A STUDY OF PERSISTENCE OF UNDERGRADUATE WOMEN MAJORING IN ENGINEERING AND MATH

by

Jessica M. Pena-Lopez

A Dissertation Submitted to the Faculty of

The College of Education

in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

Florida Atlantic University

Boca Raton, FL

December 2011

A STUDY OF PERSISTENCE OF UNDERGRADUATE WOMEN MAJORING IN ENGINEERING AND MATH

by

Jessica M. Pena-Lopez

This dissertation was prepared under the direction of the candidate's dissertation advisors, Dr. Ira Bogotch and Dr. Deborah L. Floyd, Department of Educational Leadership and Research Methodology, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the College of Education and was accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

SUPERVISORY COMMITTEE:

Dissertation Co-Advisor, Ira Bogotch, Ed.D.

Dissertation Co-Advisor, Deborah L. Floyd, Ed.D.

Sharron Ronco, Ph.D.

Robert Shockley, Ph.D.

Robert Shockley, Ph.D.
Chair, Department of Educational Leadership and Research Methodology

Valerie Bristor, Ph.D.
Dean, College of Education

Barry T. Rosson, Ph.D.
Dean, Graduate College

November 2, 2011
Date

ACKNOWLEDGEMENTS

Thank you God for being with me every step of the way, and giving me the strength to succeed.

Thanks to Dr. Bogotch, Dr. Floyd, and Dr. Ronco for giving me the honor to work with you on this dissertation. You have imparted your wisdom, compassion, skill, and dedication. Some part of each one of you will remain with me through the rest of my life. I also want to thank Dr. Shockley for providing me feedback through this dissertation.

Thanks to my parents, Maria and Victor, for you infinite love, guidance, and support, which has given me strength and encouragement. You both have always been there for me, and I can always count on you when times get hard. Thank you for your prayers and teaching me to never give up my dreams. Everything I am and everything I have accomplished is because of you. To my sisters, Jenica, Janel, and Joycelin, for being there for those things only a sister can understand and for your endless phone calls with empowering words of encouragement.

Without the assistance and cooperation of the following people, this dissertation would not have been possible. Thanks go to John Cahill from Florida Atlantic University, Mia Alexander-Snow and Paige Borden from University of Central Florida, and to Evan Rosenthal from University of South Florida.

Heartfelt thanks goes to my husband Josue, for his patience, understanding, support, encouragement, and especially his sense of humor which makes me smile daily, throughout my growth as a person and a professional. To my son, Joshua, for being a special addition to my life and future. I truly love you both.

ABSTRACT

Author: Jessica Pena-Lopez

Title: A Study of Persistence of Undergraduate Women Majoring in Engineering and Math

Institution: Florida Atlantic University

Dissertation Advisors: Dr. Ira Bogotch and Dr. Deborah L. Floyd

Degree: Doctor of Philosophy

Year: 2011

The purpose of this study was to identify factors that are associated with encourage the persistence of undergraduate women majoring in Engineering and Math (EM) at Florida Atlantic University, University of Central Florida, and University of South Florida. The persistence factors were examined through an analysis of university data and the use of a survey for enrolled senior standing students who declared their first major in engineering or math. Both quantitative and qualitative methods were utilized to collect and analyze data from the three sites. Factor analysis and logistic regression were used to analyze the quantitative data. The quantitative data retrieved from the survey instrument revealed that participants who were self motivated, felt they had a safe learning environment, and were engaged by the university were more likely to persist in engineering and math. Additionally, the survey revealed that race and ethnicity does not predict persistence of undergraduate women majoring in engineering and math.

Qualitative analysis of open-ended survey questions revealed that the most important factor that helps female students persist in engineering and math major was self-confidence and determination. They also indicated that discrimination and stereotyping were the most difficult factors for female students to overcome. To enable more women to be successful in the pursuit of a engineering or math degree, participants made an overwhelming reference to intervention as student engagement. Student engagement consists of the following: outreach programs, support programs, study groups, homework sessions, women clubs, engineering or math clubs, math and sciences activities, math and science tours, engineering and math societies, educational programs focusing on engineering and math, online courses, women organizations in STEM, positive role models, female teachers, women mentors, exposure to engineering and math, and expanding the career outlooks of young women. They suggested that student engagement must start early and must be continuous throughout every level of the educational pathway and professional life.

Recommendations are provided for policymakers and university administrators to continue supporting women majoring in EM and to increase awareness and access that encourage persistence of women in the pursuit of EM career goals.

A STUDY OF PERSISTENCE OF UNDERGRADUATE WOMEN MAJORING IN ENGINEERING AND MATH

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

Introduction

Since the 1940s, women began entering the workforce in significant numbers; therefore, women's career development has received increasing attention (Schaefers, Epperson, & Nauta, 1997). According to the U. S. Department of Labor (1993) and the U.S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education (2009), women currently make up over half of the employees in the United States workforce, but only 25 percent of the science, technology, engineering, and mathematics (STEM) workforce. In 2007, women continued to constitute the vast majority of those traditionally female occupations such as registered nurses, therapists, and non postsecondary teachers; therefore, more than three quarters of these occupations are filled by females (National Science Foundation [NSF], 2009). The most comprehensive report on the status of women in postsecondary education was published in 2009 by the NSF. It is inside these statistics that the realities of women in postsecondary education become evident. These statistics will be presented throughout the dissertation as well as in Appendix A and B. The objective here, however, is to understand and analyze the personal motivations and social conditions of women who have persisted in postsecondary education in fields of engineering and math (EM- the second half of STEM). Thus, the ultimate goal of this study was to increase awareness and understanding of critical factors that can encourage the persistence of women in the pursuit of EM career goals.

The demand for labor in the science and technology sector is rising. However, the number of students choosing to pursue EM careers is declining worldwide (Commission on the Advancement of Women and Minorities in Science, 2000; National Center for Education Statistics [NCES], 1996, 1997b). Simultaneously, the dropout rate of EM majors is significantly higher than the mean for non-EM undergraduates (Seymour & Hewitt, 1997). Attrition has been a historic problem for both men and women from EM majors. However, persistence rates for women are significantly lower than men in EM fields (Seymour, 1995b). Given the same level of interest and ability, women are far more likely than men to abandon the pursuit of a career in mathematics or engineering (Schaefers et al., 1997; Seymour, 1995a; U.S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education, 2009). Currently, only about 20 percent of undergraduate engineering students are women (Basken, 2009). A multiple institution database for investigating engineering development, which features data on 70,000 engineering students from nine institutions in the southeast over a seventeen year period ending in 2005, was managed by Matthew Ohland, an associate professor of engineering education at Purdue University. According to Mr. Ohland's database, it "shows women aren't dropping out at any greater rate than men are, suggesting more efforts should be made in recruiting women into engineering than on trying to retain them" (Basken, 2009, p.1). However, women with STEM degrees are twice as likely to leave a scientific or engineering job as men with comparable STEM degrees (U.S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education, 2009).

According to the U.S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education (2009):

> In recent years, increased attention has been paid to the issue of gender inequity in STEM. Numerous reports have highlighted the continued lack of participation of girls and young women in certain STEM fields, most notably in the fields of engineering, physics, and computer science (p. 2).

Students who entered computer/ information sciences and engineering/engineering technologies did not do as well as students in other STEM fields with respect to attaining a bachelor's degree (NCES, 2009). They have a higher percentage of leaving college without earning any credential, compared to students entering physical sciences and biological/ agricultural sciences (NCES, 2009). A new federal study reported by the National Center for Education Statistics (NCES, 2009) concluded that students who entered a STEM field between 1995-96 and 2001 earned a degree or certificate at a rate of 41 percent and another 12 percent still remained enrolled in a STEM field, but 21 percent had switched to a non-STEM field and 27 percent left postsecondary education.

In 1994, Strenta, Elliot, Matier, Scott, and Adair found that the persistence rate of men in science, math, and engineering (SME) majors was as high as 61 percent at highly selective institutions, with an average of 39 percent for national samples, compared to 46 percent and 30 percent respectively for women. This drain of female SME talent occurs at each of four successive stages in the SME career pathway: pre-collegiate, undergraduate, graduate education, and in their professional lives (Grahm, 1997; Rayman & Brett, 1995; Schaefers et al., 1997; U.S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education, 2009). In academic science, a gender gap continues despite persistent efforts at multiple levels to attract and retain talented women (Campbell & Skoog, 2004; U.S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education, 2009). "Thus, impediments to women pursuing careers in science, and particularly in academia, continue to exist" (Campbell & Skoog, 2004, p. 24). As long as women students with EM interests abandon their interests at a greater rate than men, the under representation of women in the EM will continue (Angier, 2003; Ware, Steckler, & Leserman, 1985).

In the United States, women have been underrepresented in science-related classrooms on college campuses. Statistics have shown that more women are declaring majors in engineering and math fields than in past years, but they are not necessarily graduating from those fields (NSF, 2009). More than half of all women in EM majors switch to non-EM majors before completing an undergraduate degree (Seymour & Hewitt, 1997). According to Seymour and Hewitt (1997), they found that EM majors who switched to non-EM majors left to pursue careers primarily in business, social studies, and education. Only a few women who declare a major in EM remain in these majors by the end of their final year (NSF, 1999). Overall, the percentage of female students majoring in EM fields continues to decline between freshman and senior years despite the higher numbers of freshmen interested.

On January 15, 2005, Harvard University President Lawrence Summers addressed the Nation Bureau of Economic Research Conference on Diversifying the Science and Engineering Workforce: Women, Underrepresented Minorities and Their S&E Careers (Denton, 2005). Summer's speech focused on his three broad hypotheses to explain the relatively small number of women in high level positions in science, math, and engineering. He stated that innate differences between the sexes might explain women's poor representation in science and engineering. He called for more research and suggested that there were no overwhelming body of serious research that informs this topic (American Sociological Association, 2005). Summers' remarks immediately made national news and sparked a national debate.

"Yet, there is substantial research that provides clear and compelling evidence that women, like men, flourish in science, just as in other occupational pursuits when they are given the opportunity and a supportive environment" (American Sociological Association, 2005, p.1). According to Hennessey, Hockfield, and Tilghman (2005), speculation that innate difference may be a significant cause for the underrepresentation of women in science and engineering may rejuvenate old myths and reinforce negative stereotypes and biases. They stated the question we must ask as a society is, "how can we encourage more women with exceptional abilities to pursue careers in these fields" (Hennessey et al., 2005, p.1). If the representation of women in EM does not change, these fields will look increasingly anachronistic, less attractive, and will be less strong (Hennessey et al., 2005).

Some studies have suggested that the college years have the potential to be a crucial turning point in a woman's decision-making process. Higher education is in a "unique position to facilitate and encourage women's involvement in mathematics, science, law, and business because they educate future professionals in these fields and serve as gatekeepers to the professions" (Ehrhart & Sandler, 1987, p. 3). By ensuring opportunities for women, providing special programs to facilitate women's entrance into traditionally male programs and encouraging the recruitment of women to these programs, researchers claim that postsecondary institutions can offset the decline in female science enrollment (Ehrhart & Sandler, 1987; Tobias, 1990). According to Jill Bystydzienski (2004):

> In order for SME fields to be equally open to women and men from all racial/ethnic groups, a fundamental (re)gendering has to take place-not only do women need to be represented in equal numbers, but also institutional structures and disciplinary cultures and practices need to change so that they do not provide an advantage for any particular gender (as well as race, class, or sexual orientation) over others. (p. viii).

"Only a relative thimbleful of women have reached the upper tiers of their profession-- becoming tenured professors, running large laboratories, giving keynote addresses at major scientific meetings or winning big awards" (Angier, 2003, pF2). According to Leggon (2006), women faculty comprised 12.1 percent of chemistry, 10.6

percent of computer science, 6.6 of physics, and 20.2 percent of biology. In 2006, women holders of a science and engineering doctorate in academia were found to be employed more often in temporary positions than of those in top leadership positions at four year colleges or universities (NSF, 2009). Four times as many men as women with science and engineering doctorates hold full time faculty positions (Leggon, 2006) The more prestigious the institution, the smaller the percentage of women faculty (Leggon, 2006). They are less likely to be tenured and more likely to hold lower academic ranks (Leggon, 2006). Underrepresented minority women are less likely than either white women or men of any racial group to be awarded tenure and to be full time professors (Leggon, 2006). According to Leggon (2006), at the top fifty research institutions there were no Black women or American Indian women faculty in both computer science and physics. American Indian and Asian women faculty comprised only 25 percent and 30 percent, respectively, of American Indian and Asian full time professors (Leggon, 2006). "The underrepresentation of women on faculties both reflects and reinforces the gender imbalances between the compositions of the student body and faculty" (Leggon, 2006, p. 328). In 2006, women were 39 percent of science and engineering doctorate holders with adjunct faculty positions, 41 percent of those with post doctorate positions, 27 percent of deans, and 30 percent of presidents of colleges and universities (NSF, 2009). In business or industry in 2006, underrepresented minorities were 10 percent of all scientists and engineers (NSF, 2009).

Higher paying and more secure employment means high quantitative literacy more than any other skill (NCES, 1997b). Workers in the upper quartile in mathematics and science proficiency earn more and suffer less unemployment than all other workers (NCES, 1997b). It is alarming that women have not achieved parity with men in pursuing rewarding careers in science, mathematics, and engineering. “Women are needed not only to fill vacant positions but also to bring new questions, ideas, and perspectives to these fields and to increase the likelihood that the United States will remain competitive in technological development well into the next century” (Schaefers et al., 1997, p. 173). If our nation does not draw on the entire talent pool that is capable of making a contribution to science, math, and engineering, the enterprise will inevitably be underperforming its potential (Hennessey et al., 2005). “The nation cannot afford to lose ground in these areas, which not only fuel the economy, but also play a key role in solving critical societal problems in human health and the environment” (Hennessey et al., 2005, p. 1). Thus, there has been a growing concern for the retention of women and minorities over the past several years due to the influx in the job market and financial equity (Brainard & Carlin, 1998; U.S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education, 2009). Women will continue to be denied economic and social power if they do not have access to decision making positions in technology (Brainard & Carlin, 1998). A lack of technical education and experience despite the growing technical workforce will be detrimental to our increasingly technology-oriented society (Brainard & Carlin, 1998; Hennessey et al., 2005; NSF, 1995).

Fewer researchers have investigated the causes of the disproportionate loss of woman in EM majors during undergraduate years compared to the precollege experience

(Seymour, 1995b). Also, research on the reasons some women do succeed and graduate in EM has been limited. This attention to the early years of education has affected research on the later patterns in graduate school and employment (Kohlstedt, 2004). The federal departments for education and for labor and women's organizations are no longer compiling and publishing statistical data on women in EM as they had been earlier (Kohlstedt, 2004). According to Kohlstedt, "we have now less authoritative and comparative data on women at advanced levels of education and working in academe than we had three decades ago" (p. 17). Some of the best data are provided by the National Science Foundation. This may be accredited to micro-biologist Rita R. Colwell, who heads the foundation, and key long-standing staff members attending to these issues (Kohlstedt, 2004). In October 2002, U.S. Senator Ron Wyden, chair of the Science, Technology, and Space subcommittee in the Senate, held hearings to review what had happened to advance women in mathematics, science, and technology in the thirty years since Title IX (which forbids sex discrimination at educational institutions that receive federal funds) had been passed. The Department of Education's representative, W. Todd Jones, publicized good news and presented data with increasing numbers. However, the women who testified were less complacent, and under further questioning, Mr. Jones admitted that no recent compliance studies had been done.

> The women then pressed various issues, pointing out the declining numbers of women in computer science, family issues still confronting women, and the failure of universities to follow through on earlier ambitious plans for diversity. They once again urged the Department of Education to hold universities

> accountable for lack of progress in making resources available to women-and made sure that gender issues were put on the table. (Kohlstedt, 2004, p. 20).

More data are needed to understand what has happened and is happening among women in EM.

The research on women and sciences has looked at large homogeneous samples, typically based on the experience of white women (Boli, Allen, & Payne 1985; Brainard & Carlin, 1998; Muller & Pavone, 1997; O'Brien & Crandall, 2003; Schaefers et al., 1997; Steele, James, & Barnett, 2002; Ware et al., 1985). The literature to date has not explored how progress toward EM degree completion varies by race and ethnic group. This is primarily due to the fact that samples have been too small for a meaningful analysis (Schaefers et al., 1997, p. 173). Thus, there is a gap in the literature concerning race and ethnicity in regards to persistence among women EM majors. Data on women in engineering and math by race and ethnicity may be crucial to capture factors associated with persistence and factors contributing to underrepresentation. The data may help develop effective policy, practice, and programs to increase the participation of women in EM majors. More research is needed to understand factors associated with persistence of women, by race and ethnicity, in completing EM degrees.

Purpose of the Study

The purpose of this study is to identify which factors encourage the persistence of undergraduate women majoring in Engineering and Math (EM) at Florida Atlantic University, University of Central Florida, and University of South Florida. These factors relate to a host of social, psychological, and student engagement factors, as well as factors related to their academic preparation and achievement. By identifying key factors that appear to facilitate persistence of women in EM, this study informs a larger issue about strengthening the U. S. workforce to better compete in a global economy. This study will contribute to the literature in a unique way by exploring whether these variables may vary by race and ethnicity.

Research Questions

This study is guided by three research questions:

1) What factors best explain persistence among women EM majors?
2) What is the relationship between race and ethnicity and factors that explain persistence among women EM majors?
3) What type of interventions do women in EM majors believe will enable more women to be successful in the pursuit of an EM major?

Significance of the Study

The demand for science and technology labor is the greatest, but the sciences' labor is in a shortage, causing an economic dilemma (Clausing, 1999). One of the problems to this issue is that too many talented women are switching out of the EM career pipeline. Thus, more information must be known about the conditions that favor persistence in order to (1) stimulate the retention of more talented females with an interest in an EM career, (2) attend to the problem of college EM attrition, and (3) equalize gender representation of the workforce. "The disparity between the number of male and female SME graduates needs to be eradicated to create balance and equality in science-related fields not only for financial benefits to women, but also for the benefits of a female perspective and influence in science research and teaching" (Hyde, 1997, p. 5). By conducting research on women in EM majors at Florida Atlantic University, University of Central Florida and University of South Florida, it may offer insight into the factors that motivated women to persist in an EM field.

Conceptual Framework: Factors that Influence Persistence of Undergraduate Women in EM

A review of literature from studies conducted in the last 40 years suggests that there are a few categories of variables that explain persistence behaviors of women in the EM disciplines. The primary categories that are given to explain this phenomenon include: social factors, psychological factors, student engagement in college, and academic preparation and achievement.

As the forthcoming discussion will show, research on this issue has not considered or studied race and ethnicity. However, these factors in the literature will be examined to understand the impact of race and ethnicity later in this study. For purposes of parsimony, the study has four categories of factors that explain persistence of women majoring in EM disciplines: social, psychological, student engagement in college, academic achievement. See Table 1 for a model representation of the conceptual framework.

Table 1.
Factors Associated with Persistence of EM Women

Factors: Variable Families	Independent Variables to test
Social	<u>Support And Encouragement :</u> (Brainard & Carlin,1998; Cabrera, Nora, Terenzini, Pascarella, & Hagedorn, 1999; Hennessey et al., 2005; Kuh, 2003; Pascarella & Terenzini, 1980, 1983; Schaefers et al., 1997; Ware et al., 1985) ❖ Parental Influence (Cabrera et al., 1999; Ehrhart & Sandler, 1987; Grandy 1998; Gruca, Ethington, & Pascarella, 1988; Huang, Taddese, & Walter, 2000; Maple & Stage, 1991;Trusty, Robinson, Plata, & Ng, 2000; Ware et al., 1985; Xianglei & Thomas, 2009) ❖ Faculty (Ehrhart & Sandler, 1987; Hennessey et al., 2005; Kuh, 2003; Pascarella & Terenzini, 1980, 1991; Seymour & Hewitt, 1997) ❖ Peer-Group (Ehrhart & Sandler, 1987; Pascarella, & Terenzini, 1980, 1983) ❖ Non-College Group (Frieze & Hanusa, 1984; Lips, 1992; Mercer, 1989 ; Seymour & Hewitt, 1997) ❖ Performance Pressure (Ehrhart & Sandler, 1987; Epstein, 1970; Ware et al., 1985) ❖ Discrimination And Stereotype Threat (Ehrhart & Sandler, 1987; O'Brien & Crandall, 2003; Sekaquaptewa &Thompson, 2003; Sonnert, 1998 ; Steele et al., 2002) ❖ Female Instructors (Boli et al., 1985)
Psychological	<u>Motivation:</u> ❖ Positive Interaction With Others (Brainard & Carlin, 1998; Muller & Pavone, 1997; Ware et al., 1985) ❖ Strong Desire For Control, Prestige, And Influence (a need for power) (Ware et al., 1985) ❖ Interest In Coursework (Brainard & Carlin, 1998; Muller & Pavone, 1997) ❖ Feeling Involved And Not Isolated (Brainard & Carlin, 1998; Muller & Pavone, 1997) ❖ Being Able To Work Independently (Brainard & Carlin, 1998)

Table 1.
Factors Associated with Persistence of EM Women (continued)

Factors: Variable Families	Independent Variables to test
Psychological	<u>Motivation:</u> ❖ Enjoying SME Courses (Brainard & Carlin, 1998; Ware et al., 1985) <u>Self-Confidence:</u> (Boli et al., 1985; Brainard & Carlin, 1998; Ehrhart & Sandler, 1987; Muller & Pavone, 1997; Schaefers et al., 1997; Sax, 1994; Seymour & Hewitt, 1997; Ware et al., 1985)
Student Engagement in College	<u>Student Engagement in College:</u> ❖ Institution Type (Adelman 1998; Astin, 1977; Leggon, 2006; Pascarella & Terenzini, 1991; Sax, 2001) ❖ Financial Support (Brainard & Carlin, 1998; Edmonds, 2009; Huang et al.,2000; Muller & Pavone, 1997; Paulsen & St. John, 1997) ❖ Educational Programs Or Practices (Brainard & Carlin, 1998; Campbell & Skoog, 2004; Huang et al., 2000; Kuh, 2003; Muller & Pavone, 1997; Pascarella & Terenzini, 1991; Zhao & Kuh, 2004)
Academic Achievement	<u>Academic Achievement:</u> ❖ Grades/ Scores (Brainard & Carlin, 1998; Ehrhart & Sandler, 1987; Pascarella & Terinzini, 1991; Sax, 2001; Xianglei & Thomas, 2009) ❖ SAT (Boli et al., 1985; Goldman & Hewitt, 1976; Maple & Stage, 1991; Sax, 1994; Ware et al., 1985; Xianglei & Thomas, 2009) ❖ Academic Preparation (Adelman, 1998; Adelman, Daniel, Berkovits, & Owings, 2003; Cabrera et al.,1999; Edmonds, 2009; Horn, Kojaku, & Carroll, 2001; Rayman & Brett, 1995; Sax, 1994; Xianglei & Thomas, 2009). ❖ Mathematical Achievement (Babco, 2003; Boli et al., 1985; Cabrera et al., 1999; Ehrhart & Sandler, 1987) ❖ Excellent Instruction (Brainard & Carlin, 1998; Ehrhart & Sandler, 1987) ❖ Ability (Boli et al., 1985; Huang et al., 2000; Schaefers et al., 1997)
Race and Ethnicity	<u>Race and Ethnicity</u>

The social factors associated with persistence relate to parental influence, external support and encouragement, performance pressure, same sex high school mathematics teachers, discrimination, and stereotype threat. For the psychological factor, there are significant predictors of persistence for women in EM major such as a desire for positive interaction with others, a strong desire for control, prestige, and influence (a need for power), interest in coursework, feeling involved and not isolated, self-confidence, being able to work independently, and enjoying a math, science, or engineering course more than other courses during freshman year (Brainard & Carlin, 1998; Ehrhart & Sandler, 1987; Muller & Pavone, 1997; Ware et al., 1985). The third factor, student engagement in college, primarily seems to help women majoring in EM to continue beyond their first year in college. Outlets for student engagement, including working during the school year, financial support, direct recruitment efforts, and career opportunities, emerged as a factor in persistence (Brainard & Carlin, 1998; Ehrhart & Sandler, 1987; Muller & Pavone, 1997). The last factor is academic achievement. The predictors of persistence are having high grades, having outstanding mathematics scores on the SAT, having mathematical achievement, and having excellent instruction can encourage women in EM to continue in their field and perform well (Boli et al., 1985; Brainard & Carlin, 1998; Ehrhart & Sandler, 1987).

