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They Chose to Major in Engineering: A Study of Why Women Enter and Persist in Undergraduate Engineering Programs

Item Type	dissertation
Authors	Smith, Adrienne Yvette
DOI	10.7275/2647610
Download date	2024-11-28 11:06:07
Link to Item	https://hdl.handle.net/20.500.14394/38965

THEY CHOSE TO MAJOR IN ENGINEERING: A STUDY OF WHY WOMEN
ENTER AND PERSIST IN UNDERGRADUATE ENGINEERING PROGRAMS

A Dissertation Presented

by

ADRIENNE Y. SMITH

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF EDUCATION

February 2012

Education

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DEDICATION

This dissertation is dedicated to my wonderful family.

To my husband Curtis,

who has always been so supportive and helpful in every way. I could not have done this without your love, patience, and belief in me. Thank you for taking this journey with me, and thank you for being my rock. I love you.

To my mom and dad, Sam and Shirley,

the two most wonderful parents in the world. This journey has been not only a dream of mine but also of theirs. Their pride in me and my accomplishments have kept me focused through the years. I love you both. This is for you.

To my daughter Stacey,

the sky is the limit. You are going to accomplish so much and I look forward to sharing that with you. Thank you for always being as proud of me as I am of you.

ACKNOWLEDGEMENTS

I would like to thank my committee members, Benita J. Barnes, Joseph B. Berger, and Alexandrina Deschamps. They have all been staunch supporters and provided the utmost direction and advice. As chair of my committee, Benita's guidance, support, and counsel propelled me through this process. I will be forever grateful for her patience and for pushing me to do what she knew to be best for me. Her talent for goal setting and prioritization truly helped me to make it to the finish line.

Thank you to my staff at Springfield Technical Community College. There were many times when I felt as though this journey was too tough and that I could not continue. Their constant support and encouragement helped to get me through the difficult times. They were always there for me.

My close friend, Terri, provided the friendship and belief in me that I needed. She was the shoulder that I often came to when times got tough. I appreciate her encouragement and the honest and heartfelt joy that she expressed each time another milestone was reached.

My mother and father have always believed in me and supported me in all that I have done in my life. Their love and belief in me never wavered and for that, I am truly grateful. I love them more than they will ever know.

I thank my husband Curtis, who never doubted in my ability to succeed. He understood when I had to put things off in order to get studies done, and during those times he stepped up to the plate to handle whatever needed to be done.

ABSTRACT

THEY CHOSE TO MAJOR IN ENGINEERING: A STUDY OF WHY WOMEN
ENTER AND PERSIST IN UNDERGRADUATE ENGINEERING PROGRAMS

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The purpose of this study is to identify the factors that lead female undergraduate students to pursue an academic major in engineering and to persist in their engineering studies. This research focuses on women who are currently studying in the fields of engineering in an effort to determine whether or not common themes emerge that impacted their decision to major in these academic programs. Specifically, this study aims to better understand what factors exist that influence women to study engineering. Despite the fact that research has been conducted in this area, the findings from these studies do not appear to have had an impact on the number of women who choose to major in engineering upon entering college, as this number has not been increasing. The goal of this study is to provide for the following: Policy makers, high school guidance counselors, and the colleges and universities involved in this study can be better informed and benefit from knowing what factors influence women to major and persist in the field of engineering at their respective institutions.

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CHAPTER 1

INTRODUCTION

Introduction

The current education system in the United States is not producing the necessary numbers of engineers and scientists needed in order for the United States to maintain the lead in the global economy (Women in Higher Education, 2007). Given that women comprise just over half of the population, increasing the numbers of women in these fields continues to be a key strategy in this country's ability to remain in the lead. Additionally, the lack of involvement of women in the design of technology will continue to result in the production of technologies that do not respond properly or adequately to women's concerns (Nebres & Mercado, 1998; Cuny & Aspray, 2000).

Statement of the Problem

The fact that there are fewer women, 5% of all college students (NSF, 2001), who major in science, technology, engineering, and mathematics (STEM) fields than other college academic programs means that there will be fewer role models, mentors, and female educators for young women of the future (Wan, 1994; Campbell, Jolly, & Perlman, 2005). This fact in turn maintains the ongoing problematic trend of the lack of gender equity in STEM fields. According to Rosser (2003), there is still a huge disparity in the numbers of men and women who enter and persist in the STEM fields. Similarly, there will continue to be fewer women faculty to teach and to conduct research in the mathematics, science, and engineering fields (Rosser, 2003). Having more women in the fields of science and engineering increases the diversity of these careers by adding a

different set of lenses through which problem definition and problem solving will occur (Bottomley, Rajala, & Porter, 1999; Hersh, 2000). When the first voice recognition systems were designed, they were calibrated to men's voices and the voices of women were not recognized (AAUW, 2008). Similarly, when the first automobile airbag systems were designed, they were designed around the specifications of a man's body and the lives of many women were lost (AAUW, 2008). These are the types of limitations in the design of products and services that might be improved by having more women involved in the engineering process.

Purpose of the Study

This study identifies the factors that lead female undergraduate students to pursue an academic major in engineering. There have been several studies conducted by organizations such as the National Science Foundation (2000) and mentoring programs such as the one conducted by the University of California at Berkeley (SCI-FY), designed to address the issues of women entering and persisting in this field. Despite the number of programs and the number of young women who have participated, the fact remains that there continues to be a gap between the numbers of men and women who choose to study and work in the field of engineering. According to reports issued by the National Science Foundation (NSF) and the Government Accountability Office (GAO) the trend in enrollment of women engineering majors has been consistent over the last 15 to 20 years (GAO, 2004). The numbers of women in mathematics and the physical sciences are somewhat higher, 33% and 40% respectively, but still show a disparity in enrollment (Rosser, 2003). Despite the fact that research has been conducted in this area, the findings from these studies do not appear to have had an impact on the number of women

who choose to major in engineering upon entering college, as this number has not been increasing (NSF, 2006).

Research Questions

The GAO indicates that a growing concern regarding the lack of involvement of women in the field of engineering has led to numerous outreach programs and recruiting initiatives aimed at increasing the number of women who choose to major in engineering (GAO, 2006). During the year 2004, federal agencies spent over 2.8 billion dollars on such programs in the hope of attracting more women to the field of engineering by providing them with an opportunity to learn more about the discipline and to interact with women currently employed in an engineering career (GAO, 2006). Though much money has been spent, the fact remains that the number of women who choose to major in engineering has not increased from 1995 to 2006 (NSF, 2008). According to the National Science Foundation, the number of women majoring in engineering in 1995 was 67,286 and in 2006 the number was 69,869 (NSF, 2008). It is hoped that through this study we will gain new knowledge regarding women's choice of engineering as a college major which may assist secondary schools to better prepare female students and may help colleges and universities create outreach and recruitment programs that target those students whose profiles more closely resemble those of the current women engineering students.

In order to gain a better understanding of why some women choose to major in engineering when they attend a college or university, and whether or not they fit a certain profile as it relates to their college preparedness, family background, and math and science experience, a series of interviews will be conducted with women who are

currently enrolled in an engineering program at a local Massachusetts college or university. Each student interviewed will be asked a series of questions regarding what influenced their choice to major in engineering. The goal of these interviews is to determine whether or not there are specific reasons why they chose engineering and why they persist in this field of study.

One overarching question will guide this qualitative study:

How do undergraduate women engineering students come to a decision to major in engineering?

Significance of the Study

This research focuses on women who are currently studying in the fields of engineering in an effort to determine whether or not common themes emerge that impacted their decision to major in these academic programs. Specifically, this study aims to better understand what factors exist that influence women to study engineering. This information will add to the current body of knowledge regarding women's choice of engineering as an academic program choice. Though students attrite from engineering at about the same rate as they do in other academic programs, the fact that there is a much more limited pool of students with the requisite mathematics and science skills needed to be successful in an engineering program intensifies the urgency to enlarge the pool of women applicants to engineering programs (Zhang, Min, Ohland, & Anderson, 2006).

The goal of this study is to provide for the following: Policy makers, high school guidance counselors, and the colleges and universities involved in this study can be better informed and benefit from knowing what factors influence women to major and persist in the field of engineering at their respective institutions.

