NCES 2007-467). Washington, DC: U. S. Department of Education, National Center for Education Statistics.
Shih, M., Pittinsky, T. L., & Ambady, N. (1999). Stereotype susceptibility: Identity salience and shifts in quantitative performance. *Psychological Science, 10*(1), 80-83.

Shu, X., & Mooney Marini, M. (1998). Gender-related change to occupational aspirations. *Sociology of Education, 71*(1), 43-67.
Simpson, J. C. (2001). Segregated by subject: Racial differences in the factors influencing academic major between European Americans, Asian Americans, and African, Hispanic, and Native Americans. *The Journal of Higher Education, 72*(1), 63-100.
Solnick, S. J. (1995). Changes in women's majors from entrance to graduation at women's and coeducational colleges. *Industrial and Labor Relations Review, 48*(3), 505-514.
Sonnert, G., Fox, M. F., & Adkins, K. (2007). Undergraduate women in science and engineering: Effects of faculty, fields, and institutions over time. *Social Science Quarterly, 88*(5), 1333-1356.
Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*(613-629).
Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*(5), 797-811.
Steele, C. M., Spencer, S. J., & Aronson, J. (2002). Contending with group image: The psychology of stereotype and social identity threat. *Advances in Experimental Social Psychology, 34*, 379-440.
Tobias, S. (1994). *They're not dumb, they're different: Stalking the second tier*. Tucson, AZ: Research Corporation.
Tonso, K. (1996). The impact of cultural norms on women. *Journal of Engineering Education, 85*, 217-225.
Turner, S. E., & Bowen, W. G. (1999). Choice of major: The changing (unchanging) gender gap. *Industrial and Labor Relations Review, 52*(2), 289-313.
Unrau, Y. A., & Coleman, H. (1998). Understanding and interpreting polytomous logistic regression: Applications to research on social work practice. *Research on Social Work Practice, 8*(2), 223-235.
Valian, V. (1999). *Why so slow? The advancement of women*. Cambridge, MA: MIT Press.
Valli, L. (1986). *Becoming clerical workers*. Boston, MA: Routledge &Kegan Paul plc.
Veenstra, C. P., Dey, E. L., & Herrin, G. D. (2008). Is modeling of freshman engineering success different from modeling of non-engineering success? *Journal of Engineering Education*.
Vogt, C. M., Hocevar, D., & Hagedorn, L. S. (2007). A social cognitive construct validation: Determining women's and men's success in engineering programs. *The Journal of Higher Education, 78*(3), 337-368.
Walden, S. E., & Foor, C. E. (2008). "What's to keep you from dropping out?" Student immigration into and within engineering. *Journal of Engineering Education, April, 2008*, 191-205.
Walton, G. M., & Cohen, G. L. (2007). A question of belonging: Race, social fit, and achievement. *Journal of Personality and Social Psychology, 92*(1), 82-96.
Warcholak, N. (2010). Conversation regarding methods.
Xie, Y., & Shauman, K. A. (2005). *Women in science: Career processes and outcomes*. Cambridge, MA: Harvard University Press.

Michelle Stine
Vita

Education

2010 Ph.D. in Higher Education, The Pennsylvania State University

2004 M.Ed. in Higher Education, The Pennsylvania State University

1994 B.A. in English with Honors, The Pennsylvania State University

Conferences

Dooris, M., Guidos, M., & Stine, M. (2007). *Looking Beyond Access: Academic Ability, Ability to Pay, and Degree Completion*. Paper presented at the Association for Institutional Research National Forum, Kansas City, MO.

Stine, M. (2006). *Changing Majors: The Numbers at One Campus*. Poster Session at the Penn State Advising Conference, University Park, PA.

Stine, M. (2005). *IT-Related Decision-Making within a Large, Research University*. Paper presented at the Computer Services Management Symposium, Charleston, SC.

Stine, M. (2005). *IT-Related Decision-Making within a Large, Research University*. Poster Session at The American Public Research University, University Park, PA.

Stine, M. (2004). *Using Organizational Theory to Understand Campus IT*. Paper presented at the Computer Services Management Symposium, Santa Fe, NM.