Methodology

Qualitative and quantitative approaches would be utilized to address the research questions. The study would analyze undergraduate women majoring in EM at Florida Atlantic University (FAU), University of Central Florida (UCF), and University of South

Florida (USF). Data concerning persistence among women EM would be collected from Banner, the Office of Institutional Effectiveness & Analysis at FAU, the Office of Institutional Research at UCF, the Office of the Registrar at USF, and surveys. Surveys would include open ended questions, multiple choice, and items where students rate experience on a Likert type scale. The surveys would be mailed electronically to all female students who met the following criteria: (a) entered university directly from high school or transferred into the university with an AA degree or transfer without an AA degree, (b) declared first major in mathematics or engineering, and (c) were enrolled in the university as senior standing students at the time of the study. A reminder email was sent within two weeks. The study attempted to uncover factors relating to the participants' experience that impacted their decision to persist.

Definition of Terms

EM: For the purpose of this study, it means engineering and math.

Attrition: A woman EM major who intended to pursue her degree and some point during her college career changed to a non-EM major.

Persistence: Women in EM fields who remain in EM majors.

Completer: A woman EM major who has completed a required course of study for an advanced degree in a science, math, or engineering program.

Race: For the purpose of this study, it is measured by six categories: American Indian or Alaska Native; Asian; Black or African American; Native Hawaiian or Other Pacific Islander; White; Some Other Race (U.S. Census Bureau, 2008).

Ethnicity: For the purpose of this study, it measured by two categories: Hispanic or Latino and Not Hispanic or Latino (U. S. Census Bureau, 2008).

Diversity: For the purpose of this study, it is pluralism or multiculturalism. (Levine, 2001).

Limitations and Delimitations

The study is delimited to women students in EM fields who enroll in the bachelors degree programs at Florida Atlantic University, University of Central Florida, or University of South Florida. The findings of this study may not be generalized to other universities in the state of Florida or other parts of the nation. The data are limited to information available through the Office of Institutional Effectiveness & Analysis at FAU, the Office of Institutional Research at UCF, and the Office of the Registrar at USF. Additional data will be collected through the use of a survey; therefore, the sample is limited to those women students who voluntarily agree to participate in the study and who complete the survey instrument. The survey instrument will be administered exclusively among women EM majors in FAU, UCF, and USF and will not be administered to men in EM majors or women that did not declared their first major in EM. Hence, comparisons among women EM majors and men EM majors or women EM majors and women that declared their first major in non-EM majors cannot be made or made with caution.

The survey may limit the results of this study. The analysis can be colored by the researcher's own experiences in the EM career pathway. The quality of the information will be limited by the respondents' recollections and opinions. The study may be irrelevant if each participant is untruthful and unforthcoming to the best of her ability about their experience related to EM fields. However, "a good deal of evidence shows that students are accurate, credible reporters of their activities and how much they have benefited from their college experience, provided that items are clearly worded and students have the information required to accurately answer the questions" (Kuh, 2001, p.4).

Summary

In the global economy, there is a demand for science and technology. Yet, the demand for EM graduates is growing at a time when fewer students are enrolling in EM majors (Khoon, Yatim, Abd-Shukor, Muda, & Aziz, 1997). At each stage of EM career pathway, talented women continue to withdraw; therefore, few women earn degrees in engineering and math programs (Chronicle, 1999; Commission on the Advancement of Women and Minorities in Science, 2000; NSF, 1999; Seymour & Hewitt, 1997). "The underrepresentation of women sends the wrong message to all students: that women do not or cannot belong to the academic science, math, and engineering community" (Leggon, 2006, p. 330). Thus, understanding the variables that are important to women in their pursuit of an EM profession is critical to the continued health of the EM professions. "This persistent and growing shortage of science and technology professionals demands that higher education, government, and business be informed concerning the conditions that encourage the persistence of potential talent in SME career pathways" (Kondrick, 2002, p. 21). Thus, the ultimate goal of this study was to increase awareness and understanding of critical factors that can encourage the persistence of women in the pursuit of EM career goals.

CHAPTER 2

Literature Review

This review of the literature presents an historical perspective of women's education in mathematics and engineering in the United States. The main focus of the literature investigated the factors that encourage persistence among women in mathematics and engineering majors. A review of related dissertations, studies, and reports are examined to determine the factors that best explain persistence of women in engineering and math (EM- the second half of STEM) majors.

History

"Historical participation by women in science and technology has been persistent but with inconsistent patterns because of the social, economic, and intellectual obstacles that have stood in their way" (Kohlstedt, 2004, p. 1). In the first half of the 20th century, women with advanced degrees were predominantly found on the campuses of women's college. They began to take positions at coeducational land grant schools, a few major university, and state colleges. The first half of this era expanded opportunities and new areas of scientific inquiry for women. However, engineering schools were remarkably resistant to women in the early decades of the 20th century (Bix, 2004; Kohlstedt, 2004). Women studying or working in engineering were popularly perceived as oddities, outcasts, and defying traditional gender norms (Bix, 2004). "Success for women in science came from personal perseverance and creative work (characteristics that were fundamental to surviving)" (Kohlstedt, 2004, p. 7). During the 1920s, many women with advanced degrees failed to get jobs; therefore, it limited their prospects for upward mobility. In the post-war 1950s, women pursuing science, math, and engineering careers were constrained by the expectation that they would stay at home and that children were their highest priority (Kohlstedt, 2004). As late as the 1960s, women still made up less than one percent of students studying engineering, and critics either dismissed or ridiculed women's interest in the profession (Bix, 2004).

> In many ways the issues for women in science reflected the concerns of the earlier activist generations: access and encouragement for girls and women in science, attention to opportunities for those who persisted in such studies, the patterns of discrimination that limited their opportunities, and recognition of those who demonstrated what women could accomplish (Kohlstedt, 2004, p. 14).

However, it was clear that they were positioned better than they had been earlier and that the arguments being formulated for equality were more adamant. Throughout the last half of the 20th century, activists fought to win acknowledgement of women's ability to become good engineers (Bix, 2004). Female engineers created systems of social, psychological, and financial mutual support to improve the climate for women (Bix, 2004). In the 1970s and 1980s, the number of women getting an engineering education increased dramatically. Between 1970 and 1999, women had become a larger percentage of graduate students in all categories. "However, old patterns persisted, with women gaining well above 50 percent of graduate degrees in psychology and behavioral sciences, reaching 50 percent in biological and social sciences, but still under 30 percent overall, and well below that in engineering and the physical sciences" (Kohlstedt, 2004, p. 15). In the last two decades of the 20th century, academic employment was increasing for women, but women continued to be clustered in lower ranks or even outside ranks of tenure in positions as instructors, lecturers, and adjunct faculty. Only a relatively few women become full professors (Kohlstedt, 2004). In the 1990s, women did not make substantial headway, especially in mathematics, in computer science, and in the *hot* fields of that decade (Kohlstedt, 2004). History has shown that given the opportunities women do go into science and technology and that gender equity still has a long way to go in science and technology. "The early 20th century strategies were relatively effective, but their inability to bring sustained change indicates that we must pursue more fine-tuned approaches and build strong infrastructures that can better withstand political and cultural backlash" (Kohlstedt, 2004, p. 18).

In order to recruit and retain more women in traditionally male programs, it is important to know who currently chooses these fields and what characteristics of these students can be identified as predictors in the choice of nontraditional study (Ehrhart & Sandler, 1987). In the last 40 years, a review of literature from studies conducted suggests that there are a few categories of variables that explain persistence behaviors of women in the EM disciplines. The primary categories that are given to explain this phenomenon include: social factors, psychological factors, student engagement in college, and academic preparation and achievement. For purposes of parsimony, the study has four categories of factors that predict persistence of women majoring in EM disciplines: social, psychological, student engagement in college, academic achievement.

Social

Research suggests that social influences associated with persistence relate to parental influence, external support and encouragement, performance pressure, same sex high school mathematics teachers, discrimination, and stereotype threat. In women, the social factors that significantly predicted a decision to major and persist in SME were having a positive influence or support of faculty, TAs, mentors, peers, advisors, and parents, having approachable faculty, having positive influence of math and science classes, gaining acceptance into a department, attending student societies, conferences, and events, and having highly educated parents (Brainard & Carlin, 1998; Cabrera et al., 1999; Hennessey et al., 2005; Huang et al., 2000; Schaefers et al., 1997; Ware et al., 1985).

Parental Influence

"Parental encouragement and support facilitated the transition into the academic and social realms of the institution, enhanced commitments to both the goal of college completion and to the institutions, and increased the likelihood to persist in college" (Cabrera et al., 1999, p. 147). According to Ware et al. (1985), parents who have reached high levels of academic achievement themselves are more likely to instill in their sons and their daughters the notion that such accomplishments are possible, desirable, and even expected. The researchers tested a path analytic model that was designed to test the relative effects of a variety of different types of factors on concentration choice by multiple regression analysis. They conducted a study in the summer of 1979 of 300 freshmen (150 male and 150 females) who indicated an interest in majoring in science on their college applications. These students completed questionnaires once each year during college, three-quarters of the sample also completed the Thematic Apperception Test (TAT) in the fall of their freshman year, and subsample of 20 women and 20 men participated in yearly interviews. Their study suggested that "woman, more than men, may need this encouragement in order to sustain their involvement in subject areas that traditionally have been considered male domains" (Ware et al., 1985, p. 77). Ware et al. (1985) concluded that highly educated parents are most likely to have less conventional ideas about what constitutes appropriate behavior for women and will consequently be more willing to encourage their daughters in nontraditional pursuits (Ware et al., 1985).

Ehrhart and Sandler (1987) found that there is a higher probability for female science majors to have working mothers at relatively prestigious occupations. Trusty et al. (2000) reported a stronger association between socioeconomic status and major for women. Higher socioeconomic status and higher education level of the parents have been linked to females choosing nontraditional majors and careers (Gruca, et al., 1988; Trusty et al., 2000; Ware et al., 1985; Xianglei & Thomas, 2009). In 1999, Cabrera et al. examined the role that perceptions of prejudice and discrimination play within the adjustment to college processes of African American and White studies. Their sample was selected from incoming first-year students at 18 four year colleges and universities that participated in the National Study of Student Learning, and the study was a large longitude investigation of the factors influencing student learning and personal development in college (Cabrera et al., 1999).   They discovered that minority students are more likely to drop out of school due to social factors concerning family responsibilities and working off-campus. Further, the influence of parental education has been found to differ across race and ethnicity. Some studies have found father's level of education to be influential for women whereas mother's level of education has been found to be influential for African Americans (Gruca et al., 1988; Maple & Stage, 1991; Ware et al., 1985). Yet, Grandy (1998) found that for high ability minority students, level of parental education was not significant in their success in science and engineering. According to Haung et al. (2000), financial support from parents was a significant predictor of degree completion for both women and underrepresented minorities in science and engineering. Their study examined the gaps related to gender, race and ethnicity in entrance, persistence, and attainment of postsecondary science and engineering education by selecting several variables in two NCES surveys and creating a multivariate model for use in two empirical analyses.

Faculty

According to Pascarella and Terenzini, "social integration is primarily a function of the quality of peer-group interactions and the quality of student interactions with faculty" (1980, p. 62). Their study was longitudinal and conducted at Syracuse University. A questionnaire was sent to a random sample of incoming freshmen enrollment of 1, 905 in order to assess their expectations of a variety of aspects of the college experience. Then, a second questionnaire was mailed during the spring semester to seek information on the reality of their college experience. There were 773 usable responses from freshmen. Their study suggested that the quality and impact of student-faculty relationship, student-faculty informal contacts, and faculty concern for student development may be as important to students' institutional integration and, thereby, their likelihood of persisting in college. These interactions may also enhance academic integration, which is determined primarily by the student's academic performance and his or her level of intellectual development (Hennessey et al., 2005; Kuh, 2003; Pascarella & Terenzini, 1980, 1991).

In traditionally male fields, faculty, administrators, and staff are more likely to be unused to or uncomfortable with women students than is the case in other fields. Faculty may treat women very differently than men in class, in advising and mentoring situations for a variety of reasons and may be unaware that they are doing so. Traditional EM culture values masculine qualities, and women have had to assimilate or leave their chosen EM field (Barber, 1995). Faculty can alter the culture and the climate to enhance student involvement and learning by creating an environment where interactions are frequent and friendly (Pascarella & Terenzini, 1991).

Seymour and Hewitt's (1997) study grew out of a three year and seven campus study aimed at explaining the national loss of 40 to 60 percent of undergraduates from science, mathematics and engineering majors into nonscience disciplines. They conducted extensive interviews with undergraduates to be able to offer explanations for the loss of able students, including students of color and women. Their study supports the conclusion that the classroom climate and activities are critical influences on student persistence in EM majors. In their report, the main factors for leaving EM are poor teaching and inadequate advising or help with problems.

Ehrhart and Sandler (1987) discussed reasons why more women are not studying and completing degrees in traditionally male fields. Their sources of information include; empirical studies of students at all educational levels, campus reports and surveys, interviews with college personnel and faculty involved in programs to attract and retain women in traditionally male fields, and responses to a call for information issued by the Project on the Status and Education of Women. In the their paper, they discussed a study of engineering students that found that both men and women perceive male engineering faculty members as rating men students as superior in terms of intelligence and having natural aptitude for engineering. As for female engineering faculty members, the students perceived the professor' ratings to more fair and related to ability rather than the sex of students (Ehrhart & Sandler, 1987). "Behaviors and attitudes that express different expectations for women or single out or ignore them because of their sex put women students at a severe educational disadvantage" (Ehrhart & Sandler, 1987, p.6). Some behaviors and attitudes that can affect women in EM fields are the following: belittling women's intellectual abilities, focusing on appearance as opposed to performance, discouraging classroom participation, causing students to drop or to switch majors, undermining self-confidence, using sexist humor, advising to lower their academic and career goals, giving women less time and attention than men in advising and in group work, not actively encouraging or nominating women to apply for scholarships, fellowships, awards, or graduate schools, creating an uncomfortable office environment, and so on (Ehrhart & Sandler, 1987). Hence, faculty's and administrators' attitudes toward women in EM majors are critical for women's success. "Faculty are not only advisors and mentors but also the gatekeepers who open doors for those entering the professions" (Ehrhart & Sandler, 1987). Those women in EM fields that express the greatest satisfaction are those who do well academically and find themselves surrounded by people who offer support, including teachers whom they perceive rate men and women equally for potential success and treat them accordingly (Ehrhart & Sandler, 1987).

Peer-Group

A majority of the studies addressing peer-group has been conducted in the 1980s. Positive interaction with male peers, whether in class, labs, study groups, residence halls, formal extracurricular activities, or purely social settings, helps women students in traditionally male fields to feel accepted as intellectual equals and colleagues (Ehrhart & Sandler, 1987). "Unfortunately, women are often not take seriously by male peers and are often treated more as potential dates and/or as objects of sexist humor" (Ehrhart & Sandler, 1987, p. 10). For example, a woman student reported that when an experiment failed her lab partners wrote her name on the lab report on the reason for error line as a joke (Ehrhart & Sandler, 1987). Male students may exclude women from informal study groups or interchanges, or may deny access to lab equipment, computers, so on, or may become hostile toward women's efforts to improve (Ehrhart & Sandler, 1987). Women may react by leading to wariness toward male students and by being reluctant to join in conversations or ask for help (Ehrhart & Sandler, 1987). "However, at the same time, many men reacted positively and felt that attempts to address climate issues for women were legitimate and important steps toward improving the environment for women and men” (Ehrhart & Sandler, 1987, p.11). According to Pascarella and Terenzini (1980), the quality of peer-group interactions may have been a more important factor in females’ decisions to persist or withdraw than in males. Hence, social integration appears to have a somewhat stronger direct influence than did academic integration for females. Individuals are more likely to persist when they are either academically or socially integrated; therefore, they see those interactions as positive and themselves as integrated into the institution. Usually, students with low levels of social integration have high levels of academic integration, and vice versa. When both forms of integration occur, they are even more likely to persist since academic integration directly influenced goal commitment and social integration directly influenced institutional commitment (Pascarella & Terenzini, 1983).

Non-College Groups

Groups such as significant others, employers, and community can influence one’s educational path. Societal expectations of women force them to balance competing and conflicting demands between family and career (Frieze & Hanusa, 1984; Lips, 1992; Seymour & Hewitt, 1997). Mercer’s (1989) study compared single, married, and divorced female students. Marital status and persistence were used by Mercer to group 363 female undergraduates, 25 and older, who responded to the study survey. He found that married students take longer to achieve their goals, and experience more stress due to role conflict, but were happier and had higher self-efficacy than unmarried women. According to Seymour and Hewitt (1997), there seems to be a perception that balancing family and career in science, math, and engineering is more difficult than that of other fields.

Performance Pressure

Women in a traditionally male territory can be subject to particular performance pressure. "They are likely to feel that they must do better than their male counterparts in order to be considered equal; that they must demonstrate their worthiness through superior competence before being accepted or taken seriously; and that their mistakes or inadequacies risk being construed as characteristic of woman in general" (Ware et al., 1985, p. 79). The strain of constantly striving to maintain a superior level of performance may result in exhaustion, discouragement, and the decision to pursue a different course of study for those women whose abilities are less than outstanding (Ehrhart & Sandler, 1987; Ware et al., 1985). Ware et al. (1985) were able to gain information concerning women interested in majoring in science by yearly questionnaires of 300 students and yearly interviews of 20 women and 20 men to explore aspects of concentration choice, career plans, and academic experience.

Discrimination and Stereotype Threat

Steele et al. (2002) studied a sample of undergraduate students consisting of 477 first year students and 324 final year students from a private university in the northeastern United States. The students completed a questionnaire and were allowed to omit any questions. The study focused on self reported current and future sex discrimination, stereotype threat, identification with their major (Steele et al., 2002). Female undergraduates majoring in math, science, and engineering reported higher levels of discrimination and stereotype threat than woman in a female –dominated academic areas such as arts, education, humanities, or social sciences, and men in SME or female dominated academic area (O'Brien & Crandall, 2003; Steele et al., 2002). Therefore, this can cause women in SME to lose confidence in their ability to succeed and may cause them choose to pursue another area, such as social science. "Women in math, science, or engineering may become disidentified with their academic area, defined as, a re-conceptualization of the self and of one's value so as to remove the domain as a self-identity, as a basis of self-evaluation" (Steele et al., 2002, pg 47).

Steele et al. (2002) presented a study that examines the experiences of undergraduate woman in male-dominated academic areas, such as math, science, or engineering. Their research yielded four of findings. First, women in SME were most likely to report that they were currently being discriminated against because of their sex if they were to pursue a career in a related area in the future. Second, they were mostly likely to report feeling threatened by negative gender stereotypes in their major. Third, they were not any less identified with their specific field of study than were the other students. Lastly, they were mostly likely to report thinking about changing their area. Overall, the study reported that undergraduate women in SME perceived higher levels of sex discrimination directed at themselves personally, and toward women in general, in their major than any other students. Even though the study's results suggested a continuation inequalities for woman entering into SME majors, it is reassuring that the last few decades more woman have been entering and completing university degrees in math, science, and engineering (Sonnert, 1998).

“Women are often treated not on the basis of their individual characteristics but according to stereotypes about women’s appropriate roles and behavior” (Ehrhart & Sandler, 1987, p.9). For example, there is a story that helps demonstrate this issue.

> A man and his son were riding a motorcycle and got into a serious accident. They were both unconscious and rushed to the hospital. It was established that the son needed surgery immediately. He was wheeled into the operating room when the surgeon walks in and says: “I cannot operate on this patient for he is my son.” How is this possible? (Ehrhart & Sandler, 1987, p.9)

If one tells this story, most people would assume that the surgeon is the father and would have a hard time comprehending how this is possible. By assuming the surgeon is the father, it is a form of stereotyping by appropriate roles and behavior. This story helps demonstrate that women are still being stereotyped in today’s society.

Stereotype threat research suggests that the situation matters. O’Brien and Crandall (2003) conducted a study with 164 participants (59 women and 105 men) who were enrolled in an introductory psychology class in which women were put in conditions of stereotype threat by telling the participants that a math test they are about to take is known to have gender differences. Alternatively, women were put in conditions that attenuated stereotype threat by telling the participants that the math test has no gender differences and then presented them both difficult and easy math problems. The study reported that women under stereotype threat performed better on easy math test and worse on a difficult math test than women who were not exposed to stereotype threat; therefore, it affected women’s performance (O’Brien & Crandall, 2003). For the men’s performance, they were unaffected by the manipulation. Thus, men and women may take the same tests in the same environment but not under the same condition (O'Brien & Crandall, 2003).

In order to develop understanding of the experience of women working in fields traditionally dominated by men, Sekaquaptewa and Thompson (2003) studied the dual effects of solo status and stereotype threat on women's performance. According to Sekaquaptewa and Thompson (2003), they defined "solo status as being the only member of one's race or gender present in a group, and stereotype threat as a situation wherein one's performance might be seen as confirming a negative stereotype" (p. 68). A total of 157 White introductory psychology students (77 male and 80 females) participated in the study. The participants were given math information and were allowed seven minutes to read it. The information was described as being traditional math material or a type of math information impervious to gender stereotypes. Then the participants were tested on the material in an opposite gender or same gender group. The study concluded that women performed more poorly in solo status than nonsolos and under stereotype threat than no threat. Sekaquaptewa and Thompson (2003) claimed that experiencing both factors was more detrimental to women's performance than experiencing one or the other. As for the men's performance, it was the same across all conditions. Hence, both solo status and stereotype threat negatively influenced the performance of women but not men. "The finding that these two factors build on one another to impair performance beyond the influence of each factor alone may help explain why women are underrepresented at the highest levels of male dominated fields" (Sekaquaptewa &

Thompson, 2003, p. 74).   This generation of research promoted the belief that if the barriers were removed or lowered then the number of women participating and achieving in science would increase (Xie & Shauman, 2003).