Assumptions

The number of women who choose to major in engineering has not increased but instead has decreased during the period from 1995 to 2006 (NSF, 2008) from an enrollment of 18.5% of all engineering majors to 17.2%, even though much attention has been given and much money has been spent on the matter by various federal agencies (GAO, 2006). This indicates that current efforts to recruit women into the fields of engineering are not working. This study further assumes that by gaining a better understanding of what factors are attributable to the choice of engineering as a college major by those female students currently studying in the fields of engineering, targeted outreach and recruitment programs may be created which focus on female secondary school students who possess the requisite skills, knowledge, and abilities that those factors encompass.

This study assumes that these factors will be identified by interviewing college women who are currently enrolled in an engineering program by asking them a series of questions regarding the reasons why they chose to major in engineering. College women will be asked to take part in this study and it is hoped that that they will be willing to participate based on the fact that their participation may play a role in positively impacting the numbers of women who choose to enroll in engineering programs both locally and nationally.

As a female engineer, my role in this study is to garner the trust of the study participants through our common engineering backgrounds, to foster an understanding of the nature and the importance of the study by relating impact of increasing the numbers

of women in engineering, and to promote a positive feeling about sharing their experiences through the ability to speak a common language with these women as it relates to an engineering curriculum. It is further assumed that this choice of major places us in a small and “elite” group of women which may provide a certain sense of comfort with these women about relating their stories regarding their engineering studies, especially the young women who are currently studying at my alma mater, Western New England College in Springfield, Massachusetts.

Definitions

This study employs several terms that might not have universal meaning or might have different contextual meaning. Critical terms used throughout this study are defined below. These terms include: underrepresented, socioeconomic status, technology innovation, outreach, image, and persistence.

The ACT Office of Policy Research (2003), as well as articles by Bix (2004), Baillie & Fitzgerald (2000), and Blickenstaff (2005) discussed the need for more women in the areas of science and engineering. In each of the articles and national reports, the authors specifically point to the underrepresentation of women in engineering. For the purpose of this study, *underrepresented* is defined as a lower number or quality of women in the field of engineering than is present of men in the field of engineering. In other words, the number of women in engineering is considered to be insufficiently or inadequately represented.

Socioeconomic status is defined as an individual's or group's position within a hierarchical social structure. Socioeconomic status depends on a combination of variables, including occupation, education, income, wealth, and place of residence

(Dryler, 1998; Leppel, Williams, & Waldauer, 2001; Salami, 2007; Trusty, Robinson, Plata, & Ng, 2000). Sociologists such as Richard James often use socioeconomic status as a means of predicting behavior (James, 2002).

This study focuses not only on female enrollments in engineering programs but also on the persistence of these women. *Persistence* is defined as the process that leads students to remain enrolled at an academic institution through degree completion (Tinto, 1998). As it relates to higher education, Berger and Lyon (2005) define persistence as “the desire and action of a student to stay within the system of higher education from beginning year through degree completion”.

Overview

The impacts that the science and engineering communities have on society offer huge opportunities for women; opportunities in the forms of generating substantial incomes, designing products and services that could save lives, and providing role models for the young women of the future (Wan, 1994; Campbell, Jolly, & Perlman, 2005). Unfortunately, during the period from 1995 to 2006, the percentages of young women who chose to major in the fields of science, mathematics, engineering, and technology (STEM) was stagnant (National Science Foundation, 2007). Several studies have been conducted over the last 20 years in an effort to understand what needs to be done to address the disparity in enrollment in these fields between men and women. The purpose of the study is to gain a better understanding of the reasons given for their choice of college major in the hope that these data will better inform the current body of knowledge on this subject matter.

The next chapter of this paper will discuss the existing knowledge on the subject of the choice of female undergraduate women to major in engineering. The final chapter will focus on the conceptual framework, research questions, research design, analysis, and limitations of the research study.

CHAPTER 2

LITERATURE REVIEW

Introduction

The purpose of this study is to contribute to the existing body of knowledge regarding the enrollment of women in engineering programs. The percentage of women majoring in engineering has not increased during the period from 1995 to 2006, but instead has seen a decline from 18.5 percent in 1995 to 17.2 percent in 2006 (NSF, 2008). This literature review focuses on a few of the reasons cited in the literature for the lack of women in the field of engineering, and discusses the impact on the United States of having fewer women in the field of engineering.

The topics discussed in this chapter include a broad overview of the impact of the lack of women in engineering, the trends over the last 40 years in terms of women's participation in engineering, a look at examples of the types of outreach programs that have been developed to address the problem, and some of the key factors that may be contributing to a lack of involvement of women in the field of engineering.

Background

Currently, not enough engineers and scientists are being produced in order for the United States to maintain the lead in the global economy (Women in Higher Education, 2007). This is a dramatic shift from the past when the United States was the most significant global producer in areas of science and technology innovation. According to the report "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," (2006) four actions are required to bolster United States

competitiveness. These recommended actions are:

1. Increase America's talent pool by vastly improving K-12 mathematics and science education
2. Sustain and strengthen the nation's commitment to long-term basic research
3. Develop, recruit and retain top students, scientists and engineers from both the U.S. and abroad
4. Ensure that the United States is the premier laced in the world for innovation. (Committee on Science, Engineering and Public Policy, 2005)

During the period from 1990 to 2003, the dollars expended on research in the areas of science and technology outside of this country have more than doubled (GAO, 2006), in effect closing the gap between the United States and the rest of the world. This is a shift from a time, such as the year 1995, when the United States generated the largest share of high-technology manufacturing output as compared to any other country (GAO, 2006). This prolific productivity in high-technology manufacturing output was possible due to the large amount of money spent on research in the areas of science and technology. Increasing the numbers of women in these fields will impact this country's ability to remain a world leader in engineering and technology by filling vacant engineering positions and thus ensuring that the United States maintains the competitive edge in the area of technology and innovation (Shaefers, Epperson, & Nauta, 1997).

In order to maintain its position as a world leader in engineering and technology, and to maintain its competitive edge in the area of technology and innovation, the United States needs more people to consider engineering as a possible future career. Yet, as the following tables indicate, the number of potential engineering students in total and the number of women engineering students specifically have continued to decline during the period from 1991 to 2002 (Noeth, Cruce, & Harmston, 2003). Table 1 illustrates that the total number of potential engineering majors has dropped from a high in 1993 of 67,764

to 54,175 potential engineering majors in 2001. This decline in potential engineering majors is in stark contrast to the numbers that are needed to fill the engineering pipeline in order for the United States to remain a leader in technology and innovation and to provide the necessary products and services to the current and future U.S. population (Noeth, Cruce, & Harmston, 2003). Table 2 illustrates that of the total potential [3] engineering majors during the period from 1991 to 2002, the number of potential female engineering majors has declined from a high of 13,483 in 1993 to a low of 9,345 in 2002.

Table 1 :Potential Engineering Majors

High School Class	Number
1991	63,653
1992	66,475
1993	67,764
1994	64,571
1995	64,937
1996	63,329
1997	63,601
1998	65,329
1999	65,776
2000	61,648
2001	54,175
2002	52,112

Table 2: Potential Female Engineering Majors

	High School Class Number	Percent
1991	11,710	18.4
1992	12,974	19.5
1993	13,483	19.9
1994	13,180	20.4
1995	13,389	20.6
1996	12,681	20.0
1997	12,803	20.1
1998	12,648	19.4
1999	12,480	19.0
2000	11,689	19.0
2001	10,073	18.7
2002	9,345	18.0

³ The terms “planned” and “potential” will be used interchangeably to designate those high school students who selected an engineering field as a planned college major when registering for the ACT Assessment. Students typically complete the ACT Assessment in the spring of their junior year and/or in the fall of their senior year.

Figure 1 indicates that of all the students who enrolled in a college or university between 1991 and 2002, the percentage of students who selected engineering as a major declined from 8.5% to 5.5%.