According to Ehrhart & Sandler (1987), “minority women students –American Indians, Asian-Americans, Blacks, and Hispanics-often face “double discrimination”: once because of their sex and once because of their race”. Whites can be uncomfortable dealing with minority women and act bias. Hence, white women sometimes can exclude minority women from informal and social interaction (Ehrhart & Sandler, 1987). Some academic advisers and faculty may stereotype and underestimate the competence of minority women and thus counsel them to lower their sights or misdirect them (Ehrhart & Sandler, 1987). Minority women students often feel more comfortable with minority faculty. “Given the lack of women faculty, or minority faculty of either sex, minority women often feel severely isolated with few or no people available to serve as role models, mentors, or peers” (Ehrhart & Sandler, 1987, p. 9). These factors can create an unpleasant environment that can affect their academic and social experiences.

Similarly, older women and disabled women may be experience discrimination. Ehrhart and Sandler (1987) addressed that older women on campus are frequently exacerbated by discrimination based on age. In traditionally male fields, all women, especially older and married women, are concerned that faculty and administrators do not take them seriously, and that faculty may be uncomfortable with students the same age or older than them (Ehrhart & Sandler, 1987). These issues may contribute to older woman students’ being treated differently in consultations with faculty and staff, and excluded from informal interchanges (Ehrhart & Sandler, 1987). As for disabled women, Ehrhart and Sandler (1987) discussed that disabled women face discrimination based on their disability as well as their sex. “They often must cope with even greater social and institutional invisibility” (Ehrhart & Sandler, 1987, p. 9). This happens because peers, faculty, and administrators may not understand disabled women’s actual capabilities and needs, and may be uncomfortable in dealing with these students on a one-to-one basis.

> The paradox of “underattention” and “overattention” experienced by women in general is often heightened in the case of minority, older women, and disabled women. They are still anomalies on campus. On the one hand, their problems and concerns may be ignored; on the other hand, they may be singled out as representatives of their special groups and more closely scrutinized (Ehrhart & Sandler, 1987, p. 9).

Female Instructors

Boli et al. (1985) study was carried out among students in introductory courses in mathematics and chemistry at Stanford University. They gathered information concerning completion of the course, grade earned, and other data collected by means of a questionnaire. The study evaluated that having female instructors in high school mathematics courses as role models improves the performance of women in basic mathematics and science courses. “The presence of a role model of the same sex may help college women feel that success in mathematics and the sciences is both possible and legitimate” (Boli et al., 1985, p. 609). In the study, they discovered that women with female mathematics teachers had somewhat higher SAT mathematics scores; therefore, it is reasonable to believe that the existence female high school mathematics faculty have some effect on SAT scores. “Among high-scoring women, those who had female high school mathematics teachers earned better grades, understood the instructor better, and spent less time studying for the courses than those who did not have female mathematics teachers” (Boli et al., 1985, p. 618). For women of weaker mathematics ability, a female role model made them much more likely to complete the course, but did not lead to better performance. Female mentors appear to have more of an impact on women in EM than male mentors (Seymour & Hewitt, 1997). However, women have fewer opportunities for same-sex mentoring.

Psychological

A desire for positive interaction with others, a strong desire for control, prestige, and influence (a need for power), interest in coursework, feeling involved and not isolated, being able to work independently, and enjoying a math, science, or engineering course more than other courses during freshman year are significant predictors of persistence as an EM major (Brainard & Carlin, 1998; Ehrhart & Sandler, 1987; Muller & Pavone, 1997; Ware et al., 1985). “In one national study, the fact that more men (49 percent) than women (31 percent) found a science course the most enjoyable of their first-year classes partially explains the sex difference in the choice of a science concentration” (Ehrhart & Sandler, 1987, p. 5). Some women choose science concentrations as a first step toward entering a profession that will enable them to realize their goals of servicing others and helping others, a form of positive interaction (Ware et al., 1985).

Self-Confidence

Self-confidence is another psychological factor that can encourage persistence or can be perceived as a barrier, especially during freshman and sophomore years (Boli et al., 1985; Brainard & Carlin, 1998; Muller & Pavone, 1997; Schaefers et al., 1997). Most women in EM fields begin with a very high level of self-confidence in their abilities in math and science, but these levels of self-confidence drop over the course of their first year (Brainard & Carlin, 1998). Students who do maintain a high level of self-confidence in the first year report enjoyment of math and science classes, considering competition to be a motivator, having friends who interested in EM, and a positive influence from male friends, and other students societies, conferences, and events (Brainard & Carlin, 1998). On the other hand, students who lack of confidence in their scientific abilities will be discouraged causing them to leave the program (Muller & Pavone, 1997; Seymour & Hewitt, 1997).

According to Brainard and Carlin (1998), self-confidence levels that begin to increase slightly from the general first year, decrease by the end of the sophomore year. At this point, primary predictors of high self-confidence are positive ratings of teaching quality, interest in coursework, participating in study group, and a positive influence of technical courses, faculty, and mothers (Brainard & Carlin, 1998). The end of junior year reflects high confidence if they have been accepted into a department, they had a positive influence from male friends, an advisor, and mothers. As for the fourth and fifth year, a high level of self-confidence corresponds to participation in student professional societies, interest in coursework, working during the academic year, career opportunities, and a positive influence of science courses, male and female friends, and an advisor (Brainard & Carlin, 1998). Overall, the level of self-confidence never returns to the original high level of entering first year students (Brainard & Carlin, 1998). Academic self-confidence is significantly lower for those who switched during their sophomore or junior years. The same applies for science majors during their junior and senior years, but for math, self-confidence levels remain the same, whether one persists or switches during the later years (Brainard & Carlin, 1998; Sax, 1994). Brainard and Carlin (1998) were able to gather information about self-confidence through female students interested in pursuing degrees in science and engineering at the University of Washington and who responded to Brainard and Carlin's six instruments: the Annual Freshman Interest Survey, Freshman Initial Interview Form, Freshman Follow-up Interview Form, Sophomore Follow–up Questionnaire, Junior Follow-up Questionnaire, and Senior Follow-up Questionnaire.

Many women when faced with doubts about their ability and their commitment lose self-esteem and career confidence even though they may stay in school and earn good grades (Ehrhart & Sandler, 1987). Women's lack of confidence may lead to less participation in class because of fear of being wrong, may lead to less disagreement with their instructors, and may lead to switching to a non-EM major (Ehrhart & Sandler, 1987; Seymour & Hewitt, 1997). According Ware et al.'s (1985) study, evidence of a certain lack of confidence on the part of the women students is found in their responses to a question about why a course was difficult. Men tended to place responsibility for their difficulties outside themselves, while women were more likely to place the blame internally (Ware et al., 1985). Men explained their problems in terms of the inherent nature of the course material or poor performance of instructors. The following is an example of a quotation that illustrates this pattern of response: “It has a disorganized lecturer who was more an entertainer than a teacher” (Ware et al., 1985, p. 79). Women tended more often to cite their own inadequacy as the source of the difficulty. The following is an example of a quotation that illustrates this pattern of response: “It was difficult because I didn’t give it the attention or time I needed to and it was unlike any math I’d had before” (Ware et al., 1985, p. 79). Hence, self-doubt is evident in their explanations for difficulties in coursework (Ehrhart & Sandler, 1987). Overall, high self-confidence and high aspirations for degree attainment are significant in predicting degree completion (Haung et al., 2000).

Student Engagement in College

The primary student engagement factors in college that seemed to help women majoring in EM to continue beyond their first year in college is working during the school year, full-time attendance, financial support, direct recruitment efforts, and career opportunities (Brainar & Carlin, 1998; Edmonds, 2009; Ehrhart & Sandler, 1987; Huang et al., 2000; Muller & Pavone, 1997). Student engagement in college emerged as a factor in persistence.

Institution Type

Students’ success in postsecondary education can be impacted according to the institutional type. Some studies claim that attending a two year institution decreases one’s probability of completing a bachelor’s degree in comparison to those who attend a four year institution (Astin, 1977; Pascarella & Terenzini, 1991). Other reports indicate that Women's College, liberal arts colleges, and historically black colleges have a better record of promoting SME degree attainment than state and research universities due to factors such as selectivity, lower student-faculty ratios, higher student-faculty interactions, and support for those inadequately prepared (Astin, 1977; Leggon, 2006). Most studies suggest that students who major in science, math, and engineering at four year colleges and universities are overwhelmingly persisting and completing their bachelor's degree (Adelman, 1998; Astin, 1977; Sax, 2001).

Financial Support

According to Brainar and Carlin's (1998) study, working during the school year was a persistence factor for female student in math and science class completing their sophomore and junior year. Other persistence factors included during the junior and senior year were the experiences in student societies and at conferences and events. Paulsen and St. John's (1997) research reported that students who chose their colleges so they could work and go to school were more likely than others to persist in a public college or university. Student aid can also help equalize opportunity to persist (Hu & St. John, 2001). Huang et al. (2000) found that financial aid received increased the likelihood of degree completion for a national sample of college students attending four year institutions. However, there are some financial problems affecting student persistence such as increasing cost of higher education, declining student aid, and shifting emphasis to loans rather than grants (Seymour & Hewitt, 1997). Seymour and Hewitt noted that engineering students were more adversely affected by finances than those in other science areas because the time to degree completion was longer. Their study also reported that financial debt affected student's educational outcomes by forcing many to delay graduate school in order to pay off student loans.

Educational Programs or Practices

Institutions often design special programs to promote the academic of students. According to Pascarella and Terizini (1991), college intervention programs have a statistically significant positive effect on grades and persistence. Brainard and Carlin (1998) discovered that involvement in the Women in Engineering (WIE) Initiative Big Sister Program at the University of Washington was a primary predictor of persistence for seniors. In 1990, Muller and Pavone developed the Women in Science Project at Dartmouth to increases the numbers of undergraduate women graduating with majors in SME. The paid program offered the opportunity to work in scientific research during the first year and peer mentoring. "Students affiliated with the Project are more likely to declare a major in the sciences and the total number and percentage of women declaring majors in science and engineering increased from a low of 12 percent in 1990 to projected 24 percent for the class graduating in June 1997" (Muller & Pavone, 132, 1997). Student engagement in college has contributed to the persistence of women majoring in EM.

In 1992, the Texas Tech University/ Howard Hughes Medical Institute (TITU/HHMI) Undergraduate Biological Sciences Education program was formed to increase participation by women and minorities in the sciences by involving undergraduate students in research laboratories and experiences. Campbell and Skoog

(2004) studied the TTU/HHMI program by analyzing data from questionnaires returned by 57 past female fellows and interview transcripts of seven of the fellows who were completing Ph. D. programs in science. "The data indicate that increased skills, confidence, and motivation to seek a science career resulted from research experiences, relationships with mentors, and opportunities to present research papers at state and national meetings" (Campbell & Skoog, 2004, p. 24). This study supports the premise that undergraduate programs that provide undergraduate women experiences in research laboratories, mentoring, and support have the potential to increase the number pursuing and continuing science careers. Also, their study supports the following assertions that "undergraduate research programs can markedly change the face of undergraduate science education because they provide students with experiences that cannot be duplicated in the classroom and that research opportunities immerse students in real science and allow them to develop relationships with experienced scientists" (Campbell & Skoog, 2004, p. 24). Thus, these student engagements may dramatically influence students' educational and social development, and may promote the success and increased representation of women in science (Campbell & Skoog, 2004).

In 2004, Zhao and Kuh randomly sampled 80,479 selected first year student and senior students from 365 four year colleges and university who completed the National Survey of Student Engagement (NSSE) in the spring 2002. The NSSE instrument measures the degree to which students participate in educational practices. Zhao and Kuh (2004) explored the relationships between learning communities and student academic performance and indicated that participation in some form of learning community is positively related to student success, which includes enhancement in academic performance, integration of academic and social experiences, positive perceptions of the college environment, and self-reported gains since starting college. "Student engagement in educationally purposeful activities inside and outside of the classroom is a precursor to high levels of student learning and personal development as well as an indicator of educational effectiveness" (Zhao & Kuh, 2004, p. 115). Thus, students who are involved in educational engagement in college are developing the mind and heart that enlarge their capacity for continuous learning and personal development (Kuh, 2003). The literature suggests this variable has shown to have less of an effect on persistence than social and psychological factors.

Academic Preparation and Achievement

Academic preparation and achievement constructs have received considerable attention in the past and are considered important influences on women's decision to pursue EM fields.

Grades/ Scores

One of the best predictors of bachelor degree obtainment, graduate school attendance, and advanced degree attainment is grades (Pascarella & Terinzini, 1991). In quantitative subjects, grades have been traditionally used as a predictor of academic success in EM fields, and female performance has typically lagged behind that of males. However, the gender gap in quantitative performance has started to change. According to the 1999 National Assessment of Educational Progress, the report should only a small difference in math and science test scores (Campbell, Hombo, & Mazzeo, 2000). Xie and Shauman

(2003) reported that gender differences in math and science achievement are relatively small.

SAT

In 1976, Goldman and Hewitt reported achieving outstanding mathematics scores on the SAT was a predictor of science concentration. They investigated the relationship between performance on the SAT and choice of a college major, which led them to conclude that mathematical ability, appears to be an important determinant in the choice of a scientific vs. a nonscientific major field (Ware et al., 1985). Thus, women of extraordinary mathematical ability follow through on the scientific interests, but as for men choosing science majors, their ability can vary (Ware et al., 1985). Having high math SAT score, high school grade point average, mathematical achievement, and excellent instruction can encourage women in SME to continue in their field and perform well (Boli et al., 1985; Brainard & Carlin, 1998; Ehrhart & Sandler, 1987; Maple & Stage, 1991; Sax, 1994, 2001; Xianglei & Thomas, 2009). Also, there are other factors prior to taking the SAT that can ultimately impact their ability to score well on the SAT such as parental factors, external support and encouragement factors, self-confidence factors, and etc. which along the way gave them a leg up to score well.

Academic Preparation

According to Cabrera et al. (1999), academic preparedness at the time of high-school graduation is a key factor accounting for difference in persistence behavior rather than socioeconomic backgrounds. In 2001, Horn et al. examined the relationship between high school academic curriculum and persistence of undergraduate three years after entering a four year institution. They found that students who completed a rigorous curriculum that included four years of mathematics (precalculus or higher), three years of science (biology, chemistry, and physics), and at least one advanced placement course showed a significant educational attainment advantage over those who took less rigorous courses. Mathematics preparation has been identified as a strong predictor of degree completion. Hence, math and science preparation has been noted to be important for the success of educational attainment in any field (Adelman, 1998; Adelman et al., 2003; Edmonds, 2009; Rayman & Brett, 1995; Sax, 1994; Xianglei & Thomas, 2009).

The National Assessment of Educational Progress (NAEP) and SAT scores have shown that African Americans, Native Americans, and Hispanics are underserved by the educational system in terms of gaining scientific and quantitative literacy (Babco, 2003). The gap of academic preparedness can explain why minorities' students are considerably less likely to graduate, to major in SME fields or continue in graduate study (Babco, 2003).

Ability

Schaefers et al. (1997) mailed a questionnaire to all female students (236) and a random sample of male students (348) who entered college directly from high school, declared a major in engineering upon enrolling, were enrolled in the university as 3rd, 4th, or 5th year students at the time of the study, and were American citizens or residents. The final sample was comprised of all 278 eligible participants who returned their questionnaires. The research reported that ability contributes significantly to their model of predicting persistence. It was the strongest contribution to the model. Ability was confounded with academic background, motivation, and work habits, especially, for the first semester and cumulative GPAs. "Ability is a well established and important determinant of selection of engineering and of persistence in that major" (Schaefers et al., 1997, p. 180). Those students who do not have mathematical ability will not choose or succeed in EM major unless there is an intervention that targets the specific needs of women in these disciplines (Huang et al., 2000; Schaefers et al., 1997).

Chapter Summary

As early as the 1980s, scholars began trying to understand empirically reasons for attrition and persistence of women in engineering and math. These studies have focused largely on factors related to attrition and persistence of women in EM fields.   According to the literature, social factors, psychological factors, student engagement in college, and academic preparation and achievement are associated with the ability of women to persist in an EM degree.

The persistence of women in engineering and math is an issue of critical importance. Although, women have outnumbered men in undergraduate education for the last two decades, their presence in traditionally male dominated fields of study such as EM is lacking. Additionally, underrepresented minorities in EM majors remain lacking. Such gender disparities in the EM speak to the need for more research on the status and experiences of women and underrepresented minorities in EM majors at four year universities. Thus, development of the entire talent pool in EM is necessary to stay current and competitive with other countries.

CHAPTER 3

Methodology

This study will help to build a profile of women who have persisted in the pursuit of an Engineering or Math (EM- the second half of STEM) major. The purpose of this profile is to discover how these women were able to persist in their major, to discover if race and ethnicity might be crucial to capture factors associated with persistence and factors contributing to underrepresentation, and to discover what they believed to be effective interventions that might enable other women to succeed in the pursuit of an EM major. In this study, quantitative and qualitative approaches were utilized to address the research questions.

Research Questions

This study was guided by three research questions:

1) What factors best explain persistence among women EM majors?
2) What is the relationship between race and ethnicity and factors that explain persistence among women EM majors?
3) What type of interventions do women in EM majors believe will enable more women to be successful in the pursuit of an EM major?

The Three Florida Universities Setting

Since the research on women and sciences has looked at large homogeneous samples, typically based on the experience of white women, this study aimed to explore how progress toward EM degree completion varies by race and ethnic group. Primarily, the sample has been too small for a meaningful analysis in regards to persistence among women EM majors by race and ethnicity. Thus, the study selected to focus on Florida because of its rich traditions of diversity, including language, culture, and ethnicity. The study selected to examine Florida Atlantic University, University of South Florida, and University of Central Florida since these universities are considered to be state university system (SUS) peer institutions. “SUS peer institutions are identified as those most closely related to enrollment, diversity, and population data of a university” (Heydet-Kirsch, 2006). See Table 2 for the three Florida universities common data and Table 3 for the three Florida universities common data by majors. By researching these universities, it might contribute to the literature by evaluating variables that might vary by race and ethnicity.

Florida Atlantic University

Florida Atlantic University (FAU) is a public research university with an average ACT of 23, SAT of 1078, and high school GPA of 3.3 for first time in college students (2010-2011 Fact Book, 2011). FAU has seven campuses located at Boca Raton, Jupiter, Davie, Ft. Lauderdale, Port St. Lucie, Port Pierce, and Dania Beach. At FAU, minority and international students make up almost 45 percent of its student body (2010-2011 Fact Book, 2011). According to U.S. News and World Report, the university ranks 28th nationally out of more than 240 schools studied in student body diversity (Brogan, 2008). The university is also ranked 32nd nationally in the number of bachelor’s degrees conferred upon minorities according to U.S. Department of Education data in Diverse:

Issues in Higher Education (Brogan, 2008). In 2010, the student population at FAU continues to include a more diverse population, increasing from 23 percent Black and Hispanic in 1998 to over 37 percent (2010-2011 Fact Book, 2011). The percentage of female enrollment in Fall 2010 was 58 percent; therefore, it ranked above the median in female enrollment among the Florida State University System (SUS) (Fall Student Enrollment in State University System Institutions, 2011). In 2010, the total undergraduate enrollment was 22,419 with a 57 percent female enrollment and 46 percent minority enrollment that includes Asian, Black, Hispanic and Native American students (Fall Student Enrollment in State University System Institutions, 2011). Student enrollment by ethnicity is 51 percent White, 18 percent Black, 22 percent Hispanics, 5 percent Asian, and less than 1 percent Native American (Fall Student Enrollment in State University System Institutions, 2011). Florida Atlantic University takes pride in the diversity of its student body, as well as in its faculty, and staff.

The College of Engineering & Computer Science at FAU provides clubs and organizations for their students in order to allow them the opportunity to develop leadership skills, to learn more about their chosen field of study, and to meet practicing professionals. As for women in engineering major, the college recommends the Society of Women Engineers (SWE). The SWE is not-for-profit educational and service organization. “SWE empowers women to succeed and advance in those aspirations and be recognized for their life changing contributions and achievements as engineers and leaders” (The Society of Women Engineers, 2008, p. 1). In 2008, FAU’s College of Engineering and Computer Science received a gift of $50,000 from Peter and Kerry

LoBello (King, 2008). With this gift, they have established the LoBello Innovation Leadership Endowed Scholarship Fund at the college. "The fund will support two undergraduate students each year and preference will be given to qualified female students in an effort to address the underrepresentation of woman in the field of engineering" (King, 2008, p. 1). According to King (2008), the College of Engineering and Computer Science Dean Karl Stevens said that the LoBello scholarship will provide opportunities to women who enroll in the Innovation Leadership Honors Program(ILHP), thus fostering diversity in a field in which men are prevalent. The ILHP is a program that provides a combination of new courses, a leadership development workshop series, internships, and special enrichment activities.

In the Ocean Engineering department, women constituted 14 percent of the student enrollment in 2010 (Headcount Enrollment Reports, 2011). The department considers this a significant portion of the student body. The College of Engineering states that 19 percent of the bachelor's degrees were awarded to women, 43 percent to minorities, and 13 percent to foreign nationals, out of 197 baccalaureate degrees granted in 2009-2010 (Degrees Awarded Reports, 2011). Also, the college awarded 23 percent of the 88 master's degrees to women in 2009 to 2010 (Degrees Awarded Reports, 2011). In recent ranking of 50 U.S. /Canadian engineering schools, the College of Engineering ranked 14th in engineering bachelor's degrees awarded to women (Stevens, 2004). As for the Department of Chemistry and Biochemistry, part of the Charles E. Schmidt College of Science, it has been awarded a Support of Continuous Research Excellence (SCORE) grant, totaling $4 million over the next four years from the National Institute of Health

(NIH) Minority Biomedical Research Support program (FAU science researchers get $4M grant, 2005). Former FAU President Frank T. Brogan stated that “the SCORE grant is especially significant as it will afford women and minority faculty and students in the Charles E. Schmidt College of Science support for their research” (FAU science researchers get $4M grant, 2005).

University of South Florida

The University of South Florida (USF) serves more than 36,000 students on campuses in Tampa, St. Petersburg, Sarasota-Manatee and Lakeland; therefore, it is the ninth largest public university in the nation (Fall Student Enrollment in State University System Institutions, 2011). “USF is one of only three Florida public universities classified by the Carnegie Foundation in the top tier of research universities” (Facts 2009-2010, 2010, p. 3). The Carnegie Foundation also classified USF as community engaged, the only one in Florida. In Fall 2010, the new freshman student profile included an average high school GPA of 3.81, and an average SAT score of 1176 (USF System Facts 2010/11, 2011). The undergraduate enrollment contains of 20,705 female and 15,583 male (Fall Student Enrollment in State University System Institutions, 2011). Female account for 60 percent of enrollment; therefore, USF has one of the largest female enrollments in the state just as FAU does (Fall Student Enrollment in State University System Institutions, 2011). As for minority students, the enrollment is 33 percent of the student body with 12 percent Black, 6 percent Asian, less than 1 percent of Native American and 14 percent Hispanic (Fall Student Enrollment in State University System Institutions, 2011). “The University of South Florida ranks number 17 among the

Best 366 Colleges in the nation for diversity according to the Princeton Review's 2008 Guide" (Melendez, 2007, p. 1). In USF, the students appreciate the diverse student body. A student is quoted as saying, "Everyone here is from different walks of life and everyone here is open to it, accepts, and loves it" (Melendez, 2007, p. 1).