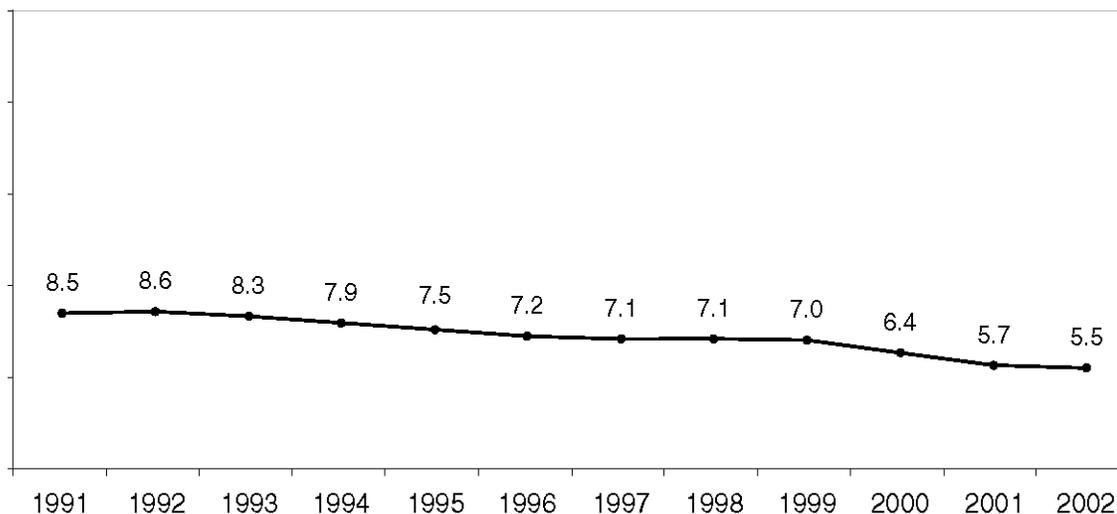


Figure 1: Percent Who Selected an Engineering Major

Source: Noeth, Cruce, & Harmston, 2003

The fact that the number of potential engineering majors is declining should be cause for alarm as the United States struggles to maintain the lead in technology and innovation. The combination of our country's changing demographics, an aging workforce, and the fiscal challenges facing our nation means that we will need more women and minorities to become engineers and scientists so that we have the necessary numbers of trained individuals to compete in a global marketplace. The leaders in the engineering community have agreed that the only way to increase the engineering labor pool is to diversify the current engineering workforce (Noeth, Cruce, & Harmston, 2003).

An example of the attention that is being drawn to the need to increase the engineering workforce in the United States through diversification is the Science and Engineering Equal Opportunities Act, which was passed by Congress in 1980. The Act states:

It is the policy of the United States to encourage men and women, equally of all ethnic, racial, and economic backgrounds to acquire skills in science, engineering

and mathematics, to have equal opportunity in education, training, and employment in scientific and engineering fields, and thereby to promote scientific and engineering literacy and the full use of the human resources of the Nation in science and engineering. To this end, the Congress declares that the highest quality science and engineering over the long-term requires substantial support, from currently available research and educational funds, for increased participation in science and engineering by women and minorities. (Sec. 32(b))

In addition to the attention that the Congress has placed on diversity of the engineering workforce, several books and articles have also touted the benefits of diversity in colleges, universities, and corporations (Ameer, 2000; Bensimon, 2000; AAUP & ACE, 2000). Having more women in the fields of engineering increases the diversity of these careers by adding a different set of lenses through which problem definition and problem solving will occur. Women make up over 50% of the population in the United States and approximately 44% of the workforce (Morgan, 2000) so it would stand to reason that women should constitute more than 20% of the engineers in this country. Additionally, since women comprise over 50% of the population, having a more diverse engineering workforce will provide a better match of products and services to this diverse customer base (Hersh, 2000).

The majority of the engineering degrees conferred in the United States are awarded to men. According to the National Science Foundation (NSF), the percentage of women earning degrees in engineering, at both the undergraduate and master's degree level, is approximately 19% annually (NSF, 1998). Approximately 20% of engineering doctoral degrees are awarded to women (NSF, 1998; Gibbons, 2004). Increasing the number of women who choose to major in engineering would positively impact the ability of the United States to remain in the lead in the areas of technology and innovation because it will increase the population of engineers and scientists involved in design, innovation, and technology. The lack of involvement of women in engineering will

allow other countries to challenge our nation's position of leadership in the areas of science and technology innovation because we will have a smaller pool of experts to address issues that impact our global economy.

In order to increase the pool of technological experts, we need to focus on not only the depth of the pool, but also the breadth of the pool by maintaining, and in some cases expanding, the current efforts in increasing the numbers of women and minorities in engineering. Though the number of students obtaining postsecondary degrees increased during the period from 1994 to 2003, the number of students obtaining degrees in engineering and other STEM disciplines has declined from 32% to 27% during this same period (GAO, 2006). In order to increase the number of students in these fields the focus must remain on attracting all types of students, including women and minorities who continue to be underrepresented in these fields. Increasing the number of women in the STEM fields will not only increase the pool of technological experts in the United States but will also increase the number of women who are involved in design and innovation of products which are used primarily by women.

The lack of involvement of women in the design of technology will continue to result in the production of technologies that do not respond properly and adequately to women's concerns (Nebres & Mercado, 1998; Cuny & Aspray, 2000). Volvo automobile company, for example, has recognized the fact that women purchase 65% of all cars and influence the purchase of approximately 80% of all car purchases (Road and Travel, 2009). In light of this fact, on April 9, 2009, Volvo unveiled its first concept car designed by team comprised of all women engineers. The car includes features that might be more attractive to women such as no hood, no gas cap, compartments for handbags, a swing-out seat for ease of entry, and gull wing doors that make it easier to

load and unload children and larger items (Road and Travel, 2009). This is but one example of why it might be beneficial to have more women involved in the design of products and technologies that are solely or largely used by women. Having a lack of women who major in engineering not only impacts the design of products and services that are used by women, but also impacts the safety and efficacy of such products for and by women (Cuny & Aspray, 2000).

Another impact of the lack of women in engineering is that there will be fewer female role models, mentors, and educators for young women of the future (Wan, 1994; Campbell, Jolly, & Perlman, 2005). In order for some women to develop confidence in their ability to succeed in an engineering career, it may be beneficial for them to see other women who have succeeded in engineering. Without the presence of women role models, girls rely on other sources of influence such as family and friends. Women who do choose to major in engineering cite the influence of family, friends, and teachers as having an impact on their choice (Seymour, 2006).

Since family members, friends, teachers, counselors, and the media have an impact on the way young women and girls view engineering and science careers (Clewell & Campbell, 2002), in the event that none of these individuals or venues provides a positive role model or depiction of women in engineering, having more female engineers as role models, mentors, and educators will provide positive reinforcement for viewing engineering as a viable career for a woman. There are now more images of women scientists on some of the more popular criminal investigation television programs; however, there is still a lack of media portrayal of women as engineers. Media modes have a direct impact on perceptions and attitudes when the opportunity for direct contact is not available (Steinke, 2004). In a joint study conducted by Midway College in

Midway, Kentucky and the University of Kentucky (UK) (2000), it was found that there exists a misconception among women regarding the image of engineers (Sasser, Lineberry, & Scheff, 2004). One of the misconceptions cited by Midway College and UK is that many women do not see engineering as a people-oriented profession. The organization Engineers without Borders, for example, builds filtration and water conveying systems in poor communities throughout the world (TietJen, 2004) yet these types of good works by engineers have received little or no media attention. The lack of media attention to this type of engineering work, which positively affects people and their communities, may continue to perpetuate the misconception.

Trends of Women in Engineering

For many years, not only were the technical fields dominated by males, but several of the leading engineering schools like Rensselaer Polytechnic Institute in Troy, New York, and the Massachusetts Institute of Technology were closed to women (Bix, 2004). In the 1960s, less than 1% of the students enrolled in an engineering program were women and these women were ridiculed and seen as oddities (Bix, 2000). The issue regarding women entering the field of engineering eventually came to the forefront during World War II when men were called to serve and this left a deficit in the number of people available to work in the technical fields. During World War II, companies like General Electric started actively recruiting women who possessed the required basic math and science skills and provided training for them so that these women could work as engineering aides (Bix, 2004). This effort to increase the number of women working in the engineering trades was happening during a time when only a handful of women ventured into the engineering studies at a small number of land grant institutions (Bix,

2004). The small number of women studying engineering was partly due to the fact that many of the top engineering schools such as Rensselaer Polytechnic Institute and the Georgia Institute of Technology were closed to women (Bix, 2004).

Though much has changed with respect to discrimination in college admissions policies, and girls are scoring as high if not higher in some cases on math and science exams as boys which would position them to do well in a field like engineering (Clewell & Campbell, 2002), women are still choosing to major in engineering in numbers significantly less than their male counterparts. Despite the fact that women have the aptitude and the ability necessary to major in a STEM curriculum (National Science Foundation, 2004), the fact remains that they still only enter at a rate of 1:4 as compared to men majoring in the same STEM fields (College Board, 2004; National Science Foundation, 2004). In 1996, more women were getting bachelor's degrees in psychology and the biological sciences, 73% and 50% respectively, and only 18% of bachelor's degrees were being earned in engineering by women (Bell, Spencer, Iserman, & Logel, 2003), illustrating the differences between the number of women earning degrees in the social and biological versus the physical sciences.

The differences between the number of women earning degrees in the social and biological versus the physical sciences may be partially attributed to the fact that women take fewer advanced mathematics and science courses in high school and that they especially shy away from calculus and physics (Bleeker & Jacobs, 2004; Blickenstaff, 2005). Because of this trend, women are often less prepared when they go to college since most first-year engineering students are required to take calculus (Noeth et. al., 2003). The data show that not only do women and men in engineering and science careers take more math and science courses in high school (Bleeker & Jacobs, 2004), but

they persist in their chosen fields of study if they participated in a science-related program in high school and received support from their teachers and parents (Packard & Nguyen, 2003).

The fact that federal agencies spent over \$2.8 billion in funding in fiscal year 2004, across over 200 programs aimed at increasing the number of women in STEM fields and the number of women employees in STEM careers (GAO, 2006), illustrates the strong need to have more women in science and engineering. Despite the fact that the nation is spending billions of dollars on these programs, as Figure 2 illustrates, the number of women employed in engineering jobs was at the same level in 2003 as the number in these same occupations in 1994. Thus, as the numbers show, though there has been an increase in the overall number of women working in STEM fields during this time, the number working in engineering have remained almost entirely stagnant. Among all of the professional fields such as medicine, law, architecture, pharmacy, and dentistry, engineering has the lowest percentage of women graduates (TietJen, 2004).

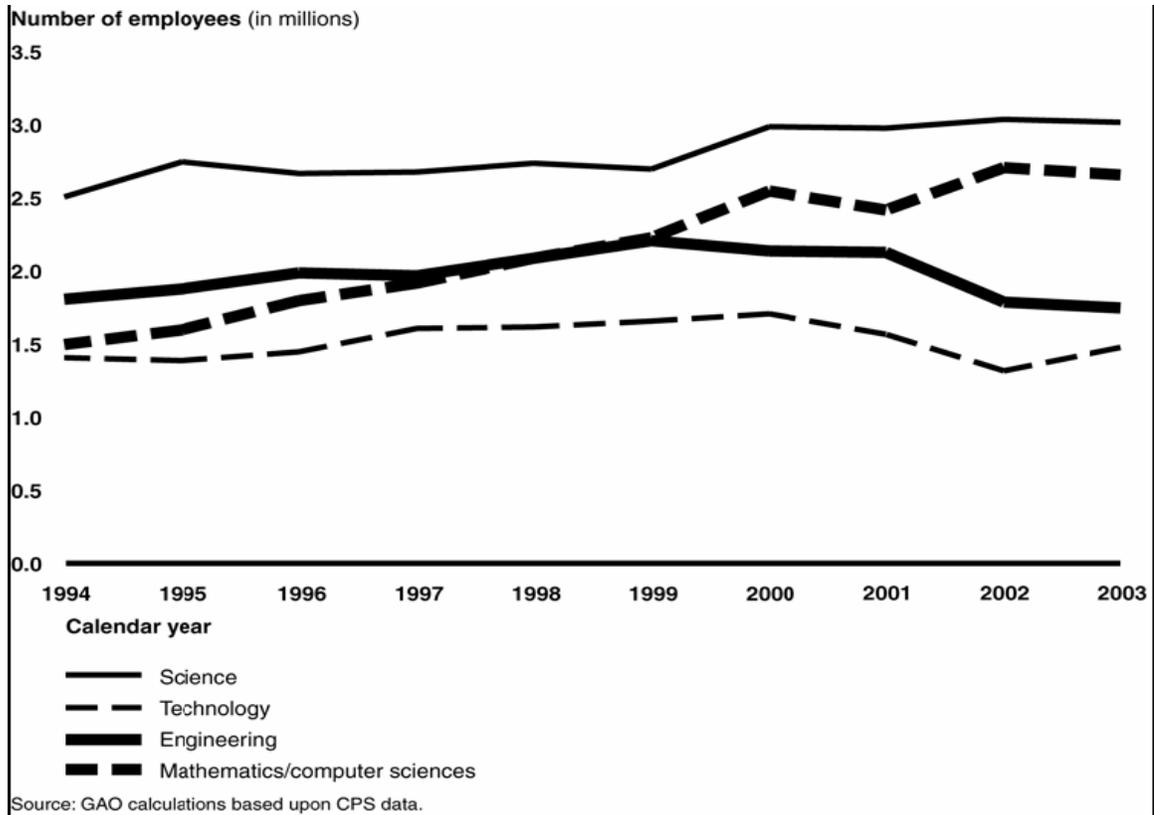


Figure 2: Employees in STEM fields

Barriers to Women’s Entry into Engineering

This literature review will focus on the issues that were found as possible causal factors for the low level of women engineering graduates. Specifically, the literature reviewed for this study cited various reasons why women choose not to major in a science, technology, engineering, or mathematics (STEM) curriculum when they enter college. The reasons cited for the failure of larger numbers of women to participate in a STEM career have similar themes. In particular, early gender identification, the expectation of secondary school teachers, mathematics and science experience, lack of confidence in mathematics and science abilities, role models and images of engineers, and familial influence are the major themes or barriers to the entry of greater numbers of

women into STEM fields, found in the literature. The ways in which each of these barriers impacts the entry of women into the field of engineering are discussed in detail in the following sections.

Early Gender Identification

From the time that a child is born and it is announced that the proud parents have a baby boy or a baby girl, that child begins the process of gender identification (Colman, 2000). Parents choose to dress a little girl in colors that are traditionally thought of as feminine, such as pink or yellow, and they dress little boys in blue to identify them as males (Thorne, 1993). Typically, one would not be able to tell the sex of a baby without these types of clues regarding the child's gender.

In these early stages of life children begin to receive messages from their parents about how to “act like a boy” or “act like a girl” (Weinraub, Clemens, Sachloff, Ethridge, Gracely, & Myers, 1984). Not only do parents provide overt messages to their young children, but also children watch what their mothers and fathers do and emulate their behavior (Kaplan, 1991; Lauer & Lauer, 1994; Santrock, 1994; Witt, 1997). Parents tend to purchase gender-specific toys for their children such as dolls, cooking and baking toys for their daughters and trucks, sports and building toys for their sons (Eccles, Jacobs, & Harold, 1990).

A study conducted by Rubin, Provenzano, and Luria (1974) demonstrated that parents have different expectations of their sons and daughters as soon as 24 hours after their birth. These differences in expectations manifest themselves in many ways, including the division of household chores as the child matures. Girls are often given more domestic chores such as cooking and cleaning and boys given more maintenance

chores such as mowing the lawn and house painting; the differentiation extends to the toys selected by parents for their child to play with (Rubin et.al, 1974; Campenni, 1999; Fagot, Leinbach, & O'Boyle, 1992). Boys' rooms usually house more masculine toys while girls' rooms are filled with dolls and more domestic toys. The division of chores leads children to associate certain types of work with gender and may lead girls to be less interested in what STEM research considers non-traditional fields for women (Zuga, 1999).

“Children are socialized by the people with whom they associate through daily interaction over the course of many years. Acceptable social customs are taught and fostered” (Zuga, 1999, p.12). So, it would make sense that if young girls do not see other women who are in STEM careers, these girls may not be able to envision these careers as a possibility for themselves.

In a research study conducted by Hamilton, Anderson, Broaddus, and Young (2007), the data show that, for children between the ages of three and five, parents engage in the reading of picture books to their young child and most of these picture books had twice as many male as female characters. Additionally, these picture books, all of which are Caldecott award winners, contained a higher percentage of male characters, and the male characters were seen more often in outdoor scenes. These same books showed the male characters as adventurous and playful whereas the female characters were portrayed as passive, most often shown in indoor scenes, and often appeared to have no salary-related occupation (Hamilton, et al., 2007). These authors state “the stereotyped portrayals of the sexes and under-representation of female characters contribute negatively to children's development, limit their career aspirations, frame their attitudes

about their future roles as parents, and even influence their personality characteristics” (p.1).

By the time the child starts to attend school, he or she has already received messages from family and from the media about how he or she is supposed to behave, and what the child is supposed to like or dislike based on gender (Plastuna, 2001). Girls, for example, are supposed to be soft, kind, loving, and nurturing (Canada & Pringle, 1995). These stereotypic ideals are reinforced in many of the children’s stories that are read such as Cinderella, Sleeping Beauty, Beauty and the Beast, and Alice in Wonderland (Canada & Pringle, 1995).