The University of South Florida's College of Arts and Science was awarded a grant called the STEP Grant by the National Science Foundation (NSF). The grant funded a project to improve student retention in STEM (science, technology, engineering, mathematics) disciplines by curricular reform and community and leadership building programs (Mathematics and Statistics, 2008). The College of Engineering announces fellowships, scholarships, student organizations such as Society of Women Engineers, Florida-Georgia Louis Strokes Alliance for Minority Participation (FGLSAMP), and programs such as Multicultural Engineering Program (MEP). The FGLSAMP provides assistantships to underrepresented minorities who are enrolled in graduate programs that lead to the Ph.D. in science, engineering, and mathematics fields. FGLSAMP graduate assistants mentor and tutor undergraduate SME majors. In addition to tutoring and mentoring undergraduates, they monitor the progress of SME students on a weekly basis, help develop four year academic plans, develop program activities to increase awareness of careers in SME areas, help prepare to take the graduate record exam, and assist with applying for research internships and for admission to graduate programs (Recruitment & Retention, 2008a). As for the Multicultural Engineering Program, the purpose is to increase the number of underrepresented minorities and women graduating in the fields of engineering by providing programs and resources (Recruitment & Retention, 2008b).

University of Central Florida

The University of Central Florida (UCF) is located in Orlando Florida. According to UCF's admission, it is one of the fastest growing, metropolitan research universities in the country (About UCF, 2009). "With a total enrollment of 50,000, UCF has become a prominent player in undergraduate education nationwide offering innovative partnerships, world-renowned faculty, and cutting edge technology and undergraduate research opportunities" (About UCF, 2009, p.1).

Today, UCF has 47,347 undergraduate and 8,065 graduate students (Fall Student Enrollment in State University System Institutions, 2011). The undergraduate enrollment contains 25,746 females and 21,601 males. First time entering students have a mean score of 1237 in SAT, 26.8 in ACT, and 3.82 in High School GPA (Facts at a Glance, 2011). Female enrollment was 54 percent and minority enrollment was 30 percent of the student body (Facts at a Glance, 2011). UCF's minority enrollment consists of 15 percent Hispanic, 9 percent Black (Non-Hispanic), 6 percent Asian-Pacific Islander, and less than 1 percent of American Indian (Fall Student Enrollment in State University System Institutions, 2011). As for transfer students from the community college, the enrollment for academic year 2008 to 2009 was 6,506 (Fact Book for AY 2008-2009, 2009).

UCF's College of Engineering and Computer Science (CECS) has 4,977 undergraduate and 1,010 graduate students. The college freshmen student's GPA average was 3.77 and math SAT was 646 (Fact Book for AY 2008-2009, 2009). The minority enrollment was 16 percent Hispanic, 6 percent Black (Non-Hispanic), 7 percent Asian-Pacific Islander, and 0 percent Indian-Alaskan (Fact Book for AY 2008-2009, 2009). CECS offers their students information about different centers, programs, tutoring, Harris computer lab, laboratories, scholarships, internships, society, seminars, student organizations and Fundamentals of Engineering (FE) Exam (College of Engineering and Computer Science: Student Services, 2009). The CECS center of tutoring is staffed by junior and senior students with exceptional academic records that can tutor calculus, physics, statistics, chemistry, differential equations, computer science and C programming, networks and systems, principles of EE, electrical networks, linear control or other courses (College of Engineering and Computer Science: Tutoring, 2009). CECS has relationships with over 150 industry partners and tries to build internships or co-ops for their students in order to have job-related experience in their chosen field (College of Engineering and Computer Science: Student Services, 2009).

UCF's College of Sciences contains the department of mathematics. The department of mathematics has 131 undergraduate and 112 graduate students. The percentage of minority enrollment was 17 percent Hispanic, 6 percent Black (Non-Hispanic), 7 percent Asian-Pacific Islander, and 0 percent Indian-Alaskan (Fact Book for AY 2008-2009, 2009). The department of mathematics offers their students information about seminars, math lab, math club, society, research, and seminars (Department of Mathematics, 2009). The department has a program called EXCEL funded by the National Science Foundation. The program goal is to improve student learning in calculus, increase retention rates in STEM majors, and enhance UCF STEM degrees (MATHEMA, 2008).

Table 2.
Undergraduate Student Descriptive Data Fall 2010

Universities:	Florida Atlantic University (FAU)	University of South Florida (USF)	University of Central Florida (UCF)
Total Undergraduates Enrollment	22,419	36,292	47,347
Male Undergraduates Enrollment	9,636	15,585	21,601
Female Undergraduates Enrollment	12,783	20,705	25,746
Average SAT Total	1078	1176	1237
Average ACT Total	23	26	27
Average H.S. GPA	3.3	3.8	3.8
Percent Female	57%	57%	54%
Percent Minority	46%	33%	30%
Percent White	51%	64%	66%
Percent Hispanic	22%	14%	15%
Percent Black (Non-Hispanics)	18%	12%	9%
Percent Asian or Pacific Islander	5%	6%	6%
Percent American Indian or Alaska Native	Less than 1%	Less than 1%	Less than 1%

Source: Florida Board of Governors

Table 3.
Descriptive Data for Undergraduate Engineering and Math Majors Fall 2010

	FAU Math Majors	FAU Engineering Majors	USF Math Majors	USF Engineering Majors	UCF Math Majors	UCF Engineering Majors
Total Undergraduates Enrollment	111	1,424	243	2,787	220	4,352
Male	58	1,232	143	2,334	150	3,702
Female	53	192	100	453	70	650
Percent Female	48%	14%	41%	16%	32%	15%
Percent Minority	46%	46%	31%	32%	25%	31%
Percent White	44%	49%	68%	62%	70%	65%
Percent Hispanic	21%	24%	9%	16%	12%	17%
Percent Black (Non-Hispanics)	25%	15%	13%	9%	5%	6%
Percent Asian or Pacific Islander	7%	6%	7%	8%	8%	7%
Percent American Indian or Alaska Native	Less than 1%	Less than 1%	2%	Less than 1%	Less than 1%	Less than 1%

Source: Florida Board of Governors

Population

The target population of this study was undergraduate senior status women whose first true major was in engineering or math at FAU, UCF, and USF. These female students were selected using the university academic records database that met the following criteria: (a) entered university directly from high school or transferred into the university with an AA degree or transfer without an AA degree, (b) declared first major in mathematics or engineering, and (c) were enrolled in the university as senior standing students at the time of the study. By targeting and analyzing this population, the study might identify factors associated with persistence of undergraduate women majoring in engineering and math at Florida Atlantic University, University of Central Florida, and University of South Florida.

Procedures

To examine factors associated with persistence of undergraduate women majoring in EM, the researcher collected data from two primary sources of data: academic records and surveys. Academic records were retrieved from Banner and provided by the Office of Institutional Effectiveness & Analysis at FAU, the Office of Institutional Research at UCF, the Office of the Registrar at USF, and the Information Resource Management of the State University of Florida (IRM-SUS). The data was collected in the Fall 2010. The data included information on degree majors and those who are senior standing women who continue to persist and those who became non-persisters in EM fields. From the academic records of FAU, UCF, and USF, the researcher sampled women from the target population of female students engaged in an EM degree at FAU, UCF, and USF. A survey (see Appendix C) and a cover letter/ consent form (see Appendix D) were mailed electronically to each of the women in this population. A reminder email was sent within two weeks. Surveys not completed within six weeks were counted among the number of failed survey responses.

Instrumentation

The survey in this study was an updated revised version of Linda C. Kondrick's (2002) survey in her dissertation called Understanding the Conditions that Encourage the Persistence of Women in Science, Math, and Engineering Career Pathways. The survey included open ended questions, multiple choice, and items where students rate experience on a five point Likert-type scale: (a) 1= Strongly Disagree, (b) 2= Disagree, (c) 3= Neither Agree or Disagree, (d) 4= Agree, and (e) 5= Strongly Agree. Each statement in the survey pertained to a variable that according to the review of the literature influences the decision to enter or persist in an EM field. The survey was designed to assess whether social factors which were then grouped into a variable called support and encouragement, psychological factors which were then grouped into two variables called self-confidence and motivation, student engagement in college, and academic preparation and achievement which were then grouped into a variable called academic achievement, and race and ethnicity were characteristics of these women who have persisted in an EM major.

Analysis Techniques

The quantitative phase attempts to identify variables that best explain persistence among women EM majors. In this phase, the researcher used a survey instrument. Each survey item or question was classified as one of the following variables: support and encouragement, self-confidence, motivation, student engagement in college, academic achievement, and race and ethnicity.   Each survey items were scored from one to five except for the factor race and ethnicity. If the item agreed with the review of literature that predicts female persistence then the score would be four or five. If the item somewhat agreed with the literature, then the item score would be three; otherwise, it would be one or two.

The researcher would conduct a factor analysis to reduce the number of predictors, and then used the factors in a logistic regression to predict retention. Factor analysis was used to describe variability among observed variables in terms of a potentially lower number of unobserved variables called factors. The type of factor analysis the researcher used was exploratory factor analysis. "Exploratory factor analysis (EFA) is used to uncover the underlying structure of a relatively large set of variables. The researcher's *a priori* assumption is that any indicator may be associated with any factor. This is the most common form of factor analysis" (Factor analysis, 2011, p. 6). The variables would come from the survey questions. Each survey questions would be given an item name (see Appendix E), and the items would become the variables for the factor analysis. Once factor analysis is performed, it would find latent variables or factors among observed variables. These latent variables or factors and race and ethnicity would be the independent variables and persistence would be the dependent variable for logistic regression in order to determine if the independent variables can be used to predict the dependent variable.

The second phase is the qualitative phase that included data from the open ended questions of the survey. The data collected from the open ended questions were assigned units of meaning through the uses of codes. In order to group the initial codes into a smaller number of themes or concepts, pattern coding was used. “Pattern coding reduces large amounts of data into smaller number of analytic units and it helps the researcher elaborate a cognitive map, an evolving, more integrated schema for understanding local incidents and interactions” (Miles & Huberman, 1994, p.69). Narratives were selected from the participants’ responses to the open ended survey question to illustrate the themes. The qualitative phase provided additional information about factors and interventions that encouraged or would have encouraged the persistence of these women at each stage of the EM degree path.

Chapter Summary

The chapter provides overview of the department of mathematics, the college of engineering, admission requirements and student enrollment for the universities of Florida Atlantic University, University of South Florida, and University of Central Florida. It also provides an overview of the research methods utilized to collect and analyze the data addressing the research questions. Through the implementation of the protocols, it is believed that the study would provide significant insight to help built a profile of women who have persisted in the pursuit of a Math, or Engineering major.

CHAPTER 4

Analysis of the Data

The purpose of this study was to identify factors associated with persistence of undergraduate women majoring in engineering and math (EM- the second half of STEM) at FAU, UCF, and USF. This study will also evaluate whether race and ethnicity explain persistence among women EM majors. This chapter restates the research questions that guided the study and presents the results from the statistical analysis of the data retrieved from the survey instrument. This chapter also presents the major themes that were revealed through qualitative analysis of open ended survey questions.

Research Questions

This study is guided by three research questions:

1) What factors best explain persistence among women EM majors?
2) What is the relationship between race and ethnicity and factors that explain persistence among women EM majors?
3) What type of interventions do women in EM majors believe will enable more women to be successful in the pursuit of an EM major?

Survey Instrument

The researcher conducted a pilot study in order to determine the validity of each question or item on the survey. A total of three hundred surveys were mailed electronically. One hundred and two participants responded. The researcher was able to establish face validity for each item. The researcher did not conduct any statistical analysis for the pilot study.

The surveys were mailed electronically to all undergraduate senior status women whose first true major was in engineering or math at FAU, UCF, and USF. In order to mail the survey electronically, the researcher needed the universities' assistances. None of the universities were able to release information of the desired population directly to the researcher. Hence, the universities sent the survey on behalf of the researcher, thereby allowing the student to self-select their inclusion into the researcher study. If the student elected to opt-in, any information they provided the researcher during the survey process is fair game.

The Office of Institutional Effectiveness & Analysis at FAU and the Office of the Registrar at USF sent a blast email to the desired population that contained the cover letter/ consent form and a link to the survey. At UCF, the Office of Institutional Research was able to locate the email addresses of the desired population and provided the full listing of email address to a UCF sponsor faculty member. The UCF faculty member sent out an email that included a cover letter/ consent form and a link to the survey on the researcher behalf to the selected student population. A total of six hundred surveys were emailed. A reminder email was sent within two weeks. Only ninety-nine responded; therefore, the researcher was unable to gain any data from the five hundred and one.

Student Characteristics

The sample consisted of ninety-nine female seniors. The participants attend FAU, USF, or the UCF. Fourteen students attend FAU; forty-three students attend USF; and, forty-two attend UCF. The ninety-nine female participants identified their racial category as the following: 70 as White, 12 as Black or African American, 4 as Asian, 3 as American Indian or Alaskan, 1 as Native Hawaiian or Other Pacific Islander, 9 as Some Other Race, 3 as International, and 4 as Prefer not to disclose. As for ethnicity, 27 identify themselves as Hispanic or Latino.

When they came to the university, fifty-five were first-time freshman, thirty were transfer students with an Associate in Arts, and fourteen were transfer students without an Associate in Arts degree. Out of the ninety-nine participants, eleven declared their first major at the university in a mathematics discipline, and eight-eight declared their first major in an engineering discipline. Six participants expect to graduate with a degree in mathematics, seventy-three in engineering, and twenty in some other major. Hence, there are only five non-persisters in mathematics (11 first declared major in math – 6 expected to graduate in math = 5 non-persisters in math) and fifteen non-persisters in engineering (88 declared major in engineering – 73 expected to graduate in engineering = 15 non-persisters in engineering). Table 4 is an overview of student characteristics.

Table 4.
Student Characteristics

		N	%
Gender:	Female	99	100.0
	Male	0	0.0
Ethnicity:	Hispanic or Latino	27	27.3
Race:	American Indian or Alaska Native	3	3.0
	Asian	4	4.0
	Black or African American	12	12.1
	White	70	70.7
	Native Hawaiian or Other Pacific Islander	1	1.0
	Some Other Race	9	9.1

Table 4.
Student Characteristics (continued)

		N	%
Race:	International	3	3.0
	Prefer not to disclose	4	4
Current Class Rank:	Senior	99	100.0
First True Declared Major:	Mathematics	11	11.1
	Engineering	88	88.9
Expect to Graduate with a Degree in:	Mathematics	6	6.1
	Engineering	73	73.7
	Other	20	20.2
Non-persisters in:	Mathematics	5	5.1
	Engineering	15	15.2
University Attend:	FAU	14	14.1
	USF	43	43.4
	UCF	42	42.4
Came to the University:	First time freshman	55	55.6
	Transfer with an AA degree	30	30.3
	Transfer without an AA degree	14	14.1

Summary of Data Collection and Analysis Procedures

The researcher conducted a factor analysis to reduce the number of predictors, and then used the factors in a logistic regression to predict retention. Factor analysis is a statistical method used to describe variability among observed variables in terms of a potentially lower number of unobserved variables called factors. In other words, factor analysis reduces the number of variables by grouping variables with similar characteristics. This can produce a small number of factors from a large number of variables, which are capable of explaining the observed variance in the larger number of variables.

The variables came from the survey questions. Each survey question was given an item name, and the items became the variables for the factor analysis. Appendix E shows the survey items under the original grouping labels. These were not used for the final factors, since the exploratory factor analysis uncovered other groupings. Once factor analysis was performed, it helped discover latent variables or factors among observed variables. These latent variables or factors and race and ethnicity were the independent variables and persistence will be the dependent variable for logistic regression, which was used to determine if the independent variables could explain the dependent variable.

Factor Analysis

There are three stages in factor analysis. First, a correlation matrix is generated for all the variables. A correlation is a rectangular array of the correlation coefficients of the variables with each other. Second, factors are extracted from the correlation matrix based on the correlation coefficients of the variables. Third, the factors are rotated in order to maximize the relationship between the variables and factors.

The researcher selected all fifty-six as variables and performed a factor analysis. The first output from the analysis was a correlation matrix. The correlation matrix was used to check the pattern of relationships. The researcher scanned the correlation coefficients, looked for weak correlations (defined as those that were less than .4), and then discarded the following variables: AdvisorHelp, FamilyEncour, HSTeachEncourMS, MentorInfluence, Status, HSCareerME, ConfidFinMaj, HSGPA, ACT, HSmathcode, YearHSSC, StudyHrPerWeek, CreditHr, PoliticalGrp, Assistants, Peertutor, HrEmploy, and EduFinance. After discarding these variables, the researcher ran the factor analysis on the new data set.

Factor analysis relies on the assumption that sets of variables are linearly related in the population. Kaiser-Mayer-Olkin measure of sampling adequacy (KMO) and Bartlett's test of sphericity test those assumptions. The KMO statistic varies between 0 and 1. "A value of 0 indicates that the sum of partial correlations is large relative to the sum of correlations, indicating diffusion in the pattern of correlations (hence, factor analysis is likely to be inappropriate). A value close to 1 indicates that the patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors" (Field, 2005, p. 6). The KMO is an index used to examine the appropriateness of factor analysis, which should be greater than 0.5 for a satisfactory factor analysis to proceed. Barlett's test tests the null hypothesis that the original correlation matrix is an identity matrix. An identity matrix is n x n matrix that consists of 1's on its main diagonal and 0's elsewhere, which means that each variable correlates perfectly with itself but has no correlation with other variables, and a factor analysis would be inappropriate. If observed significance level is less than 0.05, it is small enough to reject the hypothesis. It is concluded that the strength of the relationship among the variables is strong enough to proceed with a factor analysis for the data.

Looking at the table 5, the KMO measure is 0.681, which is greater than 0.5. Hence, factor analysis is appropriate for these data. From the same table, Bartlett's test of sphericity is highly significant ($p < 0.001$), rejecting the null hypothesis, and therefore factor analysis is appropriate.

Table 5.
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.681
Bartlett's Test of Sphericity	Approx. Chi-Square	1418.343
	df	703
	Sig.	.000

Table 6 indicates how many factors to retain. One rule is to retain only factors with eigenvalues of one or more. Eigenvalues represents the total variance explained by each factor. Hence, it would not make sense to retain factors that account for less variance than a single variable. Notice that the first factor accounts for 19.669% of the variance, the second 12.242%, the third 7.440%, and so on. After the tenth factor, the remaining factors have eigenvalues below one.

Table 6.
Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.474	19.669	19.669	7.054	18.562	18.562	5.770	15.185	15.185
2	4.652	12.242	31.911	4.154	10.932	29.494	3.386	8.910	24.094
3	2.827	7.440	39.351	2.388	6.284	35.778	3.129	8.234	32.328
4	2.272	5.978	45.329	1.788	4.705	40.483	2.469	6.497	38.825
5	2.072	5.454	50.783	1.516	3.990	44.473	1.890	4.974	43.799
6	1.810	4.762	55.545	1.304	3.431	47.904	1.560	4.105	47.904
7	1.556	4.095	59.641						
8	1.417	3.730	63.371						
9	1.209	3.183	66.553						
10	1.169	3.078	69.631						
11	.968	2.546	72.177						
12	.892	2.348	74.525						

Another device for deciding on the number of factors to retain is the scree test. The scree plot is a graph of the eigenvalues against all the factors. The point of interest is where the curve starts to flatten. At the point that the plot begins to level off, the additional factors explain less variance than a single variable. Figure 1 displays the scree plot and shows that first 10 factors have eigenvalues greater than 1. The researcher decided a six factor solution because the curve in the scree plot begins to tail off after six factors; therefore, factors 1 through 6 account for 56% of the total variance. In other words, 56% of the common variance shared by the 38 variables can be accounted for by the 6 factors.

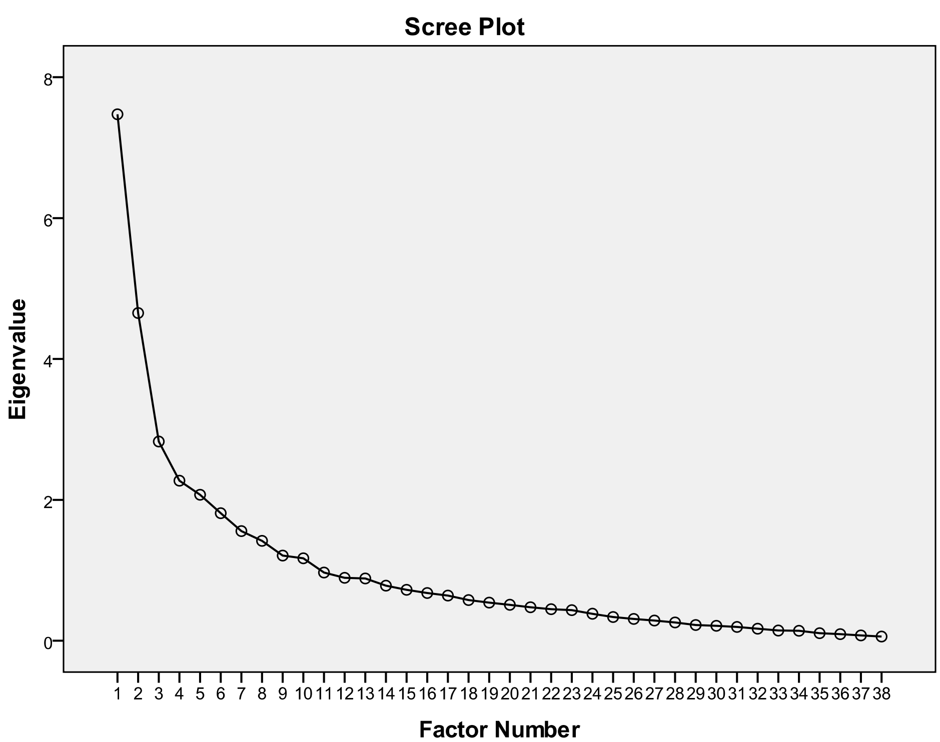

Figure 1. Scree Plot

Then, the researcher used a rotated the factor matrix, which is a matrix of the factor loadings, for each variable onto each factor. The idea of rotation is to reduce the number factors on which the variables under investigation have high loadings. Rotation serves to make the output more understandable and is usually necessary to facilitate the interpretation of factors. The researcher expected the factors to be independent then chose orthogonal rotations. Orthogonal rotations preserve the independence of the factors, geometrically they remain 90^0 apart. Orthogonal rotations consist of varimax, quartimax, and equamax rotation. The researcher decided to use varimax rotation. Varimax is the most commonly used rotation, and its goal is to minimize the complexity of the factors by making the large loadings larger and the small loadings smaller within each factor. Table 7 demonstrates the rotated factor matrix.