Research has shown that children receive messages of gender classifications several times a day in their K-12 classrooms (Buswell, 1981; Kelly, 1987; Gooden & Gooden, 2001). Children hear things like, “she’s a tomboy,” “he throws like a girl,” or the teacher may ask for “two strong boys” to carry something heavy (Buswell, 1981; Kelly, 1987; Forgasz, Leder, & Kloosterman, 2004). These types of gender classifications help to further the divide with respect to those activities and skills that are related to boys versus girls.

Despite the messages that young girls receive from the media or in classrooms, studies suggest that young girls are more likely to major in science or engineering in college if their father is a scientist or engineer (Anderson, 1995). Thus, media images, K-12 experiences, and parental role models all have a significant influence on what young women choose to major in when they enroll in college.

Familial Influence

As the previous section highlighted, the family plays a large role in the gender identity of the children in the family. Additionally, the socio-economic level of the family plays an important part in the educational aspirations of both men and women (Ermisch and Francesconi, 2000). Women brought up in families with a higher socio-economic status have a greater tendency to choose a traditionally male-dominated career such as engineering (Salami, 2007; Trusty, Robinson, Plata, & Ng, 2000). Additionally, the effect of socio-economic status on college academic choice is greater for women than it is for men (Leppel et. al, 2007). The combination of the factors of a father holding a technical position combined with a high socio-economic status increases the propensity for a daughter to study in a nontraditional college academic program (Dryler, 1998). People most often choose a career that is consistent with their social class so that girls from a high socio-economic background are more likely to choose nontraditional occupations in order to maintain the status to which they have become accustomed (Trusty et al., 2000).

There are differences between men and women when comparing who selects traditional versus nontraditional college majors. In a study conducted by Leppel, Williams, and Waldauer (2001), it was found that female students are more likely to choose science or engineering if their father is a professional or in an executive position. Women currently studying engineering have a higher percentage of fathers who are engineers than their male counterparts (Anderson, 1995). The study by Leppel et al. concluded that the same is not true if the mother holds a professional or executive position. Instead of being influenced by the type of position held by the mother, the data reveals that young women are inspired to obtain a highly skilled job that will afford them

the ability to earn higher wages, when the mother works outside of the home in lieu of being a housewife (Leppel et al., 2001).

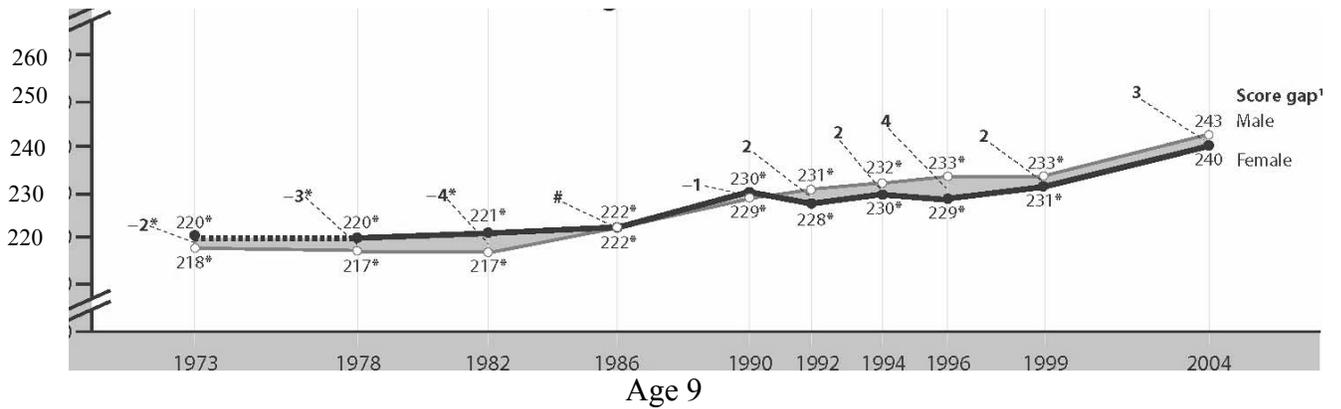
Several studies also mention that the young women who do choose to major in engineering are inspired to do so due to a paternal influence or inspiration by the father (Turner, Bernt, & Pecora, 2002; Dryler, 1998). The role of parent has a major impact on the choice of major by their children and parental influence has the strongest impact on young adult career decision (Bleeker & Jacobs, 2004). A study conducted by Turner, Bernt, and Pecora (2002) at Ohio University included statements by women citing their desire to major in computer science engineering because it pleased their fathers. The authors state that the positive manner in which their fathers reacted to their interest in the field further excited them in the subject matter and inspired them to continue their studies.

Math and Science Experience

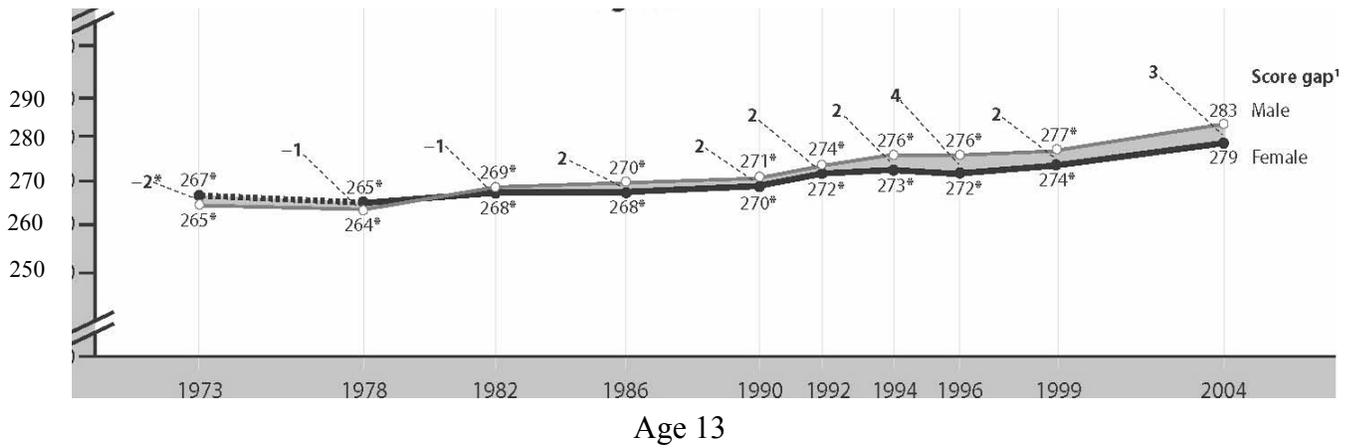
Gender differences between boys and girls in their attitudes about science develop at an early age with boys having a more positive attitude about science and their ability to do science-related work (Bleeker & Jacobs, 2004). These attitudes regarding ability to do science and math persist even though the test scores of young men and women show no differences in their aptitude for the subject matter (Bleeker & Jacobs, 2004; Blickenstaff, 2005, Kerr & Kurpius, 2004). Figure 3 (Perie, Moran & Lutkus, 2005) illustrates the differences in the attitudes of boys and girls regarding the math and science abilities or identities. Girls perceive math and science to be something that boys do well, something that they will have no use for, and they generally have a negative attitude about math and science (Clewell & Campbell, 2002). The fact that these attitudes exist has spurred the

Girl Scouts of America to launch a science and technology campaign with the tag line “It’s her future, do the math” (TietJen, 2004).

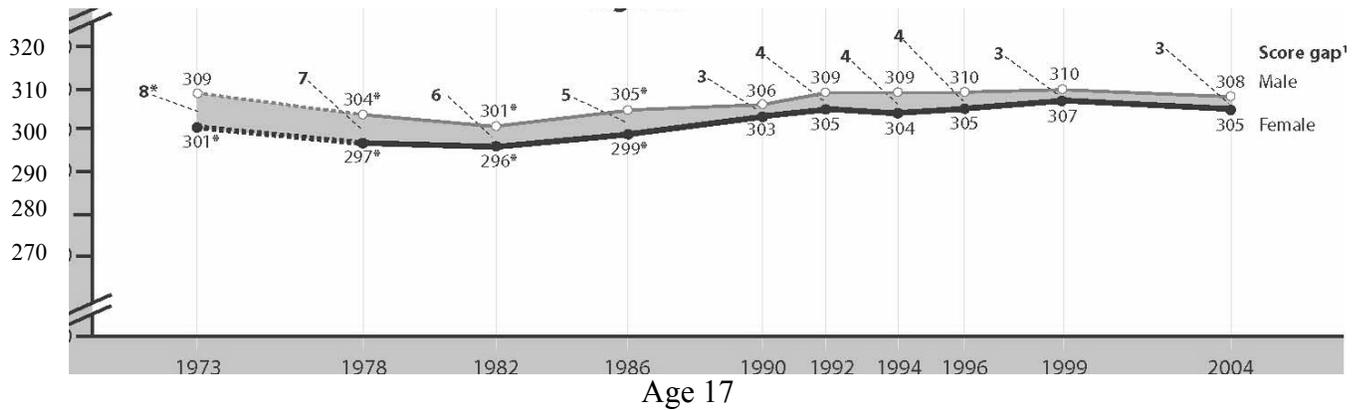
The difference in attitudes between boys and girls regarding math and science can continue into their later years in life thereby impacting their math and science course taking throughout high school and college. These differences in math and science course choices during high school has a direct impact on the readiness of these young women to enter an engineering program once they attend a college or university. There is a need for an early intervention strategy for young women before they reach high school. Some of the strategies that can be employed include encouraging more young women and girls to take advanced math and science courses in high school, reviewing and revising the current math and science pedagogy to be more inclusive of the way that girls learn math (e.g. more hands-on and less spatial), and by planting seeds of encouragement early in a young woman’s life that she can be successful in math and science.



*= Statistically significant difference from score in 2004



Age 13



Age 17

Figure 3: Trends in Math Achievement of Boys and Girls

Source: M. Perie, R. Moran, and A.D. Lutkus, *NAEP 2004 Trends in Academic Progress: Three Decades of Student Achievement in Reading and Mathematics*. Washington, D.C., Institute of Education Sciences, National Center for Education Statistics, 2005.
<http://nces.ed.gov/nationsreportcard/ltr/results2004/>

Confidence in Math and Science Abilities

The evidence that young women have the ability to major in engineering begs the question, “Why don’t more young women choose to major in engineering?” One of the answers may lie in the fact that although they possess the mathematical ability and have the knowledge and the skills to do the science, as Figure 4 illustrates, young women lack the self-confidence and grossly underestimate their ability to succeed in what is perceived as such a rigorous field (Bleeker & Jacobs, 2004; Kerr et al., 2004). Since self-confidence, or self-perception, is directly tied to career choice (Bleeker & Jacobs, 2004), it is no wonder why more women do not choose to major in engineering.

In addition to their lack of self-confidence in their math and science ability, girls report that their interactions with high school math and science teachers negatively impacts their interest or desire to major in science related careers (Blickenstaff, 2005; Kerr & Kurpius, 2004). Boys’ work tends to be rated more highly than girls’ work with regard to factors such as accuracy, organization, and conciseness with girls’ work being rated higher in neatness (Blickenstaff, 2005). Additionally, not only do boys receive more attention from their teachers, and are called on to answer questions more often than their female peers, but the teachers of the subject matter are more often males than females and there are more boys than girls in these required upper-level math and science classes in high school (Blickenstaff, 2005; Kerr et al., 2004). By the time they reach high school, girls choose to opt out of taking higher-level math and science classes and instead choose to take classes where they feel that they are being more valued and recognized for their contributions (Blickenstaff, 2004). The young women who choose not to take advanced mathematics classes in high school are less prepared to major in engineering in college and tend to either not be accepted into engineering programs or to drop out due to

a lack of preparation which indicates that the high school experience is critical to the success of an engineering college major (Brake, Bellamy, Bertso, & Bhatnagar, 2007).

The combination of the lack of self-confidence and relationship with the high school math and science teachers leads to the “chilly climate” those young women feel exists in their math and science classes in high school as well as college (Kerr et al., 2005). The other factor that leads to a chilly climate is the fact that the boys frequently dismiss what the girls think and therefore the girls often feel left out and eventually choose not to participate since their opinions are not being valued (Blickenstaff, 2004).

The lack of confidence of some young women regarding their math and science ability creates a vicious cycle. The lack of confidence combined with the lack of encouragement from their teachers creates a feeling of disinterest in the subject matter. This lack of interest leads to these young women only taking enough math and science courses to fulfill the necessary secondary school graduation requirements (Sasser, Lineberry, & Scheff, 2004). Since a college engineering curriculum relies on a solid mathematics and science foundation, the young women who do not take advanced mathematics and science courses are not prepared to tackle such a rigorous course of study. As a result of the fact that fewer women than men are taking the necessary course work in their high school years, most of the students that are recruited into college engineering programs are men (Sasser et. al., 2004).

Though there has been some indication of change, the pedagogy employed in high school math and science classes favors young men (Sullins, Hernandez, Fuller, & Tashiro, 1995; Steinke, 2004). With the use of textbooks that often cite examples of people who work in technical fields with masculine pronouns, such as he and his, the young women are not able to see themselves in this type of role based on what is being

taught in the classroom (Packard & Nguyen, 2003). Both male and female teachers treat boys and girls differently and the fact that boys dominate the attention of these teachers disadvantages girls in the classrooms (Hersh, 2000). The combination of teachers' attitudes, pedagogy, and the tools and resources used in the classroom, do not create an environment that is encouraging of young women in the areas of mathematics and science (Hersh, 2000). There is evidence that girls learn best from a pedagogy that encourages collaboration and cooperation, is interactive, and has a curriculum that reflects a woman's perspective (Sullins et. al., 1995).

Gender Equity in Secondary School Education

Throughout the years, the attitude regarding the education of boys versus girls has continued to permeate our classrooms and impact the way teachers treat boys versus the way they treat girls in their classrooms (Sadker & Sadker, 1994). Boys are called upon more often to answer questions and solve problems in math and science classes than are girls (Sadker & Sadker, 1994). Teachers spend more time with boys and give boys more praise for the work that they do (Campbell, 1991; Chipman, Brush, and Wilson, 1995). If girls give a wrong answer, they are more likely lead to believe that it is not expected that they will have the correct answers, or they are lead to believe that they aren't really expected to know the answer anyway (Sanders, 2000; Davidson, Dweck, Enna, & Nelson, 1978). Research shows that teachers expect less from girls than they do from boys and are more likely to criticize boys when they are wrong on math and science problems (Sanders, 2000; Stockard, 1980).

In a 1984 study conducted by Margaret Goddard Spear for a Master's degree course in Science Education at Exeter University, mean grades awarded to 11-year-old

boys and girls on the topic of “Distillation” were rated in five different areas: richness of ideas, scientific accuracy, organization of ideas, conciseness, and neatness. The girls received higher mean ratings in the category of neatness (Kelly, 1987).

Another subtle gender bias exists in the classroom in the form of the resources that are used to teach boys and girls. Most, if not all, of the textbooks used in the classrooms are authored by men despite the fact that there are books available that have been written by women on the subjects of mathematics and science (Sanders, 2000; O’Grady, 1995; Tetreault, 1986). Young students are not afforded the opportunity to study about the accomplishments of the many famous women in the areas of math, science, and engineering (Belenky, Clinchy, Goldberg, & Tarule, 1997). When studying subjects such as history and literature, students learn about American history and women’s history as if the two are distinct and separate (Shakeshaft, 1986). The danger here is that the study of the works and accomplishments of women need to be woven into material as an integral part of the subject matter and not an addendum. If the contributions of women are seen as an add-on or a supplement, then these works may appear to be secondary or not as important as those contributions made by men (Sanders, 2000; Rutherford & Ahlgren, 1989).

Bridge Programs

In an effort to increase the numbers of women who choose to major in science and engineering, many colleges and universities have implemented outreach programs for young girls and women. Many of these programs are federally funded by agencies such as the National Science Foundation. The primary objective of these programs is to provide an opportunity for young girls and women to participate in hands-on engineering

and science activities in the hope of attracting more women to these fields. It is also hoped that these programs will help to dispel or reverse the negative stereotypes that exist regarding women scientists and engineers (Steinke, 2004).

It is important to understand which of the more than 200 outreach programs, which were designed and implemented to increase the numbers of women in engineering, are working so that individuals and organizations that are concerned with increasing the number of women in engineering can focus their attention accordingly. Programs such as Program for Women and Girls (PWG) which is funded by NSF, Women in Science Experimental Project (WISE), and KISS Institute for Practical Robotics' Botball, are examples of the kinds of programs and initiatives which have been implemented to increase the number of women in the sciences and in engineering and which are touting success. These programs each have a track record of success in encouraging more young women to take higher-level mathematics and science courses in high school (Campbell, Wahl, Slaer, Iler, Haruna, & Mueller, 1998).