Table 7.
Rotated Factor Matrix

	Factor					
	1	2	3	4	5	6
FacFriendAvail	.765	.161	.196	-.245	.017	.004
InteractWFac	.488	.310	.211	-.020	.019	.114
FacGoodTeach	.503	.253	.089	-.124	.001	.113
AtmosFemaleFriend	.350	.788	-.024	-.084	-.076	.098
SupportPeerGrp	.368	.683	.211	.063	.066	-.014
UnivAtmosDiscSter	.164	.768	-.145	-.182	-.128	-.002
DoBettrThanMale_R	-.020	.544	.059	.101	.019	-.076
CAtmosFreeDisSter	.201	.809	-.028	-.165	-.040	.010
HSIncome	-.047	.094	.057	.097	.019	.561
ParntGuardEdu	.036	-.082	-.113	-.072	.082	.730
ParntCareerSME	.066	-.058	.168	-.081	-.124	.592
SelfconfAbility	.756	.251	.031	-.024	.099	.064
SpeakOutChall	.457	.263	.084	-.008	.145	-.102
DidntWaverCareerME	.330	.244	.186	-.281	-.168	-.156
EnjoyLearn	.853	.013	.127	-.093	-.075	-.080

Table 7.
Rotated Factor Matrix (continued)

	Factor					
	1	2	3	4	5	6
LookForwrdC	.722	.101	.159	-.024	-.107	-.136
WorkIndepCwork	.746	.032	-.021	-.043	.134	.010
InvolvedC	.610	.438	.154	.066	.055	.005
AimToExcel	.762	-.045	-.170	.078	-.131	.046
AimToStud	.622	-.048	-.117	.099	.159	.086
HighGPAHSMS	.136	.152	-.200	.153	.268	.010
VSAT	-.080	-.137	.160	.128	.513	.086
MSAT	.003	-.080	.101	.080	.526	-.003
UGGPA	.253	.037	.030	.186	.252	.302
AcadOrg	.079	.060	.495	.614	.014	.049
NonAcadOrg	-.055	-.053	.129	.729	.092	.014
Volunteer	-.130	-.005	.145	.698	-.037	-.034
MinorProg	.033	.222	.425	.234	-.156	.059
FacResearchProj	.172	.043	.319	.141	.114	.012
TutorProg	-.057	-.046	.078	.233	-.851	-.019
PeerMentor	.000	-.069	.332	.367	-.180	.257
MentorProg	-.064	-.038	.269	.139	-.454	.138
LeadershipProg	.055	-.161	.363	.510	.008	-.061
PeerRecruit	-.026	.042	.795	.163	-.072	-.028
RecruitProg	.039	.018	.669	.029	.062	-.009
OutreachProg	-.036	-.015	.616	.360	-.034	-.086
StudentRetentionProg	.089	-.010	.581	.016	.043	.194
ConfidLifeGoal	.397	.096	-.119	.050	-.031	.080

The researcher looked for at least three large loadings for each factor in order to confirm that six factors was the appropriate number of factors to retain. For example, a seventh factor did not have at least three large items with a high factor loading. The final step is to look at the context of variables that loaded highly onto the same factor to try to identify common themes and name the factor. By applying this process, it provided the results of factor analysis. The researcher named the factors by looking at the items for patterns of similarity between items that load on a factor and deciding on what latent characteristics they share. The name for the factor should be brief and should communicate the nature of the underlying construction.

In table 7, the variables that loaded highly on factor 1 were FacFriendAvail, SelfconfAbility, EnjoyLearn, LookForwrdC, WorkIndepCwork, InvolvedC, AimToExcel, and AimToStud. These variables seem to all relate to motivation. Therefore, the factor 1 was labeled self motivated. The variables that loaded highly on factor 2 were AtmosFemaleFriend, SupportPeerGrp, UnivAtmosDiscSter, and CAtmosFreeDisSter. These variables seem to relate to learning environment. Factor 2 was labeled safe learning environment. As for factor 3, the variables that loaded highly were PeerRecruit, RecruitProg, and Outreach. Factor 3 all contained some component of social engagement with or support from the university; therefore, it was labeled university engagement. The three variables that loaded highly on factor 4 were AcadOrg, NonAcadOrg, and Volunteer. Factor 4 seem to relate to activity and was labeled extra-curricular activity. Factor 5 had two variables loaded highly positive such as VSAT and MSAT and one variable loaded highly negative such as TutorProg. Thus, factor 5 all seem to relate to preparation and was labeled precollege preparation. Finally, the variables that loaded highly on factor 6 were HSIncome, ParntGuardEdu, and ParntCareerSME. These variables seem to all relate to parent’s status; hence, factor 6 was labeled social status. These six factors or latent variables are the result of factor analysis. Out of 38 variables, factor analysis reduced the number of variables to six factors. These six factors can be used as latent variables for logistic regression.

Logistic Regression

Logistic regression is used to predict the presence or absence of a characteristic or outcome from a set of predictor variables. Logistic regression coefficients can be used to estimate odds ratios for each of the independent variables in the model. One can estimate models using block entry of variables.

In this study, the researcher used persistence as the dependent variable for logistic regression. The six factors or latent variables, (‘self motivated’, ‘safe learning environment’, ‘university engagement’, ‘extra-curricular activity’, ‘precollege preparation’, and ‘social status’), and race and ethnicity were the independent variables. Due to a low number in some race/ethnicity categories, the researcher renamed and reclassified some of the original titles of race combining Some Other Race, International, and Prefer not to disclose under Some Other Race and Asian, Native Hawaiian, and Pacific Islander as Asian or PI. From the question on ethnicity on the survey, the researcher was able to discern how many participants viewed themselves as Hispanic. Hence, race and ethnicity included White, Black, Hispanic, Asian or PI, AmerInd, and Some Other Race coded as dummy variables. In logistic regression, the variables self motivated, safe learning environment, university engagement, extra-curricular activity, precollege preparation, and social status were entered in one block, and the variable race and ethnicity was entered in the next block. The race category “white” was excluded and became the comparison group. The researcher ran the logistic regression with the two blocks.

A critical step in assessing the appropriateness of the model is to examine its fit or how well the model describes the observed data. Without such an analysis, the inferences drawn from the model may be misleading or even incorrect, meaning that failure to address model adequacy may lead to misleading or incorrect inferences. The researcher examined how well the logistic regression model fit the data by looking at the -2 Log Likelihood. The -2 Log Likelihood measures how well the estimated model fits the data. The smaller the statistic the better the model. Under the Model Summary for Block 1 (table 8), the -2 Log Likelihood statistic is 59.031. In table 9, the Model Summary for Block 2 showed that the -2 Log Likelihood statistics has dropped to 52.576. Also, the data showed that the block 1 significance indicates that the coefficients are significantly different from 0, but the addition block 2 variables does not improve the model.

The researcher also looked at the Cox and Snell R^2 and the Nagelkerke R^2 to measure the strength of association. The Cox and Snell R^2 and and the Nagelkerke R^2 attempts to measure the proportion of variance in the dependent variable explained by the independent variable. The Cox and Snell R^2 can be interpreted like R^2 in a multiple regression, but cannot reach a maximum value of 1. In logistic regression, the variance is typically less than what one would expect in multiple linear regression. According to the Cox and Snell R^2, it was .334 in table 8 and increased in table 9 to .378. The Nagelkerke R^2 can reach a maximum of 1, and in the model summary for block 1 (table 8), it is .530. The R^2 statistics have also increased in table 9.

Table 8.
Model Summary for Block 1

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	59.031[a]	.336	.530

Table 9.
Model Summary for Block 2

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	52.576[a]	.378	.596

Lastly, the researcher examined how well the logistic regression model fit the data by looking at table 10 called Hosmer and Lemeshow Test. In table 10, the chi-square statistic is computed by comparing frequencies with those expected under the linear model. The p-value is .001 computed from the chi-square distribution with 8 degrees of freedom (df) and indicates that the logistic model is a not a good fit. Since Hosmer and Lemeshow Goodness-of-fit test statistic is less than .05, the researcher rejected the null hypotheses that there is no difference between the observed and predicted values of the dependent variables. Hence, the model is not a good fit since the predicted and the observed values are not the same. This model calibration tests failed because of the small N’s.

Table 10.
Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	26.023	8	.001

The model fit for block 1 indicated that at least some of the variables explained persistence in the model. However, block 2 does not improve the model and does not predict persistence. For the R^2, it barely increased once race was added for block 2. In the Hosmer and Lemeshow Test, the model fit was not a good fit because of the small N's. The small sample size may have affected the all the goodness of fit tests. According to Yu & Cooper (1983), low response rates decrease the statistical power of the data. However, the researcher continued with logistic regression.

The results of logistic regression can be determined by analyzing table 11. In table 11 called Variables in the Equation, regression coefficients (B), Wald Chi-Square, p-value (Sig.), and odd ratios (Exp(B)) are given. The Wald Chi Square statistics tests the unique contribution of each predictor. Notice that the predictors self motivated, safe learning environment, and university engagement were the only ones that met the conventional .05 standard for statistical significance. The Exp(B) column is the odd ratio of the row independent with the dependent for the predictors. It is the predicted change in odds for a unit increase in the corresponding independent variable. Odds ratios less than 1 correspond to decreases in odds, and odds ratios more than 1 corresponds to increases in odds. Odds ratio close to 1 indicate that unit changes in that independent variable do not affect the dependent variable.

Using table 11, the researcher interpreted the odds ratios which also presents the results of logistic regression. The odds ratio for self motivated indicates that when holding all other variables constant, an undergraduate women majoring in engineering and math who is self motivated is 3.892 times more likely to persist than a women who is not self motivated. For each one point increase on the safe learning environment scale associated with the odds of persistence, there was an increase by a multiplicative factor of 5.577. With a one point increase on university engagement scale associated with the odds of persistence, there was an increase by a multiplicative factor of 9.562. The three factors, self motivated, safe learning environment, and university engagement, are positively associated with persistence. However, their magnitude of the odds-ratio is difficult to interpret because the predictor is a factor score from the factor analysis and not from the underlying survey instrument. The odd ratios of the race dummy variables compare each race to White. None of the race dummy variables meet the conventional .05 standard for statistical significance, none can be compared. Hence, race and ethnicity do not predict persistence of undergraduate women majoring in engineering and math in this sample. Overall, the odd ratios are suggestive at best, not conclusive.

Table 11.
Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	SelfMotivated	1.359	.409	11.051	1	.001	3.892
	SafeLearningEnvironment	1.719	.527	10.637	1	.001	5.577
	UniversityEngagement	2.258	.823	7.519	1	.006	9.562
	ExtraCurricularActivity	-.269	.405	.443	1	.506	.764
	PrecollegePreparation	-.254	.494	.265	1	.607	.775
	SocialStatus	-.504	.477	1.115	1	.291	.604
	AsianorPI	-1.894	1.255	2.276	1	.131	.150
	AmerInd	20.795	20009.458	.000	1	.999	1.075E9
	Hispanic	.764	.997	.587	1	.443	2.147
	Black	.449	1.059	.179	1	.672	1.566
	SomeOtherRace	-1.045	1.041	1.008	1	.315	.352
	Constant	2.985	.744	16.102	1	.000	19.783

Reason Why Not Persisted

Participants who did not persist in engineering and math were asked question number 25 or 26 on the survey instrument. They were asked to mark all that apply to reasons that explained why they did not persist as a engineering or math major. For non-persisters in mathematics, three out of five declared eight items were factors in their decision to not persist. The two most influential in the students' decision to not persist were no guidance (100%) and feeling isolated (100%). The next two following reasons were no faculty support and encouragement (67%) and no mentor or role model (67%). The final choices were that they were not confident of their ability to succeed (33%), did not enjoy the major (33%), and felt discrimination and stereotype on the basis of gender at the university (33%).

For non-persisters in engineering, fourteen out of fifteen participants declared thirteen items were factors in their decision to not persist. The two most influential in the students' decision to not persist were that they did not enjoy the major and felt isolated. These were followed by not having a mentor or role model and low level of self-confidence in their abilities in engineering. The factors, in order of most influential to least influential with percentage, were:

- Did not enjoy the major- 64%
- Felt isolated- 64%
- No mentor or role model- 50%
- Low level of self-confidence in my abilities in engineering- 50%
- No guidance- 43%

- Not confidence of my ability to succeed- 36%
- Entered the university unprepared in math and science- 36%
- No faculty support and encouragement- 23%
- Unable to work independently in engineering coursework- 23%
- Did not dedicate enough studying time- 21%
- Discrimination and stereotyping on the basis of gender inside the classroom- 14%
- Worked too many hours- 14%
- Discrimination and stereotyping on the basis of gender at the university- 7%

Qualitative Analysis of Open-ended Survey Items

"Qualitative data are a source of well-grounded, rich descriptions and explanations of processes in identifiable local contexts. With qualitative data one can preserve chronological flow, see precisely which events led to which consequences, and derive fruitful explanations" (Miles & Huberman, 1994, p.1). The data for the qualitative part of this study was collected through the open-ended questions in the survey instrument. The three open-ended questions asked in the survey instrument were the following:

1. What is the most important factor that helps female students persist in Engineering and Math major?
2. What are the most difficult factors for female students to overcome in the pursuit of Engineering and Math degree?
3. What type of interventions do you believe will enable more women to be successful in the pursuit of an Engineering or Math degree? What about these

interventions makes you believe that it will be effective in encouraging the persistence of women in Engineering and Math major?

Question one and two were located in the last section of the survey called open ended questions. As for question three, it was located in the section called undergraduate years, which was the third to last section. The data collected from the open-ended questions were transcribed into an Excel document and read and re-read to find emergent themes by constant comparative method. Then the data were assigned units of meaning through the uses of codes. The researcher grouped the initial codes into a smaller number of themes or concepts by using pattern coding. “Pattern coding reduces large amounts of data into smaller number of analytic units and it helps elaborate a cognitive map, an evolving, more integrated schema for understanding local incidents and interactions” (Miles & Huberman, 1994, p.69). Once these procedures were done, the researcher was able to analyze the data. The researcher did not do any co-rater reliability regarding the qualitative data analysis. The qualitative measures served the purpose of gaining a deeper understanding of undergraduate senior status women whose first true major was in engineering and math as well as understanding factors and interventions that encouraged or would have encouraged the persistence of these women at each stage of the EM degree path.

Most Important Factors

Out of ninety-nine students that completed the survey, seventy-one students shared what was the most important factor that they believe will help female students persist in engineering and math major. Thirty-one students indicated that self-confidence and determination helps female students persist in engineering and math. One student responded, “For me, if someone doubted my ability to do the work, it would push me harder just to show that I was capable.”

Another student shared the following comment about her confidence:

> I never had confidence in high school and although I initially went to college with the hopes of obtaining an engineering degree, I never thought that I would actually do it. I failed in my first attempt, quit school, got married, and had children. In breaking away from my parents and starting my own family, I have gained confidence on my own. I am now 8 credits from graduating.

Twenty-one participants responded that support and encouragement from faculty, mentors, peers, advisors, friends, and family helped contribute to their ability to persist in engineering and math major. Having a social support network seemed to help women get through these periods of low morale. One student responded with the following comment about support, “I believe that the most important factor is to have a support group that constantly encourages female students that they will be successful in engineering. This can be in the form of peers or a mentor or role model.” Another student mentioned, “Having other female students to confide in makes the time a bit easier. I also believe having a good support system at home really helped me excel. My parents believed in me and always supported me in everything I did.”

One student commented about a good support system and as well as having male friends as part of their support system:

> One thing that I think helps is having a good support system. Also even though I did notice that there weren't that many females it never bothered me. I also have always had many male friends and at times prefer to have male friends so having male friends as part of my support system was never an issue. So the most important factor I think in persisting in any major is a good support system.

Another student offered the following comment about mentor, friend support, and study group:

> A strong mentor to encourage you through the program even when you meet Male engineers (outside of the program, through field trips to engineering firms) that clearly do not respect you or believe you could be an engineer because you're a woman. Also a strong friend support/study group throughout the engineering program (friends you can ask questions of regarding homework and concepts, etc.).

Nine participants felt by being interested and having enjoyment of what they were learning was one of the most important factors that helped them to persist in the pursuit of a engineering and math career goal. A student added, "Your heart has to be in it. If you don't want it with all you have then you will not succeed!"

Most Difficult Factors

Of the ninety-nine completed surveys, seventy-one students shared their opinion on what are the most difficult factors for female students to overcome in the pursuit of engineering and math degree. Twenty-nine students indicated that discrimination and stereotyping was the most difficult factors for female students to overcome. Many students mentioned some of the stereotypes that that they face were the following: that men know more than women in the math and sciences, that women are not as smart as men, that women lack abilities in engineering and math, that women can't finish or keep up with the men, that women belong in liberal arts degrees, that men are better than women at engineering and math, that an engineering or math profession is for man, and that females are more inept than males.

One student discussed discrimination and stereotyping towards females:

> Often females (myself included) experience--even if indirectly/in a "polite" manner-- a kind of brushing-aside behavior from male peers (and sometimes professors) when there is some sort of difficulty/obstacle in the material at hand, often with the excuse that being female means being incapable/needing "help" from the "better" males.

One student shared the following comment about the "man factor":

> I feel the "man factor" is the single most difficult factor to overcome. I am a nontraditional student (43 years old). I have found the most difficult aspect of Engineering is men. They make life very difficult for women especially if you are very smart. I have had no issues … however I have at the Community College level and in the work place as well. I also think it is an age factor. Young men now don't discriminate as much as anyone over 35. Younger guys are more female friendly because they have grown up in an era where there are not as many stereotypical aspects of roles. 20 years ago a male nurse was not heard of now we don't think twice about it. However men who grew up in the era of male and

> female jobs still hold true to this “stinking thinking.” I wish I was 18 right now and starting my career; I know my accomplishment would have been more valued and I would have been more successful. Nevertheless, I think as one generation hands over the reins to the next, women will not have as many barriers to success from their male counter parts.

Some professors may stereotype, discriminate, and underestimate the competence of women. One student shared the following comment about harassment concerning male professors, “Many of the professors harass you and make it hard for you to compete with the men in the class. They are also much more comfortable talking to men than they are talking to women.” When working in groups in classes, male students may not take female students as seriously as males or may feel they are less competent. One student commented on her experience working with group projects:

> The most common issue occurs when there are group projects in the engineering course. Most groups are all male, or are predominately male. Being the only female in a group with males, sometimes it was difficult to be heard when I made suggestions. Usually, because the guys would dismiss it we would encounter a problem, one that was preventable assuming anyone else in my group would have agreed with me. This scenario happened far too often to the point I would expect to encounter a problem and have the solution ready once the others in the group realized it was not correct, thereby making it known that I am competent, and that they were wrong in not wanting to listen. Not only did I forewarn the problem, but I was also capable of providing the solution.

Fourteen of the participants indicated that engineering and math was a male dominated field; therefore it lacked female presence causing isolation. Some felt that this theme was the most difficult factors to overcome in the pursuit of engineering and math degree. One student responded “The overwhelming male presence and the resultant isolation from the majority due to that difference.” Another female student simply stated, “Being in a class of guys, some of which feel more dominate over the field.”

Another student offers the following comment about the lack of female presence:

> I think the most difficult part or at least for me is finding female friends even though males are very cool and some of my best friends are males at times is good to have a female to talk about females stuff. It took me like 3 years to find two female friends at school, maybe being involved in a club or something might have helped but I always felt and feel like I have no time due to research and studying.

Another theme that emerged was lack of self-confidence. Eleven students stated that lack of self-confidence was a difficult factor to overcome. They recommended not to give up or to assume that one is not as smart as their male counterparts instead to accept the fact that one belongs there and to gain confidence to know that it can be done. Other major themes were lack of support and encouragement from faculty, staff, advisors, peers, and family, and performance pressure. Both these themes were stated by nine participants. One student added this comment about lack of support and encouragement from their peers during group work, “Group work, female students are not picked for groups and forced to work individually or when in a group they are automatically assigned note taking or some job that does not showcase knowledge.” As for performance pressure, some felt that they must over-achieve to be seen as equal to a male student. One student mentioned, “Getting over the fact that, as a female, you'll have to perform at 150% to be considered legitimate and not "lucky".”

Proactive Interventions

Fifty-four students out of 99 shared their view on what type of interventions they believed would enable more women to be successful in the pursuit of a engineering or math degree. Some students also explained why these interventions would be effective in encouraging the persistence of women in Engineering and Math major. Twenty-five of the participants made an overwhelming reference to intervention as student engagement such as outreach program, support program, study groups, homework sessions, women clubs, engineering or math clubs, math and sciences activities, math and science tours, engineering and math societies, educational programs focusing on engineering and math, online courses, women organization in STEM, providing positive role models, female teachers, women mentors, exposure to engineering and math, and expanding the career outlooks of young women. Participant advised that intervention must start early. One student responded:

> I think that women need to be exposed to the Engineering and Math degrees and careers at an earlier age, middle school or perhaps even elementary. This way the girls who would be interested in pursuing these degrees are exposed to it earlier and therefore will be more likely to make it their goal. I was not exposed until high school and I think I would have liked it an earlier age too.

Many also voiced the opinion that interventions must be continuous throughout every level of the educational pathway and professional life. One student responded, “I believe starting outreach programs at a young age will encourage girls to think about pursuing Math or Engineering as a career. When we are younger, our minds are like sponges and take in everything that goes on around us.” Another student simply stated:

> I believe that more advertising for these degrees with women in them needs to be more prevalent and that the women in these fields need to be more visible in their communities. Once more young women see just how common this is becoming they might not think it so difficult to pursue these math and science degrees as well.

One student shared the following comment about educating young women about pursing challenging careers:

> I believe if more women spoke to young girls who plan on pursuing challenging careers in the future, they will understand that other women have been through the struggles. Being in a male dominated field is very intimidating, and I believe recruitment of women who enjoy science and math needs to start in high school!

One student offered the following comment about female support group:

> I think having a female support group would also be helpful. Then engineering and math degree seeking females would know that they are not alone. That in itself is very comforting and can give you enough self-esteem to continue when it gets rough.

Another student commented on online courses “Offering more online courses in engineering so that women, who often are the ones to take care of households/families, have a greater opportunity to complete courses”.

Sixteen of the participants responded that the type of interventions that was needed was in support and encouragement through mentors, female friendships, female teachers, business, family, advisors, and positive role model.

One student commented on female mentor:

> Assigning a specific female mentor to each female student as soon as they enter the mathematics program to guide them through their undergraduate degree and goals both academically and professionally would certainly help matters. A mentor/advisor that would be able to help them choose courses, ensure they know where to go to get help, and inform them of groups/societies that would make them feel included and supported during the often challenging courses to build a strong base to enable a successful pursuit within the mathematics or engineering field rather than simply switching to another that is more female-friendly is key. The lack of female presence in the classroom, among the students, faculty, and lab assistants certainly made me feel like an oddity in a sea of males who explained concepts with an air of inherent superiority based on gender.

One student offers the following comment about great professors and support:

> I believe that the way to get women to be successful in the pursuit of a math or engineering degree is to get great professors and a support program. If women have people around them that are constantly supporting them and helping them in

> what they are doing, then they will be encouraged and keep pushing through to success. If professors are not helpful and do not try to explain concepts in multiple ways, it hurts all students because not everyone learns the same way.

Another student shared the following comment about positive role models:

> If female students had positive role models and encouragement throughout their studies, I believe more women would be successful in the engineering and math fields. Having an example (role model) to confide in, receive advice, words of encouragement, resources, etc. will not only enable female students to maintain an above average performance scale, they will also gain confidence in their abilities to become successful and knowledgeable in their respective fields.

Overall, it is recommended by the participants that intervention programs should include student engagement, support and encouragement through mentors, female friendships, female teachers, business, family, advisors, positive role model, public schools, universities, industry, community outreach organizations, and the government. By creating intervention programs in EM, it will provide opportunities to give young women the confidence to succeed in EM.

Chapter Summary

This chapter presented the analyses of the data retrieved from the survey instrument to answer the research questions concerning persistence of undergraduate women majoring in engineering and math at FAU, UCF, and USF. The responses on the survey instrument administered to undergraduate senior status women whose first true major was in engineering or math at FAU, UCF, and USF identify factors associated with persistence. The participants who were self motivated, felt they had a safe learning environment, and were engaged by the university were more likely to persist in engineering and math. On the survey, non-persisters explained why they did not persist as an engineering or math major. For non-persisters in mathematics, the most influential factor in the students' decision to not persist was no guidance and feeling isolated.   As for non-persisters in engineering, the most influential factor in the students' decision to not persist was that they did not enjoy the major and felt isolated.

Responses to open ended questions on the survey instrument provided details that the quantitative research misses. It revealed that the most important factor that helped female students persist in engineering and math major was self-confidence and determination. They also indicated that discrimination and stereotyping was the most difficult factors for female students to overcome. To enable more women to be successful in the pursuit of a engineering or math degree, participants made an overwhelming reference to intervention as student engagement. They suggested that student engagement must start early and must be continuous throughout every level of the educational pathway and professional life.

CHAPTER 5

Summary

This chapter provides a summary of the study of persistence among women engineering and math (EM- the second half of STEM) majors. A statement of the problem, conclusions, and a discussion of both quantitative and qualitative findings as well as the integration of these sets of findings are presented. The chapter concludes with recommendations to policy, university practices, and future study regarding persistence among women EM majors.

Summary of the Study

This study identified factors associated with persistence of undergraduate senior status women whose first true major was in engineering and math at FAU, UCF, and USF. This study also evaluated whether race and ethnicity explained persistence among women EM majors. The female students were selected by using the university academic records database that met the following criteria: (a) entered university directly from high school or transferred into the university with an AA degree or transfer without an AA degree, (b) declared first major in mathematics or engineering, and (c) were enrolled in the university as senior standing students at the time of the study. The researcher conducted quantitative and qualitative approaches by using a survey to investigate factors associated with persistence of undergraduate women majoring in EM. The survey included open-ended question, multiple choice, and items where students rated experiences on a Likert type scale. The responses to these questions were analyzed to determine if there were any factors associated with persistence among women major in EM. Open-ended survey items revealed more about the most important factor that helped students persist, the most difficult factor for female students to overcome, and the type of interventions that will enable more women to be successful in the pursuit of an EM degree.

Statement of Problem

In the United States, there is an economic dilemma. The demand for science and technology is the greatest, but the sciences' labor force is in a shortage (Clausing, 1999). Two of the problems related to this issue are that too many talented women are not majoring in EM nor persisting in an EM career pipeline. Thus, more information must be known about the conditions that favor persistence among women in EM degrees. By conducting research on women in EM majors at FAU, UCF, and USF and identifying key factors that appear to facilitate persistence of women in EM, this study can contribute and offer insight into the factors that motivated women to persist in an EM field.

Discussion of Findings

Quantitative

The first research question for the study was to identify what factors best explain persistence among women EM majors. The findings in the study indicated that three factors best explain persistence. The first factor positively associated with persistence was participants who were self motivated. By being self motivated, a student has self-confidence in her ability, feels that professors are accessible to students outside the classroom, aims to excel in the subject, aims to be one of the top students, is interested and involved in coursework, looks forward to coursework, is able to work independently, enjoys math, science, or engineering courses (Brainard & Carlin, 1998; Ehrhart & Sandler, 1987; Muller & Pavone, 1997; Pascarella & Terenzini, 1980; Ware et al., 1985). Self motivated is essential to the persistence of women majoring in EM.

The second factor positively associated with persistence was participants having a safe learning environment. A safe learning environment consists of the following: the atmosphere at the university and inside the classroom is free from discrimination and stereotyping on the basis of gender, the atmosphere in EM classes is female friendly, and the atmosphere of peer group is supportive. By having a safe learning environment, barriers were removed or lowered. Hence, the number of women participating, achieving, and persisting in EM would increase (Xie & Shauman, 2003).

University engagement is the third factor positively associated with persistence among women in EM majors. University engagement consists of direct recruitment efforts, either by recruiting peer members to recruit students to the EM programs or by recruiting students to get involved in the EM programs. It also consists of outreach programs in EM. This factor may dramatically influence student's educational and social development, and may promote the success and increased representation of women in EM (Campbell & Skoog, 2004).

The second research question for the study examined the relationship between race and ethnicity and factors that explained persistence among women EM majors. The findings indicated there was no effect on the relationship between race and ethnicity that explain persistence of undergraduate women majoring in engineering and math. It might also mean that race and ethnicity was an irrelevant variable for the three institutions since, the three institutions dealt regularly with diverse students and might be more successful than other universities in diversity. Findings from previous research were unable to explore how progress toward EM degree completion varies by race and ethnic group. Hence, this finding is important, and it implies that persistence among women EM majors need to be addressed in separate settings between race and ethnicity. It is crucial that one recognize diversity where it does exist, noting progress toward equity and offering empirical evidence that can impede the further perpetuation of stereotypes about who belongs in STEM fields (Riegle-Crumb & King, 2010). It is important for all minority women in EM students to be self motivated, to have a safe learning environment, and to be engaged by the university in order to persist in EM. "Seen through the lens of national interest, the importance of diversity was recently underscored by reports from the National Academy of Sciences, suggesting that, without the participation of individuals of all racial/ ethnic backgrounds and genders, the increasing demand for workers in these fields will not be met, potentially compromising the position of the United States as a global leader" (Riegle-Crumb & King, 2010, p. 656).

Additional information was gained through the survey about non-persisters in EM. Non-persisters explained why they did not persist as a engineering or math major. The two biggest influences in the students' decision to not persist as a math major were no guidance and feeling isolated. As for non-persisters in engineering, the two most influential factors in the student's decision to not persist were not enjoying the major and feeling isolated. Both felt isolated as an EM major. Therefore, academic and social support networks are very important to women in time of stress or isolation. Faculty, role models, mentors, peers, parents, friends, and family all play an important role in keeping a woman focused on the objective issues when the subjective issues of the experience overwhelm them.

Previously, the review of literature from studies suggested that there were a few categories of variables that explain persistence behaviors of women in the EM disciplines. The primary categories included social factors, psychological factors, student engagement in college, academic preparation and achievement. Once exploratory factor analysis was performed, it uncovered other groupings. These latent variables or factors were called self motivated, safe learning environment, university engagement, extra-curricular activity, precollege preparation, and social status. These factors do not confirm the groupings that were in the literature. Then, logistic regression was used to predict the presence or absence of a characteristic or outcome from the latent variables or factors. Logistic regression found that out of the six factors only three were statistically significant and thus could explain persistence in this sample. The findings indicated that the participants who were self motivated, felt they had a safe learning environment, and were engaged by the university were more likely to persist in engineering and math. Hence, these finding add new knowledge to the literature.

Overall, this study contributes to the literature by identifying which factors best explain persistence among undergraduate senior status women whose first true major was in EM. It revealed that participants who were self motivated, felt they had a safe learning environment, and were engaged by the university were more likely to persist in EM. For each of these three findings, the study was able to provide descriptions or specific meanings. The study also contributes to the literature by examining the relationship between race and ethnicity and factors that explained persistence among women EM majors. Even though the study found no statistically significant relationship between race and ethnicity and factors that explained persistence, it offers insights to create a starting point in the literature. Additionally, this study provides information why non-persisters in EM did not persist.

Qualitative

The data for the qualitative part of this study were collected through three open-ended questions in the survey instrument. The data was assigned units of meaning through the uses of codes. The researcher grouped the initial codes into a smaller number of themes or concepts by pattern coding. Once these procedures were done, the researcher was able to analyze the data.

The first open-ended question for the study examined the most important factor that helped female students persist in EM major. The findings indicated that self-confidence and determination helped female students persist in engineering and math. Women develop self-confidence in the early years through high expectations and recognition of achievement, mostly from parents and teachers. Confidence in math and science begins with a good foundation in math and science college preparatory classes. Students who do maintain high level of self-confidence reported enjoyment of math and science classes, considering competition to be a motivator, having friends who are interested in EM, and a positive influence from male friends, and other students societies, conferences, and events (Brainard & Carlin, 1998). Overall, high self-confidence and high aspirations for degree attainment are significant in predicting degree completion (Haung et al., 2000).

The second open-ended question for this study investigated the most difficult factors for female students to overcome in the pursuit of EM degree. The findings indicated that discrimination and stereotyping was the most difficult factor for female students to overcome. Some professors, advisors, and peers may stereotype, discriminate, and underestimate the competence of women. Several studies (O'Brien & Crandall, 2003; Steele et al., 2002) stated that female undergraduates majoring in math, science, and engineering reported higher levels of discrimination and stereotype threat than women in a female-dominated academic areas such as arts, education, humanities, or social sciences, and men in SME or female dominated academic area. According to Xie & Shauman (2003), their research promoted the belief that if the barriers were removed or lowered then the number of women participating and achieving in science would increase.

The third open-ended question and the third research question for this study examined what type of interventions do women in EM majors believe will enable more women to be successful in the pursuit of an EM major. The significant findings indicated student engagement as an intervention to enable more women to be successful in the pursuit of a engineering or math degree. Student engagement consists of the following: outreach programs, support programs, study groups, homework sessions, women clubs, engineering or math clubs, math and sciences activities, math and science tours, engineering and math societies, educational programs focusing on engineering and math, online courses, women's organizations in STEM, providing positive role models, female teachers, women mentors, exposure to engineering and math, and expanding the career outlooks of young women. Student engagement must start early and continue throughout every level of the educational pathway and professional life. Without early intervention, young women may never know about fields in EM. Student engagements may dramatically influence student's educational and social development, and may promote the success and increased representation of women in math, science, and engineering (Campbell & Skoog, 2004).

In this study, the participants' responses contribute to the literature. Their responses informed the study of the most important factors that help female students persist, the most difficult factor for female to overcome, and what type of intervention would enable more women to be successful in the pursuit of EM degree.

Integrated Discussion of Findings

The primary focus of this study was to identify factors associated with persistence of undergraduate women majoring in EM. The quantitative component of the study investigated the statistical factors that best explained persistence and the relationship between race and ethnicity and factors that explained persistence among EM majors. The analyses were conducted by factor analysis to reduce the number of predictors, and then used the factors in a logistic regression to predict retention. Four findings emerged from the quantitative analysis. A qualitative inquiry occurred as well, utilizing three open-ended questions in the survey instrument to investigate the most important and most difficult factors for female students to persist or to overcome in EM major, and further investigate what type of interventions will enable more women to be successful in the pursuit of an EM major. Three main findings emerged from qualitative inquiry.

Both quantitative and qualitative methods were utilized in this study, offering a balance of broad data collection through statistical analysis with depth of qualitative inquiry. The qualitative piece provided details that the quantitative missed. Since the statistical analysis used factor analysis, which reduces variation to observe correlations for the sample, it extracts commonalities and loses details. Meaning that in this small sample, only the top topics were rated by a significant number of respondents. Therefore, just because a topic did not enter the quantitative model and did enter the qualitative model, it does not mean that the results are contradictory. It means that the qualitative piece was able to provide details that the quantitative missed. It is important to note, however, that the findings of both the quantitative and qualitative investigation are limited in that they can only conclusively be applied to the three institutions that participated in this study.

In the quantitative part, participants who were self motivated was associated with persistence. In the qualitative part, self-confidence and determination were indicated as a factor that helped female students persist in engineering and math. By being self motivated, one would have to be self-confidence and determined. Therefore, the integration of these data did not indicate any difference but rather supported one another. Participants who felt they had a safe learning environment were associated with persistence in the quantitative part. As for the qualitative part, participants felt that the most difficult factor for female students to overcome in the pursuit of EM degree was discrimination and stereotyping. These two findings were also integrated. Participants who felt they had a safe learning environment did not feel discriminated and stereotyped at the university, inside the classroom, by their professors, by their advisors, or by their peers. Hence, they were more likely to persist more than someone who did feel discriminated and stereotyped. By feeling discriminated and stereotyped, one can lose confidence in her ability to succeed and may choose to pursue another area (Steele et al., 2002).

University engagement was also associated with persistence among women in EM majors in the quantitative part. In the qualitative part, student engagement was identified as an intervention that would enable more women to be successful in the pursuit of an EM major. Since student engagement consists of university engagement, they are both integrated and support persistence among women in EM majors. "Student engagement in educationally purposeful activities inside and outside of the classroom is a precursor to high levels of student learning and personal development as well as an indicator of educational effectiveness" (Zhao & Kuh, 2004, p.115). The quantitative and qualitative findings for this study were related through the investigation of factors associated with persistence.

Limitations of Study

There were a few limitations that affected this study. One limitation to this study was its small sample size. The survey was available to six hundred participate. Only ninety-nine female seniors completed the online survey from the three universities combined. The overall response rate was 16.5. According to Yu & Cooper (1983), low response rates decrease the statistical power of the data and increase the size of the confidence interval regarding the sample. Additionally, low response rates challenge the perceived credibility of the study and undermine the actual generalizability of the study by producing misleading conclusions generated by nonresponse bias (Rogelberg & Stanton, 2007). However, Rogelberg and Stanton also state that if a study falls short of an expected response rate it does not mean that the data obtained was biased and that the research with low response rates should be discounted particularly when it examines new uncharted territory.

An important limitation is the lack of data from the five hundred and one non-responders; therefore, the researcher could not make any definite statements about the five hundred and one students. Furthermore, the researcher could not compare how the ninety-nine related to the five hundred and one. This limitation can undermine the generalizability of the three institutions.

Another possible limitation was utilizing the web. According to Pradhan (1999), response rates in web surveys have been reported to be as low as zero percent while overall response rates are typically less than thirty percent (Kaplowitz, Halock, & Levine, 2004). By using factor loading scores from the factor analysis and not from the underlying survey instrument, odds-ratio is difficult to interpret. Hence, it limits the interpretation to be suggestive at best and not conclusive. The final limitation to this study is sample bias. In this study, participation was optional; therefore, volunteering introduces a potential for subject bias, which reduces the credibility of the questionnaire results. According to Trochim (2001) respondents may answer less than truthfully in an attempt to make themselves look better to the researcher.

Recommendations for Policy, University Practices, and Future Research

Recommendations for Policy

Policymakers with an interest in persistence among women engineering and math majors should consider the following recommendations for implementing and expanding persistence among women engineering and math majors. The recommendations are based on the findings from the surveys. Each of these recommendations will encourage self-motivation, safe learning environment, and student engagement.

a. Provide female students with a good foundation in math, science, and engineering courses and require as many preparatory science and math courses as possible in the lower grades of school and high school to assist in the persistence of women majoring in EM.
b. Provide elementary and secondary female students with lots of enrichment activities in math and science.
c. Educate elementary, middle, and high school teachers to the broad range of math and science career options especially for female students.
d. Educate parents of female and minority students to the career possibilities in EM through public schools. Public schools need to educate parents to their role in setting high expectations and supporting their daughter's interest in an EM career choice.

e. Afford tutoring programs and mentoring relationship with EM career women at after school community outreach programs or camps. This will allow female students to have role models in EM and build self-confidence.
f. Start intervention programs for female students in EM early to expand the career outlooks of young women besides being a doctor or a lawyer.
g. Assist schools, universities, community outreach groups, business, and industry in being able to conduct intervention programs in EM by government assistance or grants. Government assistance or grants can also fund female students enrolled in EM program through grants and programs that target women and minorities that are underrepresented in EM programs.
h. Counteract the negative effects of sex-bias by broadening the awareness of female pre-teens to the realities of women in the STEM workplace. That task is a simple as taking every opportunity one-on-one to give young women the confidence that math and science are not just for boys.
i. Policymakers should continue to promote women majoring in EM and encourage more female students to participate.

Recommendations for University Practices

University need to help women majoring in EM in order for them to continue beyond their first year. By ensuring opportunities for women, postsecondary institutions can offset the decline in female EM enrollment. The recommendations below will encourage self-motivation, safe learning environment, and university engagement.

a. Increase personal interaction and guidance between women majoring in EM and faculty or advisors.

b. Mentor undergraduate women in EM in order to promote success. The participants' responded to one of the open-ended questions that they believe mentoring would enable more women to be successful in the pursuit of an EM major.

c. Strive to add female faculty to their math and science department, especially at introductory levels where likely recruits into the EM programs are to be found.

d. Promote the value of the contributions of female EM professionals.

e. Conduct interventions via peer tutoring groups for female undergraduates.

f. Develop opportunities for research and career exploration. An opportunity to engage in research during the undergraduate years is a powerful motivator for many female students. The open-ended comments revealed that student engagement was identified as an intervention that would enable more women in EM majors to be successful in the pursuit of an EM degree.

g. Provide student professional organizations in EM for female students.

h. Give more attention to be given to active recruitment of female underclassmen by the undergraduate science and math programs.

i. Develop an organizational structure through which women majoring in EM believe they play an integral and participative role in the operations of recruiting and retention of female students in EM.

j. Form partnerships with public schools, business, and industry to offer a variety of interventions programs for female students that begins with elementary school math and science camps and continue through internship programs for work and research experience at the undergraduate level.

k. Form a collaboration between academic and student affairs departments to provide student engagement that integrates programs that benefit the University, faculty, students and community. This collaboration enables the academic and development needs of students, the instructional and research needs of faculty and the professional competencies expected by employers. FAU has accomplished this through experiential learning, which explores professional areas of interest, develop intercultural skills, gain credits towards graduation, network with professionals, and contribute to the community.

l. Conduct continuous assessment of persistence of undergraduate women majoring in EM through the utilization of formal assessment instruments and informal exit interviews of those female students who depart the major in EM.

Recommendations for Future Research

This study identifies what factors best explain persistence among women EM majors. The findings offer insights for future study. Hence, further study is recommended.

a. Expand the research base beyond the three institutions for this study to provide a greater number of participants to analyze the statistical data.

b. Revise the survey and eliminate the survey questions that gave weak correlations.
c. Conduct more research on the relationship between race and ethnicity and factors that predict persistence of undergraduate women majoring in STEM.
d. Conduct a similar study for undergraduate women majoring in science and technology to determine the factors associated with persistence.
e. Conduct research on undergraduate women who discontinue majoring in EM to determine the contributing factors of non-persistence in EM.
f. Conduct an analysis of an individual university to examine more deeply the factors associated with persistence of undergraduate women majoring in EM.
g. Conduct a similar study for private institutions to determine the factors associated with persistence of undergraduate women majoring in EM.
h. Compare the factors associated with persistence of undergraduate women majoring in EM at private and public colleges and universities.
i. Explore the factors associated with persistence among women who majored in EM beyond the four year degree by looking at graduate program enrollment, involvement in alumni organizations in EM, job placement, income, career satisfaction, career changes, and as well as involvement in professional organizations.
j. Continue developing studies that compare women to women. The body of literature mainly compares women to men. They are just different (Rhode, 1990).

Conclusion

This chapter presented the findings and conclusions of the study of factors associated with persistence of undergraduate women majoring in engineering and math at FAU, UCF, and US. Without the assistance and cooperation of these institutions, this dissertation would not have been possible. The study involved an analysis of the survey results and revealed that participants who were self motivated, felt they had a safe learning environment, and were engaged by the university more likely to persist in engineering and math. The survey also revealed that participants viewed that the most important factor that helps female students persist was self-confidence, that the most difficult factor for female to overcome was discrimination and stereotyping, and that student engagement as an intervention will enable more women to be successful in the pursuit of a engineering or math degree. However, the survey did not reveal that race and ethnicity predict persistence of undergraduate women majoring in engineering and math. Based on the findings of the study, policymakers and university administrators are encouraged to continue supporting women majoring in EM and to increase awareness and access that encourage persistence of women in the pursuit of EM career goals by expanding programs based on models that have been proven successful. The researcher urges further study of women in EM majors in an effort to promote persistence of women in the pursuit of engineering and math career goals.

APPENDIX A

Narrative Summary of 2009 National Science Foundation Report

Statistical Picture of Women in Postsecondary Education and Careers: Half of postsecondary teachers were women, as well as one-third of lawyers and judges, and 30 percent of physicians. In science and engineering occupations, 64 percent of psychologists, 41 percent of biological and life scientists, 26 percent of mathematics and computer scientists, and 11 percent of engineers were women.

Women receive 57.8 percent of all bachelor degrees, 60 percent of all master degrees, and 50.8 percent of all doctoral degrees when all disciplines are combined. "The number of non-S&E bachelor's degree awarded to women is substantially higher than those awarded to men and is substantially higher than the number of S&E bachelor's degree to either men or women" (NSF, 2009, p.4). Thus, they are underrepresented in science, mathematics, and engineering. More men than women at the postsecondary level enroll in the areas of math, science, and engineering (NCES, 1997a). Hence, woman are underrepresented among SME degree recipients at all levels, particularly at the graduate level, 50.5 percent earning of bachelor's degrees, 44.9 percent of master's degree, and 38.4 percent of doctoral degrees went to women. Ever since 1966, the number of SME bachelor's degrees awarded to women has increased almost every year. Since 2000, women and men have earned approximately the same number of SME bachelor's degrees. However, females were more likely than males to have their baccalaureate origin institution in a liberal arts college (Leggon, 2006). Predominantly women's colleges have played a major role in producing females who earn doctorates in SME (Leggon, 2006).

Women constituted a greater percentage of graduate students in SME in 2006 (43 percent) than in 1996 (39 percent). Women accounted for 56 percent of graduate students in biological sciences, 23 percent in engineering, and 25 percent in computer sciences. From 1996 to 2006, women's share of SME graduate students increased in every field but computer sciences. The doctoral degrees awarded in SME to female holders rose over three decades and then flattened after 1995.

In 2006, women received 44.9 percent, 55.7 percent, and 19.5 percent of the bachelor's degrees awarded in math, science, and engineering, respectively, a much smaller percentage of doctoral degrees in math 29.6 percent, science 44.2 percent, and engineering 20.2 percent were awarded to women. Even through in the past thirty years the number of science, math, and engineering (SME) bachelor's, master's, and doctoral degrees awarded to women has increased by 106 percent, 150 percent, and 267 percent, respectively, woman remain underrepresented in traditionally male fields (NSF, 1995).

The number of SME master's degrees awarded increased for all minority groups and for white women since 1990 (NSF, 2007). In 2006, underrepresented minorities (blacks, Hispanics, American Indians/Alaska Natives as a group) earned 17 percent of both SME and non-SME bachelor's degree. The percentage of SME bachelor's degree earned by white female was 31.6, Asian/Pacific Islander female was 4.6, Black female was 5.3, Hispanic female was 4.3, American Indian/ Alaskan Native female was .4, other or unknown race/ethnicity female was 2.7, and temporary resident female was 1.6. The percentage of science, mathematics and statistics, and engineering bachelor's degree earned by white female was 30, 1, and1.6, respectively, Asian/Pacific Islander female was 4.2, 0.1, and 4.4, respectively, Black female was 5.1, 0.09, and 0.2, respectively, Hispanic female was 4.1, 0.08, and 0.25, respectively, American Indian/ Alaskan Native female was .38, 0.0065, and 0.015, respectively, other or unknown race/ethnicity female was 2.5, 0.07, and 0.11, respectively, and temporary resident female was 1.4, 0.07, and 0.22, respectively.

Master's and doctorate's degree in SME and non-SME from 1989 to 2006 has increased for minorities. Underrepresented minorities earned a higher proportion of non-SME master's and doctorate's degrees than SME master's and doctorate's degree. The exception to this case is Asians/Pacific Islanders. According to the NSF (2009), underrepresented minorities (blacks, Hispanics, and American Indians/ Alaska Natives) increased their share of SME graduate and doctoral students and earned 12 percent and 10 percent of SME master's and doctorate's degrees, respectively. However, their overall participation remained low. The SME graduate and doctoral study participation rates are well below the 17 percent of SME baccalaureate degrees earned by underrepresented minorities.