The Program for Women and Girls (PWG) which was funded by the National Science Foundation states that their focus is to increase the number of women and girls entering in and completing programs in science, technology, engineering, and mathematics. NSF has spent millions of dollars on PWG alone. PWG has funded over 180 projects since 1993 (NSF, 2000). Many of the federally funded programs and initiatives have touted successful outcomes for the participants. One such program is the Gateway to Higher Education program in New York City. This program includes an after-school component during which time students take additional mathematics and science courses and do hands-on science laboratory experiments and writing projects. Additionally, the program provides opportunities for students and their parents to attend

college visits and field trips, help with preparation for the SAT, obtain assistance with application documentation for financial aid, apply for internships, and be exposed to science professionals (WEPAN, 2004). The outcomes of this indicate that Gateway students have gone on to take more math and science courses and are moving on to college in greater numbers (Campbell, Wahl, Slaer, Iler, Haruna, & Mueller, 1998). What is not yet known is whether or not these students are majoring in the sciences and engineering once they matriculate to a college or university.

SUNY Stony Brook and the Brookhaven National Laboratory collaborated on the Women in Science Experimental Project (WISE). The program includes both after-school research opportunities for high school students and academic support for first-year college and university students who are enrolled in a science, technology, engineering, or mathematics (STEM) curriculum. The project was initially funded by the NSF in the amount of \$1.4 million but has become a regular offering of the institution now that the NSF funding has expired (NSF, 2004). What is of note here is that the college thought the program was successful and decided to continue this offering even though NSF is no longer funding the program.

The KISS Institute for Practical Robotics' Botball Program is yet another outreach program that is designed to increase the awareness of young women and girls of the opportunities available to them in a STEM career. The Botball program targets 7th grade boys and girls and provides opportunities for both cooperative and competitive engagement. According to Weinberg, Pettibone, Thomas, Stephen, & Stein (2007), the programs positively increased the attitudes of the female participants regarding traditional gender roles. Again, there is no data to show where these young women go for their college education or whether or not they choose to major in an engineering field.

Each of the outreach programs has similar components. Summer camps, extracurricular activities, parental involvement, mentoring, and professional development were common occurrences throughout each program. Though each outreach program may have implemented these components in its own unique way, it is worth noting that the same types of activities were seen time and time again. In addition to the components of the outreach programs listed above, several of the outreach programs stated in their goals that they strive to

- a. Enrich the experience of girls in the areas of math and science,
- b. Draw attention to the women who are currently working in the fields of math and science so that these women may act as role models,
- c. To heighten the awareness of and sensitivity of teachers regarding gender issues in the STEM fields
- d. To assist in modifying the math and science curricula (Siann & Callaghan, 2001).

Several agencies, such as the ones mentioned earlier, have created and implemented outreach programs for young girls and women, which provide opportunities to be mentored by women in the sciences and engineering. Instead, it is advised to integrate role models into the current curriculum versus making them an extracurricular activity (Packard & Hudgings, 2002). Although many of the programs claimed that they saw some success in terms of the attitudes of the participants (Weinberg et al., 2007), there are little or no data regarding the number of women who participate in these outreach programs who actually do go on to college and major in an engineering curriculum.

Access and Equity

If these bridge programs are going to be successful in increasing the number of women who choose to pursue a career in engineering, then it would be beneficial for the

students who participate to be a racially diverse group in an effort to increase the numbers of African American and Latina women in the field (Weinberg et al., 2007). In order to increase the pipeline of women who choose an undergraduate engineering major, we must also increase the numbers of underrepresented groups of women who can see a future for themselves in the field of engineering (Weinberg et al., 2007).

The fact that a large income gap exists between African Americans (and Latinos) and Whites has resulted in a largely racially segregated residential population with many underfunded urban schools which have fewer financial and physical resources than those schools found in predominately White communities (Weinstein, Gregory, & Strambler, 2004). Large urban school districts educate 25% of all school-age students, 35% of all poor students, 30% of all English-language learners, and nearly 50% of all minority children (p. 1131).

African American and Latino children are more likely to be placed in special education classes, less likely than White children to be placed in gifted classes, and more likely to receive some form of corporal punishment (Weinstein, et al., 2004). Students who attend urban schools have higher rates of truancy, lower achievement rates than those of their peers in suburban settings, and lower rates of graduation (Hewson, Kahle, Scantlebury, & Davies, 2001).

Additionally, teacher expectations for the student in an urban school are lower than that of a student in a nonurban school (Weinstein, et al., 2004). These lowered teacher expectations have more of an impact on math performance of African American students than math performance of White students (Weinstein, et al., 2004).

Fast forward a few years, and some of the students who attended the urban schools are now applying to colleges and universities. These students have a lesser

chance of being accepted to a highly ranked college or university due to the fact that these institutions have a selective admissions policy favoring students with a high GPA or SAT score (Astin & Oseguera, 2004). Thus, the criteria for admittance to the highly ranked colleges and universities are merit based rather than need based and it seems that those who have the merit are most often White and come from a nonurban area (Clancy & Goastellec, 2007). Fortunately, some states such as Texas have decided to reserve spaces in their prestigious universities for students who place in the top of their graduating high school classes regardless of test scores (Clancy & Goastellec, 2007). This type of policy may provide a mechanism to increase the number of African American and Latino students who attend top-ranked colleges and universities and hopefully some of the women attendees may choose to major in engineering.

Gender Appropriate Career Development

In an earlier section the reason for a need to increase the number of students who choose to study in undergraduate engineering programs was outlined, and specifically the need to increase the number of women who major in engineering. In order to effectively address increasing these numbers, it would be helpful to gain a better understanding of the reasons why women choose not to pursue STEM fields in greater numbers and specifically engineering careers.

One theory that addresses the reasons that more women do not choose to major in STEM fields is the Social Cognitive Career Theory (SCCT). SCCT extends Albert Bandura's (1986) social cognitive theory to include academic and career behaviors. "SCCT posits that career development is shaped by variables related to one's self (person variables) and one's environment (environmental variables). The three primary person

variables are *self-efficacy*, one's belief that one can succeed at a given task; *outcome expectations*, one's belief about what will occur if one succeeds at said task; and *goals*, or one's desire to achieve a given outcome" (Nolan, Buckner, Marzabadi, & Kuck, 2007, p. 236). Self-efficacy may lead one to ask the question "Can I do this?" Outcome expectations may lead to the question of "If I do this, what will happen?" and goals may lead to the question of "How much do I want to do this?" How an individual responds to these questions will have an impact on his/her overall career decision making process.

In addition to these person variables, SCCT suggests that environmental variables such as mentoring and other methods of support (or barriers) play a key role in career development for women. According to Lent, Brown, and Hackett (1994), the impact that environmental variables such as mentoring and "chilly climate" have on the career choices of women is the same regardless of whether these barriers are actual or perceived. This is an important component of SCCT. The fact that some women may perceive that they will encounter difficulties in an engineering career combined with questions regarding their self-efficacy may lead to the fact that the number of women majoring in undergraduate programs has not increased over the last 20 years (NSF, 2000).

In 1992 Hackett, Casas, Betz, and Rocha-Singh conducted a study which included 218 engineering students at a college on the West coast. The purpose of their study was to analyze the relationship between the social cognitive variables of self-efficacy and outcome expectations to the academic achievement of these 218 engineering students. The results of their study indicate that self-efficacy and outcome expectations are important factors in the career progress of all students. The researchers suggested that in order to increase the numbers of women and underrepresented groups in the field of

engineering, a proactive approach by counselors and administrators, for example, including giving these students more opportunities for successful activities in these areas and providing role models who look like these students, may help to increase these numbers.

According to Betz (1989) and Holland (1985), many factors such as family influence, the availability of finances for college education, support systems, and the community, may impact one's decision of career choice. In other words, career choice may not be simply a matter of one's personal interests. SCCT describes the ways that other factors influence career choice and favors a multifaceted socio-cognitive approach.