APPENDIX B

Statistical Data Summary of 2009 National Science Foundation Report Based on the Year 2006

Table 1.

The percentage of women received degrees in all fields at US colleges and universities

Degree	Percentage (%)
Bachelor's degree	57.8
Master's degree	60
Doctorate's degree	50.8

Table 2.

The percentage of non-SME and SME degrees earned by women

	Percentage (%) of non-SME Bachelor's Degree	Percentage (%) of SME Bachelor's Degree	Percentage (%) of SME Master's Degree	Percentage (%) of SME Doctorate's Degree
Women	61.2	50.5	44.9	38.4
Minorities- Blacks, Hispanics, and American Indians/ Alaska Natives	17	17	12	10

Table 3.

The percentage of women received degrees in science, math, and engineering

Degree	Percentage (%) awarded in math	Percentage (%) awarded in science	Percentage (%) awarded in engineering
Bachelor's degree	44.9	55.7	19.5
Master's degree	42.6	52.4	22.9
Doctorate's degree	29.5	44.2	20.2

Table 4.

The percentage of SME bachelor's degree awarded to all minority groups and white women

Female	**Percentage (%) of SME Bachelor's Degree**	**Percentage (%) of Science Bachelor's Degree**	**Percentage (%) of Mathematics and Statistics Bachelor's Degree**	**Percentage (%) of Engineering Bachelor's Degree**
White	31.6	30	1	1.6
Asian/ Pacific Islander	4.6	4.2	0.1	4.4
Black	5.3	5.1	0.09	0.2
Hispanic	4.3	4.1	0.08	0.25
American Indian/ Alaskan Native	0.4	.38	0.0065	0.015
Other or unknown race/ ethnicity	2.7	2.5	0.07	0.11
Temporary resident	1.6	1.4	0.07	0.22

Table 5.

Occupations filled by females

Occupations	**Percentage (%)**
Psychologists	64
Postsecondary Teachers	50
Biological and Life Scientists	41
Lawyers and Judges	33
Physicians	30
Mathematics and Computer Scientists	26
Engineers	11

APPENDIX C

Survey Questions

A Study of Persistence of Undergraduate Women Majoring in Math or Engineering

Part I

Screening Questions

1) Gender

- ◯ *Male* 1
- ◯ *Female* 2

2) What is your current class rank?

- ◯ *Freshman* 1
- ◯ *Sophomore* 2
- ◯ *Junior* 3
- ◯ *Senior* 4

3) My first true declared major at the university was:

- ◯ *In a Mathematics discipline* 1
- ◯ *In a Engineering discipline* 2
- ◯ *In another discipline* 3

4) I expect to graduate with a degree in:

- ◯ *Mathematics* 1
- ◯ *Engineering* 2
- ◯ *Other* 3

Part II

Please rate your agreement with these items using the following scale:

		Strongly Disagree 1	Disagree 2	Neither Disagree or Agree 3	Agree 4	Strongly Agree 5
5a)	The math faculty at the university are friendly and available outside class.					
5b)	My interaction with faculty has enhanced my academic performance in math.	1	2	3	4	5
5k)	The math faculty are good classrooms teachers and lab instructors.	1	2	3	4	5
5l)	The atmosphere in my math classes is female friendly.	1	2	3	4	5
5m)	I feel that I have a supportive peer group in math.	1	2	3	4	5
5q).	The atmosphere inside the classroom is free from discrimination and stereotyping on the basis of gender.	1	2	3	4	5
5y)	I have a high level of self-confidence in my abilities in math.	1	2	3	4	5
5ab)	I am not afraid to speak out or even challenge others in my math classes.	1	2	3	4	5
5o)	I enjoy learning math.	1	2	3	4	5

Please rate your agreement with these items using the following scale:

		Strongly Disagree 1	Disagree 2	Neither Disagree or Agree 3	Agree 4	Strongly Agree 5
5ac)	I look forward to taking math courses.					
5ad)	I am comfortable working independently in math coursework.	1	2	3	4	5
5ae)	I am involved and not isolated in math courses.	1	2	3	4	5
5af)	I aim to excel in the subject matter of mathematics.	1	2	3	4	5
5p)	I aim to be one of the top students in my math courses.	1	2	3	4	5

17

Part II

Please rate your agreement with these items using the following scale:

		Strongly Disagree	*Disagree*	*Neither Disagree or Agree*	*Agree*	*Strongly Agree*
5n)	The engineering faculty at the university are friendly and available outside class.	1	2	3	4	5
5ah)	My interaction with faculty has enhanced my academic performance in engineering.	1	2	3	4	5
5ai)	The engineering faculty are good classrooms teachers and lab instructors.	1	2	3	4	5
5al)	The atmosphere in my engineering classes is female friendly.	1	2	3	4	5
5am)	I feel that I have a supportive peer group in engineering.	1	2	3	4	5
5ao).	The atmosphere inside the classroom is free from discrimination and stereotyping on the basis of gender.	1	2	3	4	5
5aj)	I have a high level of self-confidence in my abilities in engineering.	1	2	3	4	5
5ak)	I am not afraid to speak out or even challenge others in my engineering classes.	1	2	3	4	5
5an)	I enjoy learning engineering.	1	2	3	4	5

Please rate your agreement with these items using the following scale:

		Strongly Disagree	*Disagree*	*Neither Disagree or Agree*	*Agree*	*Strongly Agree*
5ap)	I look forward to taking engineering courses.	1	2	3	4	5
5bh)	I am involved and not isolated in engineering courses.	1	2	3	4	5
5ar)	I am comfortable working independently in engineering coursework.	1	2	3	4	5

5as)	I aim to excel in the subject matter of engineering.	1	2	3	4	5
5aq)	I aim to be one of the top students in my engineering courses.	1	2	3	4	5

19 **Part II**

Please rate your agreement with these items using the following scale:

		Strongly Disagree	*Disagree*	*Neither Disagree or Agree*	*Agree*	*Strongly Agree*
		1	2	3	4	5
5at)	When I was a math major, my college advisors helped me with my class schedule and career goals.					
5au)	When I was a math major, the math faculty at the university were friendly and available outside class.	1	2	3	4	5
5av)	When I was a math major, my interaction with faculty had enhanced my academic performance in math.	1	2	3	4	5
5ax)	When I was a math major, the math faculty were good classrooms teachers and lab instructors.	1	2	3	4	5
5ay)	When I was a math major, the atmosphere in my math classes was female friendly.	1	2	3	4	5
5az)	When I was a math major, I felt that I have a supportive peer group in math.	1	2	3	4	5
5ba)	When I was a math major, the atmosphere inside the classroom was free from discrimination and stereotyping on the basis of gender.	1	2	3	4	5
5bb)	When I was a math major, I felt that I must do better than my male counters in order to be considered equal.	1	2	3	4	5

	Please rate your agreement with these items using the following scale:	Strongly Disagree 1	Disagree 2	Neither Disagree or Agree 3	Agree 4	Strongly Agree 5
5bc)	When I was a math major, I had a high level of self-confidence in my abilities in math.					
5aw)	When I was a math major, I was not afraid to speak out or even challenge others in my math classes.	1	2	3	4	5
5bd)	When I was a math major, I enjoyed learning math.	1	2	3	4	5
5be)	When I was a math major, I looked forward to taking math courses.	1	2	3	4	5
5bf)	When I was a math major, I was comfortable working independently in math coursework.	1	2	3	4	5
5bg)	When I was a math major, I was involved and not isolated in math courses.	1 2	3	4	5	6
5bi)	When I was a math major, I aimed to excel in the subject matter of mathematics.	1 2	3	4	5	6
5bj)	When I was a math major, I aimed to be one of the top students in my math courses.	1 2	3	4	5	6

20

Part II

	Please rate your agreement with these items using the following scale:	Strongly Disagree 1	Disagree 2	Neither Disagree or Agree 3	Agree 4	Strongly Agree 5
5ag)	When I was an engineering major, my college advisors helped me with my class schedule and career goals.					
5bk)	When I was an engineering major, the engineering faculty at the university were friendly and available outside class.	1	2	3	4	5
5bl)	When I was an engineering major, my interaction with faculty had enhanced my academic performance in engineering.	1	2	3	4	5

5bp)	When I was an engineering major, the engineering faculty were good classrooms teachers and lab instructors.	1	2	3	4	5
5bq)	When I was an engineering major, the atmosphere in my engineering classes was female friendly.	1	2	3	4	5
5br)	When I was an engineering major, I felt that I have a supportive peer group in engineering.	1	2	3	4	5
5bm)	When I was an engineering major, the atmosphere inside the classroom was free from discrimination and stereotyping on the basis of gender.	1	2	3	4	5
5bs)	When I was an engineering major, I felt that I must do better than my male counters in order to be considered equal.	1	2	3	4	5
	Please rate your agreement with these items using the following scale:					
		Strongly Disagree 1	*Disagree* 2	*Neither Disagree or Agree* 3	*Agree* 4	*Strongly Agree* 5
5bt)	When I was an engineering major, I had a high level of self-confidence in my abilities in engineering.					
5bn)	When I was an engineering major, I was not afraid to speak out or even challenge others in my engineering classes.	1	2	3	4	5
5bu)	When I was an engineering major, I enjoyed learning engineering.	1	2	3	4	5
5bv)	When I was an engineering major, I looked forward to taking engineering courses.	1	2	3	4	5
5bo)	When I was an engineering major, I was comfortable working independently in engineering coursework.	1	2	3	4	5
5bw)	When I was an engineering major, I was involved and not isolated in engineering courses.	1	2	3	4	5
5bx)	When I was an engineering major, I aimed to excel in the subject matter of engineering.	1	2	3	4	5

5by)	When I was an engineering major, I aimed to be one of the top students in my engineering courses.	1	2	3	4	5

Please rate your agreement with these items using the following scale:

		Strongly Disagree	*Disagree*	*Neither Disagree or Agree*	*Agree*	*Strongly Agree*
		1	2	3	4	5
5cd)	I had a high GPA in my high school math and science classes.					
5ce)	My family encouraged me to pursue a math major.	1	2	3	4	5
5cm)	My family encouraged me to pursue an engineering major.	1	2	3	4	5
5ch)	I knew before I left high school that I wanted a career in math.	1	2	3	4	5
5ci)	I knew before I left high school that I wanted a career in engineering.	1	2	3	4	5
5cj)	I have a long term math career goal from which I did not waver once I declared a math major.	1	2	3	4	5
5ck)	I have a long term engineering career goal from which I did not waver once I declared a engineering major.	1	2	3	4	5
5bz)	I had high school teachers who encouraged girls in math and science classes.	1	2	3	4	5

Please rate your agreement with these items using the following scale:

		Strongly Disagree	*Disagree*	*Neither Disagree or Agree*	*Agree*	*Strongly Agree*
		1	2	3	4	5
5cf)	I feel that I must do better than my male counterparts in order to be considered equal.					
5ca)	My college advisors helped me with my class schedule and career goals.	1	2	3	4	5

Please rate your agreement with these items using the following scale:

		Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly Agree
5cb)	I have mentor or role model whose influence helps me get through undergraduate years.	1	2	3	4	5
5cl)	The atmosphere at this university is free from discrimination and stereotyping on the basis of gender.	1	2	3	4	5
5cc)	I am confident that I will achieve my life goals.	1	2	3	4	5

High School Years

Depending on the question, one may fill in the blanks or select the best description of your high school years.

8) What was your high school GPA?

- *2.00-2.60* 1
- *2.61-3.20* 2
- *3.21-3.80* 3
- *3.81-4.40* 4
- *4.41-5.00* 5

9) What was your Verbal SAT score?

- *200-320* 1
- *330-440* 2
- *450-560* 3
- *570-680* 4
- *690-800* 5
- *Not applicable* 6

10) What was your Math SAT score?

- *200-320* 1
- *330-440* 2
- *450-560* 3
- *570-680* 4
- *690-800* 5
- *Not applicable* 6

11) What was your ACT score?

- *2-8* 1
- *9-15* 2
- *16-22* 3
- *23-29* 4
- *30-36* 5
- *Not applicable* 6

12) Which of the following mathematics courses listed below did you take in high school? Mark all that apply.

- *Algebra* 1
- *Geometry* 2
- *Algebra II* 3
- *Statistics* 4
- *Integrated Math* 5
- *Precalculus/ Trigonometry* 6
- *Calculus* 7

13) How many years of science courses did you complete in high school?

- *4* 1
- *3* 2
- *2* 3
- *1* 4

14) How would you describe your household income during your high school years?

- *An upper income household* 1
- *A middle income household* 2
- *A low income household* 3

Undergraduate Years

15) What university do you attend?

- *Florida Atlantic University* 1
- *University of South Florida* 2
- *University of Central Florida* 3

16) What is your current GPA?

- *2.00-2.40* 1
- *2.41-2.80* 2
- *2.81-3.20* 3
- *3.21-3.60* 4
- *3.61-4.00* 5

17) On average, how many credit hours did you complete each semester?

- *12 or more* 1
- *Fewer than 12* 2

18) On average, how many hours per week did you spend studying for each college level mathematics course?

- *None* 1
- *Less than 1 hour* 2
- *1-2 hours* 3
- *2-4 hours* 4
- *More than 4 hours* 5

19) On average, how many hours per week did you spend studying for each college level engineering course?

- *None* 1
- *Less than 1 hour* 2
- *1-2 hours* 3
- *2-4 hours* 4
- *More than 4 hours* 5

During your college years, how often have you participated in the following types of activities?

		Never	*Once*	*Several Times*	*Almost every semester*
20a)	Academic department clubs, organizations, society, or seminars	1	2	3	4
20b)	Clubs, organizations, society, or seminars that are not academic department related	1	2	3	4
20c)	Political or social action groups	1	2	3	4
20d)	Campus or community volunteer work	1	2	3	4

20e)	Assistantships, fellowships, internships, or co-op program	1	2	3	4
20f)	Minority support program	1	2	3	4
20g)	Faculty research project or publication	1	2	3	4
20h)	Tutoring program- being a peer tutor	1	2	3	4
20i)	Tutoring program- being a student who gets tutored	1	2	3	4
	During your college years, how often have you participated in the following types of activities?				
		Never	*Once*	*Several Times*	*Almost every semester*
20j)	Peer mentoring program- being a peer mentor	1	2	3	4
20k)	Peer mentoring program- being a student who gets mentored	1	2	3	4
20l)	Leadership program	1	2	3	4
20m)	Recruiting program- being a peer member that helps to recruit students to the math program	1	2	3	4
20n)	Recruiting program- being a peer member that helps to recruit students to the engineering program	1	2	3	4
20o)	Recruiting program- being a peer member that helps to recruit students to the math program	1	2	3	4
20p)	Recruiting program- being a peer member that helps to recruit students to the engineering program	1	2	3	4
20q)	Recruiting program- was recruited by this program to get involved in the math program	1	2	3	4
20r)	Recruiting program- was recruited by this program to get involved in the engineering program	1	2	3	4

20s)	Recruiting program- was recruited by this program to get involved in the math program	1	2	3	4
20t)	Recruiting program- was recruited by this program to get involved in the engineering program	1	2	3	4
20u)	Outreach program- a program that implements activities or services to the community as an act of charity or goodwill	1	2	3	4
20v)	Student retention program- a program that helps students persist in their major and the university	1	2	3	4

21) What type of interventions do you believe will enable more women to be successful in the pursuit of a Math or Engineering degree? What about these interventions makes you believe that is will be effective in encouraging the persistence of women in Math and Engineering major?

22) On average, how many hours per week have you been employed while attending the university?

- *Mostly on campus during the school term* 1
- *Mostly off campus 10 hours or less per week* 2
- *Mostly off campus between 10 and 20 hours per week* 3
- *Mostly off campus more than 20 hours per week* 4
- *Seldom employed on or off campus during the school term* 5

23) What is your main source of financing for your college education?

- *Parents or family* 1
- *Employment* 2
- *Personal savings* 3
- *Scholarships or grants* 4
- *Loans* 5

24) What of the following do you believe were reasons that you did not persist as a math major? Mark all that apply.

☐ *No family support and encouragement*	01
☐ *No faculty support and encouragement*	02
☐ *No guidance*	03
☐ *No mentor or role model*	04
☐ *Not confident of my ability to succeed*	05
☐ *Did not enjoy the major*	06
☐ *Felt isolated*	07
☐ *Lack of financial aid*	08
☐ *Entered the university unprepared in math and science*	09
☐ *Unable to dedicate time to the major because of family commitments*	10
☐ *Discrimination and stereotyping on the basis of gender inside the classroom*	11
☐ *Discrimination and stereotyping on the basis of gender at the university*	12
☐ *Low level of self-confidence in my abilities in math*	13
☐ *Unable to work independently in math coursework*	14
☐ *Did not dedicate enough studying time*	15
☐ *Worked too many hours*	16

25) What of the following do you believe were reasons that you did not persist as a engineering major? Mark all that apply.

☐ *No family support and encouragement*	01
☐ *No faculty support and encouragement*	02
☐ *No guidance*	03
☐ *No mentor or role model*	04
☐ *Not confident of my ability to succeed*	05
☐ *Did not enjoy the major*	06
☐ *Felt isolated*	07
☐ *Lack of financial aid*	08
☐ *Entered the university unprepared in math and science*	09
☐ *Unable to dedicate time to the major because of family commitments*	10
☐ *Discrimination and stereotyping on the basis of gender inside the classroom*	11
☐ *Discrimination and stereotyping on the basis of gender at the university*	12
☐ *Low level of self-confidence in my abilities in engineering*	13
☐ *Unable to work independently in engineering coursework*	14
☐ *Did not dedicate enough studying time*	15
☐ *Worked too many hours*	16

Part III
Demographics

26) When you came to the university were you:

First time freshman	1
Transfer with an Associate in Arts degree	2
Transfer without an Associate in Arts degree	3

27) Ethnicity:
Are you Hispanic or Latino (Include persons from Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture origin, regardless of race)?

Yes	1
No	2

28) Race:
Please select the racial category or categories with you most closely identify by selecting the appropriate box or boxes. Check all that apply.

American Indian or Alaska Native	1
Asian	2
Black or African American	3
White	4
Native Hawaiian or Other Pacific Islander	5
Some Other Race	6
International (not an USA citizen or a permanent resident)	7
Prefer not to disclose	8

29) When you selected a major in math, how confident were you that you would be able to finish that major?

Very confident	1
Somewhat confident	2
Uncertain	3
Not very confident	4
Not applicable	5

30) When you selected a major in engineering, how confident were you that you would be able to finish that major?

Very confident	1
Somewhat confident	2
Uncertain	3
Not very confident	4
Not applicable	5

31) What is the highest level of education achieved by your parent (or guardian)?

- Less than High School 1
- High School/ GED 2
- Some College 3
- 2 year College Degree (Associates) 4
- 4 year College Degree (BA, BS) 5
- Master's Degree 6
- Doctoral Degree 7
- Professional Degree (MD, JD) 8

32) Have your parents pursued careers in science, math, or engineering?

- Yes, both parents 1
- Yes, one parent 2
- No 3

33) Please check all that apply:

- I am married 1
- I have children whom I care for in my household 2
- I have dependent, ill, or invalid adult family members whom I care for 3

Open Ended Questions

5) What is the most important factor that helps female students persist in a Math major?

6) What is the most important factor that helps female students persist in a Engineering major?

7() What are the most difficult factors for female students to overcome in the pursuit of Math degree?

20) What are the most difficult factors for female students to overcome in the pursuit of Engineering degree?

34) Survey participants, please indicate whether or not you would like to receive a Starbucks gift card.

- ○ *Yes* 1
- ○ *No* 2

35) If you said yes, please provide your name and address in order to receive the gift card in the mail.

You must be a female senior who started In Math or Engineering in order to take the survey.

If you are please click the back button below to return to the previous questions and select the appropriate responses, otherwise please click submit below to exit the survey.

Thank you for your participation and input

Please click submit below to complete the survey

APPENDIX D

Cover Letter/Consent Form

Greetings Students:

You have been selected to represent women who declared first major in mathematics or engineering. Participation in this study will receive a Starbucks gift card. As students or former students in a engineering or math major, you are aware of the unique obstacles, and gender-specific demands that women in the pursuit of a engineering or math major may encounter. Your experience and insight are sought in this study.

1) <u>Title of Research Study:</u> A Study of Persistence of Undergraduate Women Majoring in Engineering and Math.

2) <u>Investigator:</u>, Jessica M. Pena-Lopez- Doctoral Candidate, Florida Atlantic University
Dr. Ira Bogotch- Professor of School Leadership, Florida Atlantic University
Dr. Deborah Floyd- Professor and Coordinator of Higher Education Program

3) <u>Purpose:</u> The purpose of this study is to identify which factors encourage the persistence of undergraduate women majoring in Engineering and Math (EM) at Florida Atlantic University, University of Central Florida, and University of South Florida.

4) <u>Procedures:</u> If you are willing to participate in this study, you are asked to complete a survey. You will be asked about your experiences as a engineering or math major. The electronic form survey may take approximately 15 minutes to complete.

5) <u>Risks:</u> The risks involved in participating in this study are no more than one would experience in normal daily activities. You may, however, refuse to participate, refuse to answer any questions, or withdraw from the study at any time without penalty.

6) <u>Benefits:</u> Benefits to the participants are anticipated to be positive. By reflecting on past experiences and sharing them with the researchers, the participants may find satisfaction in knowing that they have contributed to a better understanding of undergraduate women majoring in engineering and math. Further, participating in this study will help provide useful information about the conditions that affect the persistence of women in the pursuit of a engineering or math degree.

7) <u>Data Collection & Storage:</u> All of the results will be kept confidential and secure and only the people working with the study will see your data, unless required by law. Data will be stored on a secure server hosted in the Office of Institutional Effectiveness & Analysis at FAU, only accessible by departmental staff. Confidentiality will be maintained and will involve storing all data in a locked file cabinet (or password protected computer) for the duration of five years. The researchers have instituted several safeguards to protect the confidentiality of your information in this research. However, as with any online transmission of data, access to this information is a possibility.

8) <u>Contact Information:</u> For related problems or questions regarding your rights as a research subject, contact the Florida Atlantic University Division of Research at (561) 297-0777. For other questions about the study, you should call the principal investigators, Dr. Ira Bogotch at (561) 297-3558 or Dr. Deborah Floyd at (561) 297-2671, or Mrs. Jessica Pena-Lopez at (561) 358-1411.

9) <u>Consent Statement:</u> I have read or had read to me the preceding information describing this study. All my questions have been answered to my satisfaction. I am 18 years of age or older and freely consent to participate. I understand that I am free to withdraw from the study at any time without penalty. I have received a copy of this consent form.

Please print this letter and keep it for your records. By clicking on the link below and answering the following survey questions, you are consenting to participate in this study and agree to the above.

Both your time and effort are greatly appreciated. Thank you.

Sincerely,
Jessica M. Pena-Lopez
Ph.D. Candidate

http://iea.fau.edu/surveys/snap/penastudyfall2010.htm

APPENDIX E

Survey Questions with Item Names

Support and Encouragement

	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q5a	Q5n	Q5au	Q5bk	FacFriendAvail
2	Q5b	Q5ah	Q5av	Q5bl	InteractWFac
3	Q5k	Q5ai	Q5ax	Q5bp	FacGoodTeach
4	Q5l	Q5al	Q5ay	Q5bq	AtmosFemaleFriend
5	Q5m	Q5am	Q5az	Q5br	SupportPeerGrp
6	Q5ca	Q5ca	Q5at	Q5ag	AdvisorHelp
7	Q5cl	Q5cl	Q5cl	Q5cl	UnivAtmosDisSter
8	Q5cf	Q5cl	Q5bb	Q5bs	DoBettrThanMale
9	Q5ce	Q5cm	Q5ce	Q5cm	FamilyEncour
10	Q5q	Q5ao	Q5ba	Q5bm	CAtmosFreeDisSter
11	Q5bz	Q5bz	Q5bz	Q5bz	HSTeachEncourMS
12	Q5cb	Q5cb	Q5cb	Q5cb	MentorInfluen
13	Q14	Q14	Q14	Q14	HSIncome
14	Q31	Q31	Q31	Q31	ParntGuardEdu
15	Q32	Q32	Q32	Q32	ParntCareerSME
16	Q33	Q33	Q33	Q33	Status

Self-Confidence

	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q5y	Q5aj	Q5bc	Q5bt	SelfconfAbility
2	Q5ab	Q5ak	Q5aw	Q5bn	SpeakOutChall
3	Q5ch	Q5ci	Q5ch	Q5ci	HSCareerME
4	Q5cj	Q5ck	Q5cj	Q5ck	DidntWaverCareerME
5	Q5cc	Q5cc	Q5cc	Q5cc	ConfidLifeGoal
6	Q29	Q30	Q29	Q30	ConfidFinMaj

Motivation

	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q5o	Q5an	Q5bd	Q5bu	EnjoyLearn
2	Q5ac	Q5ap	Q5be	Q5bv	LookForwrdC
3	Q5ad	Q5ar	Q5bf	Q5bo	WorkIndepCWork
4	Q5ae	Q5bh	Q5bg	Q5bw	InvolvedC
5	Q5af	Q5as	Q5bi	Q5bx	AimToExcel
6	Q5p	Q5aq	Q5bj	Q5by	AimTopStud

Academic Achievement

	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q5cd	Q5cd	Q5cd	Q5cd	HighGPAHSMS
2	Q8	Q8	Q8	Q8	HSGPA
3	Q9	Q9	Q9	Q9	VSAT
4	Q10	Q10	Q10	Q10	MSAT
5	Q11	Q11	Q11	Q11	ACT
6	Q12	Q12	Q12	Q12	HSMathCode
7	Q13	Q13	Q13	Q13	YearHSSC
8	Q16	Q16	Q16	Q16	UGGPA
9	Q18	Q19	Q18	Q19	StudyHrPerWeek

Student Engagement in College

	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q17	Q17	Q17	Q17	CreditHr
2	Q20a	Q20a	Q20a	Q20a	AcadOrg
3	Q20b	Q20b	Q20b	Q20b	NonAcadOrg
4	Q20c	Q20c	Q20c	Q20c	PoliticalGrp
5	Q20d	Q20d	Q20d	Q20d	Volunteer
6	Q20e	Q20e	Q20e	Q20e	Assistantships
7	Q20f	Q20f	Q20f	Q20f	MinorProg
8	Q20g	Q20g	Q20g	Q20g	FacResearchProg
9	Q20h	Q20h	Q20h	Q20h	PeerTutor
10	Q20i	Q20i	Q20i	Q20i	TutorProg
11	Q20j	Q20j	Q20j	Q20j	PeerMentor
12	Q20k	Q20k	Q20k	Q20k	MentorProg
13	Q20l	Q20l	Q20l	Q20l	LeadershipProg
14	Q20m	Q20n	Q20o	Q31p	PeerRecruit
15	Q20q	Q20r	Q20s	Q20t	RecruitProg
16	Q20u	Q20u	Q20u	Q20u	OutreachProg
17	Q20v	Q20v	Q20v	Q20v	StudentRetentionProg
18	Q22	Q22	Q22	Q22	HrEmploy
19	Q23	Q23	Q23	Q23	EduFinance

Race and Ethnicity

Ethnicity	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q27	Q27	Q27	Q27	Ethnicity

Race	Major in Math	Major in Engineerin g	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q28	Q28	Q28	Q28	Race

Biographical Data

	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q1	Q1	Q1	Q1	Gender
2	Q2	Q2	Q2	Q2	CurrentClassRank
3	Q3	Q3	Q3	Q3	FirstTrueDeclaredMaj
4	Q4	Q4	Q4	Q4	Expected Degree
5	Q26	Q26	Q26	Q26	CameToUniversity
6	Q15	Q15	Q15	Q15	UniversityAttend

Open Ended Questions

	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1	Q21	Q21	Q21	Q21	Proactive Interventions
2	Q5	Q6	Q5	Q6	Most Important Factors
3	Q7	Q20	Q7	Q20	Most Difficult Factors

Reason why not persisted

Ethnicity	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering	Item Name
1			Q24	Q25	NotPersist

Starbucks Questions

Ethnicity	Major in Math	Major in Engineering	Non-persisters in Math	Non-persisters in Engineering
1	Q34	Q34	Q34	Q34
2	Q35	Q35	Q35	Q35

REFERENCES

About UCF. (2009). University of Central Florida Undergraduate Admissions. Retrieved from http://www.admisions.ucf.edu/about .asp

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

Adelman, C., Daniel, B., Berkovits, I., & Owings, J. (2003). *Postsecondary attainment, attendance, curriculum, and performance: Selected results from the NELS: 1988/2000 postsecondary education transcript study*. Washington, DC: U.S. Department of Education. National Center for Education Statistics.

American Sociological Association. (2005). *ASA Council statement on the causes of gender differences in science and math career achievement*. Retrieved from http://www.asanet.org/cs/root/topnav/press/asa_council_statement_on_causes_of_gender_differences_in_science_and_math_career_achievement

Angier, N. (2003, May 6). No parity yet, but Science Academy gains more women. *The New York Times*. p.F2.

Astin, A. (1977). *Four critical years*. San Francisco, CA: Jossey-Bass.

Babco, E. (2003). Trends in African American and Native American participation in STEM higher education. Retrieved from Commission on Professionals in Science and Technology website: http://www.cpst.org/STEM.pdf

Barber, L. A. (1995). U.S. women in science and engineering, 1960-1990. Progress toward equity*? Journal of Higher Education*, *66*(2), 213-234.

Basken, P. (2009, August 4). Female students just as persistent as men in engineering, database shows. *The Chronicle of Higher Education*. Retrieved from http://chronicle.com/article/Female-Students-Are-Just-as/47933/

Bix, A. S. (2004). From "Engineering" to "Girl Engineers" to "Good Engineers": A history of women's U. S. engineering education. *National Women's Studies Association*,*16*(1), 27.

Boli, J., Allen, M. L., & Payne, A. (1985). High-ability women and men in undergraduate mathematics and chemistry courses. *American Educational Research Journal*, *22*(4), 605-626.

Brainard, S., & Carlin, L. (1998). A longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education*. Retrieved from http://www.iwitts.com/html/brainard.pdf

Brogan, F. T. (2008). *Affirming diversity*. Retrieved from Florida Atlantic University, Office Of The President website: http://www.fau.edu/president/diversity/

Bystydzienski, J. M. (2004). (Re)Gendering science fields: Transforming academic science and engineering. *NWSA Journal*, *16*(1), viii-xii.

Cabrera, A. F., Nora, A., Terenzini, P. T., Pascarella, E., & Hagedorn, L. S. (1999). Campus racial climate and the adjustment of students to college: A comparison between white students and African-American students. *Journal of Higher Education*, 70.2 (March-April), 134.

Campbell, A. & Skoog, G. (2004). Preparing undergraduate women for science careers. *Journal of College Science Teaching*. *33*(5), 24-26.

Campbell, J. R., Hombo, C. M., & Mazzeo, J. (2000). *NAEP 1991 trends in academic progress: Three decades of student performance.* Washington, DC: U.S. Department of Education. National Center for Education Statistics.

Chronicle. (1999, August 27). Almanac Issue. *The Chronicle of Higher Education*, *46*(1), 1-132.

Clausing, J. (1999, August 27). Bills reopen debate over visa limit. *The New York Times*. Retrieved from http://www.programmersguild.org/archives/lib/Abuse/nyt1990831fraud.htm

College of Engineering and Computer Science: Student Services. (2009). University of Central Florida. Retrieved from http://www.cecs.ucf.edu/students/

College of Engineering and Computer Science: Tutoring. (2009). University of Central Florida. Retrieved from http://www.cecs.ucf.edu/students/tutoring.php

Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. (2000). *Land of plenty: Diversity*. Retrieved from http://www.nsf.gov/pubs/2000/cawmset0409/cawmset_0409.pdf

Degrees Awarded Reports. (2011). IEA Interactive Reporting. Retrieved from http://iea.fau.edu/Reports/degrees.aspx

Denton, D. (2005). President Summers' remarks offer global 'teachable moment'. *UC Santa Cruz Currents Online*. *9*(23). Retrieved from http://currents.ucsc.edu/04-05/01-31/opinion-denton.asp

Department of Mathematics. (2009). University of Central Florida. Retrieved from http://www.math.ucf.edu/

Edmonds, K. (2009). ACE Publication sheds new light on minority students who pursue science, technology, engineering, and math majors. *American Council on Education*. Retrieved from http://www.acenet.edu/AM/Template.cfm?Section=Press_Releases2&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=15602

Ehrhart, J. K., & Sandler, B. R. (1987). Looking for more than a few good women in traditionally male fields. *Project on the status and education of women*. Retrieved from Association of American Colleges website: http://www.aacu.org/ocww/documents/OCWW_20_4_Spring_1991.pdf

Epstein, C. F. (1970). Encountering the Male Establishment: Sex-Status Limits on Women's Careers in the Professions. *American Journal of Sociology. 75*(6), 965-982

Fact Book for AY 2008-2009. (2009). University of Central Florida. Retrieved from http://www.iroffice.ucf.edu/factbooks/2008-2009/index.html

Facts 2009-2010. (2010). University of South Florida. Retrieved from http://www.usf.edu/pdfs/USF_PocketFacts.pdf.

Facts at a Glance. (2011). University of Central Florida. Retrieved from http://www.iroffice.ucf.edu/character/current.html#Head

Factor analysis. (2011). Wikipedia. Retrieved from http://en.wikipedia.org/wiki/Factor_analysis

FAU science researcher get $4M grant. (2005, June 13) *South Florida Business Journal*. Retrieved from http://www.bizjournals.com/southflorida/stories/2005/06/13/daily11.html

Fall Student Enrollment in State University System Institutions. (2011). State University System of Florida. Board of Governors. Retrieved from http://www.flbog.org/resources/iud/enrollment_search.php

Field, A. (2005). Factor analysis using SPSS. Retrieved from http://www.statisticshell.cm/factor.pdf

Frieze, I. H., & Hanusa, B. H. (1984). Women scientists: Overcoming barriers. *Advancements in Motivation and Achievement*, *2*, 139-163.

Goldman, R. D., & Hewitt, B. W. (1976). Predicting the success of Black, Chicano, Oriental, and White college students. *Journal of Educational Measurement, 13,* 107-117.

Grahm, S. E. (1997). *The exodus from mathematics: When and why?* (Master's thesis). Available from ProQuest Dissertations and Theses database.

Grandy, J. (1998). Persistence in science of high-ability minority students: Results of a longitudinal study. *Journal of Higher Education*, *69*(9), 589-620.

Gruca, J. M., Ethington, C. A., & Pascarella, E. T. (1988). Intergenerational effects of college graduation on career sex a typicality in women. *Research in Higher Education*, *29*(2), 99-124.

Headcount Enrollment Reports. (2011). IEA Interactive Reporting. Retrieved from http://iea.fau.edu/Reports/Headcount.aspx

Hennessey, J., Hockfield, S., & Tilghman, S. (2005, February 12). Women and science: The real issue. *The Boston Globe*. Retrieved from http://www.boston.com/news/education/higher/articles/2005/02/12/women_and_science_the_real_issue/

Heydet-Kirsch, P. (2006). *Diversity Data Report*. Florida Atlantic University. Retrieved from http://www.coe.fau.edu/reports/PDF/DiversityDataReport2007.pdf

Horn, L., Kojaku, L. K., & Carroll, C. D. (2001). *Higher school academic curriculum and the persistence path through college. Persistence and transfer behavior of undergraduates 3 years after entering 4-year institutions.* Washington, DC: U.S. Department of Education. National Center for Education Statistics.

Hu, S., & St. John, E. P. (2001). Student Persistence in a Public Higher Education System: Understanding Racial and Ethnic Differences. *The Journal of Higher Education*, *72*(3), 265.

Huang, G., Taddese, N., & Walter, E. (2000). *Entry and persistence of women and minorities in college science and engineering education* (NCES –601). Washington, DC: U.S. Department of Education. National Center for Education Statistics.

Hyde, M. S. (1997). *A case study of undergraduate female students majoring in math, science, and engineering: An analysis of persistence and success* (Doctoral Dissertation). Available from ProQuest Dissertations and Theses database.

Kaplowitz, M., Hadlock, T., & Levine, R. (2004). A comparison of web and mail survey response rates. *Public Opinion Quarterly, 68*(1), 94-101.

Khoon, K. A., Yatim, B., Abd-Shukor, R., Muda, W. M. W., & Aziz, A. Z. A. (1997). Addressing the issue of declining interest in science worldwide. *College Student Journal*, 31 (1, March), 2-5.

King, D. M. (2008). LoBello gift aids FAU College of Engineering and Computer Science. *Boca Raton News*. Retrieved from http://www.eng.fau.edu/eng_news/archive/pdf/bocanews/070408_lobellogift.pdf

Kohlstedt, S. G. (2004). Sustaining gains: Reflections on women in science and technology in 20th –century United States. *National Women's Studies Association*, *16*(1).

Kondrick, L. C. (2002). *Understanding the conditions that encourage the persistence of women in science, mathematics, and engineering career pathways* (Doctoral Dissertation). Available from ProQuest Dissertations and Theses database.

Kuh, G. D. (2001). *The National Survey of Student engagement: Conceptual framework and overview of psychometric properties*. Bloomington, IN: Indiana University Center for Postsecondary Research and Planning.

Kuh, G. D. (2003). What we're learning about student engagement from NSSE: Benchmarks for effective educational practices. *Change*, *35*(2), 24-32.

Leggon, C. B. (2006). Women in Science: Racial and Ethnic Differences and the Differences They Make. *Journal of Technology Transfer*, *31*, 325-333.

Levine, A. (2001). National diversity 'think tank' could aid diversity goals. Diversity Exchange. Retrieved from http://www.census.gov/population/www/socdemo/race/racefactcb.html.

Lips, H. M. (1992). Gender- and science-related attitudes as predictors of college students' academic choices. *Journal of Vocational Behavior*, *40*(1), 62-81.

Maple, S. A., & Stage, F. K. (1991). Influences on the choices of math/science major by gender and ethnicity. *American Educational Research Journal*, *28*(1), 37-60.

MATHEMA. (2008). University of Central Florida. Retrieved from http://www.math.ucf.edu/newsletter.pdf

Mathematics and Statistics. (2008). *A STEP to grow in science-engineering-mathematics undergraduate degrees*. Retrieved from http://www.math.usf.edu/resources/step/

Melendez, B. (2007). *USF cited in Princeton Review's "Best 366 Colleges"*. Retrieved from University of South Florida website: http://usfweb3.usf.edu/absolutenm/templates/?a=295&z=11

Mercer, D. (1989). Difference between older women undergraduates when compared by marital status. *National Academic Advising Journal*, *9*(2), 55-66.

Miles, M. B., & Huberman A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Muller, C. B., & Pavone, M. L. (1997). *Retaining undergraduate women in science, math, and engineering: A model program*. Frontiers in Education Conference, 27th Annual Conference, 1, 130-133. Retrieved from http://fie-conference.org/fie97/papers/1267.pdf.

National Center for Education Statistics. (1996). *Education in states and nations: Indicators comparing U.S. states with other industrialized countries in 1991*. Retrieved from http://nces.ed.gov/pubs96/96160.pdf

National Center for Education Statistics. (1997a). *Findings from the condition of education 1997: Women in mathematics and science.* Retrieved from http://nces.ed.gov/pubs97/97982.pdf

National Center for Education Statistics. (1997b). *Findings from education and the economy: An indicators report*. Retrieved from http://nces.ed.gov/pubs97/97269.pdf

National Center for Education Statistics. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education.* Retrieved August 4, 2009, from http://nces.ed.gov/pubs2009/2009161.pdf

National Science Foundation. (1995). *Science and engineering degrees: 1966-93*. NSF 95-312 Retrieved from http://www.nsf.gov/statistics/nsf01325/pdf/nsf01325.pdf

National Science Foundation. (1999). *Despite increases, women and minorities still underrepresented in undergraduate and graduate S&E education*. (Data Brief No. NSF 99-320). Retrieved from http://www.nsf.gov/statistics/databrf/sdb99320.htm

National Science Foundation. (2007). *Women, minorities, and persons with disabilities in science and engineering*. Retrieved from http://www.nsf.gov/statistics/wmpd/pdf/nsf07315.pdf

National Science Foundation. (2009). *Women, minorities, and persons with disabilities in science and engineering*. Retrieved from http://www.nsf.gov/statistics/wmpd/pdf/nsf09305.pdf

O'Brien, L. T., & Crandall, C. S. (2003). Stereotype threat and arousal: Effects on women's math performance. *Personality and Social Psychology Bulletin*, *29*(6), 782-789.

Pascarella, E. T., & Terenzini, P. T., (1980). Predicting freshman persistence and voluntary dropout decisions from a theoretical model. *The Journal of Higher Education*, *51*(1), 60-75.

Pascarella, E. T., & Terenzini, P. T., (1983). Predicting voluntary freshmen year persistence/withdrawal behavior in a residential university: A path analytic validation of Tinto's model. *Journal of Educational psychology*, *75*(2), 215-226.

Pascarella, E. T., & Terezini, P.T. (1991). *How college affects students: Finding and insights from twenty years of research*. San Francisco, CA: Jossey-Bass.

Paulsen, M. B., & St. John, E. P. (1997). The Financial Nexus Between College Choice and Persistence. *New Directions for Institutional Research*, *1997*(95), 65–82.

Pradhan, K. (1999). The Internet in Nepal: A survey report. *The International Information and Library Review, 31*(1), 41-47.

Rayman, P., & Brett, B. (1995). Women science majors: What makes a difference in persistence after graduation? *Journal of Higher Education*, *66*(4), 388-414.

Recruitment & Retention (2008a). *Florida-Georgia Louis Stokes Alliance For Minority Participation-FGLSAMP*. Retrieved from http://rnr.eng.usf.edu/200-007.htm

Recruitment & Retention (2008b). *Multicultural Engineering Program-MEP*. Retrieved from http://rnr.eng.usf.edu/200-011.htm

Rhode, D. L. (1990). *Theoretical differences on sexual differences*. New Haven, CT: Yale University Press.

Riegle-Crumb, C. & King, B. (2010). Questioning a white male advantage in STEM: Examining disparities in college major by gender and race/ ethnicity. *Educational Researcher*, *39*(9), 656-664.

Rogelberg, S. G., & Stanton, J. M. (2007). Understanding and dealing with organizational survey nonresponse. *Organizational Research Methods*, *10*(2), 195-209.

Sax, L. J. (1994). Mathematical self-concept: How college reinforces the gender gap. *Research in Higher Education*, *35*(2), 141-166.

Sax, L. J. (2001). Undergraduate science majors: Gender differences in who goes to graduate school. *The Review of Higher Education*, *24*(2), 153-172.

Schaefers, K. G., Epperson, D. L., & Nauta, M. M. (1997). Women's career development: Can theoretically derived variables predict persistence in engineering majors? *Journal of Counseling Psychology*, *44*(2), 173-183.

Seymour, E. (1995a). Guest Comment: Why undergraduates leave the sciences. *American Journal of Physics*, *63*(3), 199-202.

Seymour, E. (1995b). The loss of women from science, mathematics, and engineering undergraduate majors: An explanatory account. *Science Education*, *79*(4), 437-473.

Seymour, E. & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Sekaquaptewa, D., & Thompson, M. (2003). Solo status, stereotype threat, and performance expectancies: Their effects on women's performance. *Journal of Experimental Social Psychology*, *39,* 68-74.

Society of Women Engineers. (2008). Retrieved from http://societyofwomenengineerings .swe.org

Sonnert, G. (1998, May). Women in science: A status report. *Scientific American Exploration.* Retrieved from http://www.sciam.com/explorations/1998/051898 women/women.html

Steele, J., James, J. B., & Barnett, R. C. (2002). Learning in A man's world: Examining the perceptions of undergraduate women in male-dominated academic areas. *Psychology of Women Quarterly*, *26*(1), 46-50.

Stevens, K. K. (2004). *Program review and departmental performance review*. Retrieved from http://www.eng.fau.edu/pdf/dean_review.pdf

Strenta, C., Elliot, R., Matier, M., Scott, J., & Adair, R. (1994). Choosing and leaving science in highly selective institutions. *Research in Higher Education*, *35*(5), 513-547.

Tobias, S. (1990). They're not dumb, they're different. Tucson, AZ: Research Corporation.

Trochim, W. (2001). *The research methods knowledge base* (2nd ed.). Cincinnati, OH: Atomic Dog Publishing.

Trusty, J., Robinson, C. R., Plata, M., & Ng, K. (2000). Effects of gender, socioeconomic status, and early academic performance on postsecondary educational choice. *Journal of Counseling and Development*, *78*(4), 463-472.

U. S. Census Bureau. (2008). *Racial and ethnic classifications used in census 2000 and beyond*. Retrieved from http://www.census.gov/population/www/socdemo/race/racefactcb.html

U. S. Department of Labor. (1993). *Time of change: Handbook on women workers* (Bulletin 298). Washington, DC: U. S. Department of Labor, Women's Bureau.

USF System Facts 2010/11. (2011). University of South Florida. Retrieved from http://www.usf.edu/pdfs/USF_PocketFacts.pdf

U. S. House of Representatives Committee on Science and Technology Subcommittee on Research and Science Education (2009). *Encouraging the participation of female students in STEM fields.* Retrieved from http://democrats.science.house.gov/Media/File/Commdocs/hearings/2009/Research/21jul/Hearing_Charter.pdf

Ware, N. C., Steckler, N. A., & Leserman, J. (1985). Undergraduate women: Who chooses a science major? *The Journal of Higher Education*, *56*(1), 73-84.

Xianglei, C., & Thomas, W. (2009, July). Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education. *National Center for Education Statistics.* Retrieved from http://nces.ed.gov/pubs2009/2009161.pdf

Xie, Y., & Shauman, K.A. (2003). *Women in science. Career processes and outcomes.* Cambridge, MA: Harvard University Press.

Yu, J., & Cooper, H. (1983). A quantitative review of research design effects on response rates to questionnaires. *Journal of Marketing Research, 20*(1), 36-44.

Zhao, C., & Kuh, G. D. (2004). Adding value: Learning communities and student engagement. *Research in Higher Education*, *45*(2).

2010-2011 Fact Book. (2011). Florida Atlantic University. Retrieved from http://iea.fau.edu/factbk/home09.htm