Role Models and Images of Engineers

The combination of a lack of women professionals in the field of engineering coupled with the negative stereotypes associated with individuals in the profession, such as the Dilbert cartoon character who is portrayed as geeky, nerdy, and unable to secure a date with the opposite sex, provide an image of engineering that is not appealing to most young women (Bell, Spencer, Iserman, & Logel, 2003). In addition, the field of engineering is often seen as dirty, comprised of heavy manual labor, and one that is not suitable for women (Hersch, 2000). Engineering is still seen as a profession for men, a field that is devoid of human contact and interaction, does not allow one to help serve mankind, and is generally a field filled with geeks (Sasser, Lineberry, & Scheff, 2004). Women also feel that they will receive little support if they have a job in a technical field such as engineering (Pickering, & Thompson, 2002). Since this negative perception of engineering is prevalent, fewer young women than men are attracted to the field which has led to a gendering of the field, and as such the negative image has created a self-

fulfilling prophecy. The profession of engineering is seen as one that does not allow for feminine qualities and therefore the belief is that any woman working in the field of engineering must have more masculine tendencies (Phipps, 2001).

It is necessary to dispel the myths regarding the engineering persona by providing more positive images of engineers. One way that this can be accomplished is by providing opportunities for young women and girls to have positive interactions with women who are currently working in the field of engineering. In a study conducted by Baylor, Rosenberg-Kima, and Plant (2006), female participants who interacted with a female engineer or role model were more likely to see engineers as being cool and less geeky. This is a significant finding because girls learn at an early age that it is “not cool” to be smart in math and science (Sasser, Lineberry, & Scheff, 2004).

Another problem with attracting women to engineering is the obscure nature of the field (Sasser, Lineberry, & Scheff, 2004). Not many people know what engineers do unless they have a family member or friend who is an engineer. According to a Harris poll, greater than half of the population of the United States and almost 75% of women in this country do not know what engineers do (TietJen, 2004). Women are less likely than men to be drawn to a field that they know little or nothing about (Sasser et. al., 2004). Most people think that all engineers sit in a cubicle all day and solve problems, and that they have no contact with any other human beings (Lightbody & Gerda, 1997). Women are not attracted to the field of engineering because they do not see its value to the world and the way in which engineers help people and enrich our lives by providing products and services that make things better (TietJen, 2004).

Additionally, women look for careers that will allow them to balance their lives, family, and career, and engineering is seen as a profession that does not allow for this

balance (Packard, 2002). Seeing few or no women in the science and engineering classrooms at colleges and universities adds to this feeling of concern about being able to balance it all (Packard, 2002). In addition to a concern about balance, women tend to shy away from fields which are seen as not playing a social role and allowing for significant levels of social contact (Lightbody & Gerda, 1997). The lack of portrayal of women in many pieces of engineering literature adds to this feeling of concern regarding the appropriateness of engineering as a career for women (Phipps, 2001).

The Society of Women Engineers (SWE) has taken on the challenge of improving the image of engineers. SWE is committed to educating young women about the fact that engineers are attractive, financially successful, have fun in their jobs, are women, and that engineering provides them with a fulfilling career (Sasser et. al., 2004). The organization originally committed to “inform the public of the availability of qualified women for engineering positions; to foster a favorable attitude in industry toward women engineers; and to contribute to their professional advancement; to encourage young women with suitable aptitudes and interest to enter the engineering profession, and to guide them in their educational programs” (SWE, 1953).

Chilly Climate and Critical Perspectives

Despite the efforts of organizations such as the Society of Women Engineers to improve the image of engineers, an issue that they have yet to overcome is that of whether or not a chilly climate exists for women who enter the STEM fields. The issue of a chilly climate has been a subject of much debate (Whitt, Nora, Edison, Terenzini, & Pascarella, 1999). Hall and Sadler (1982) issued a report entitled *The Classroom Climate: A Chilly One for Women?* This report has been cited many times in current

literature discussing the existence or non-existence of the chilly climate and the ramifications on enrollment of women in engineering (Morris, 2003).

According to Morris's (2003) literature review on chilly climate, Hall and Sandler (1982) state that "overt examples of the chilly climate include discouraging women's participation in class; preventing women from seeking help outside of class; causing women to drop classes or switch majors; making disparaging comments about women; disparaging women's intellectual abilities; implying that women lack commitment; making comments about women's physical attributes or appearance; disparaging women's professional accomplishments; referring to males as 'men' and females as 'girls'; making sexist jokes; ridiculing scholarship that deals with women's perceptions and feelings; and making direct sexual overtures to women" (p.4).

Whether real or perceived, it has been theorized that chilly climate has an effect on the cognitive outcomes of women during their time in college (Pascarella, Whitt, Edison, Nora, Hagedorn, Yeager, & Terenzini, 1997). Pascarella et al. conducted a study in the fall of 1992. The study was conducted with 3,840 participants from 23 institutions across 16 states. The results of the study showed that there was a statistically significant negative association with cognitive development as a result of the perception of a chilly climate on the college campus.

Chilly climate presents more as an issue of bias than of discrimination. Title IX of the Education Amendments of 1972 prohibits sex discrimination in any educational programs and educational activities that receive federal funds. The law states "No person in the United States, shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any educational program or activity receiving federal financial assistance" (20 U.S. Code § 1681). Though critics

argue that women do not face discrimination in admittance to or persistence in STEM fields, Title IX can help to create a climate where women who want to be engineers have an equal opportunity to do so (AAUW, 2008).

Summary

Through the review of the literature it has been shown that there is a need to increase the number of women who choose to major in undergraduate engineering programs. The literature also highlights the benefits of increasing the number of women in engineering as well as the negative impacts of not increasing these numbers. Additionally, it has been demonstrated that there are several barriers that prevent some women from majoring in engineering. Those barriers include early gender identification, the expectation of secondary school teachers, mathematics and science experience, lack of confidence in mathematics and science abilities, role models and images of engineers, and familial influence.

The literature review also identified programs and initiatives that have been developed in an effort to address the low enrollment of women in undergraduate engineering programs. Despite these efforts, enrollment of women in undergraduate engineering programs has either been stagnant or has seen minimal increase over the past 25 years (GAO, 2004). The lack of women entering undergraduate engineering programs creates a situation whereby the pipeline of engineers required to allow the United States to remain competitive in the global economy is not sufficiently filled. An engineering analogy would apply here. In order to increase the flow of electrical current (or women engineering students), we could decrease the electrical resistance (or barriers to

enrollment by women) or increase the electrical voltage (positive images and role models).

Despite the barriers mentioned above, some women do choose to major and persist in undergraduate engineering programs. The purpose of this study is to determine the factors that lead these female undergraduate students to do so.

The theories that my conceptual framework is based upon (Self-Efficacy Theory, Expectancy-Value Theory, and Gottfredson's Theory of Circumscription and Compromise), are informed by the literature reviewed for this study. The next chapter explains in detail the research methodology employed for this study.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

This chapter outlines the conceptual framework, research questions, research design, analysis, and limitations of the study. These topics will be discussed in detail so the reader fully understands the conceptual framework, how the study was conducted, the research methodology employed, and methods of data analysis.

Conceptual Framework

The purpose of this study was to form a better understanding of the reasons some young women choose an engineering major upon enrolling in a college or university. Studies have been conducted on this subject previously (NSF, 2000), yet the field has not seen any significant increase in the number of women enrolling in engineering programs in the nation's colleges and universities (GAO, 2004). Several theories and constructs directly related to the proposed research have been explored. These theories and constructs include career development theory and the constructs of self-efficacy, explained fully later in this section, and academic ability, both of which form the basis of the conceptual framework.

Early career development theories reflected male worldviews, and did not adequately address the complexity of women's career development (Astin, 1984; Betz & Fitzgerald, 1987; Fassinger, 1990). For example, few of the early theories took into account the separation of work and family roles. Recently, however, Gottfredson (2005)

developed a theory that places an emphasis on gender appropriateness and status as critical developmental factors in career decision-making. Gottfredson asserts that initially, all young children have a positive attitude toward all professions. As gender identities develop, however, children begin to think only of those occupations that are considered normative and appropriate for men or for women (Gottfredson, 2005). From this perspective, girls are more likely to limit their own career aspirations to careers traditionally defined for females, while viewing traditional male careers as less viable options for themselves.

These notions of “appropriate” and traditional career choices do not occur in a vacuum for girls and young women. A study conducted by Leedy, LaLonde, and Runk (2003), showed that many young women with a high aptitude for mathematics still maintain a lower confidence in their mathematical abilities. Family members play influential roles in the career aspirations of high school girls and college-age women, helping young women develop the self-efficacy necessary to pursue and persist in a career. This is particularly true for careers with a math and science focus (Caldera, Robitschek, Frame, & Pannel, 2003; Ferry, Fouad, & Smith, 2000; Flores & O’Brien, 2002; O’Brien & Fassinger, 1993; Rainey & Borders, 1997; Zheng, Saunders, & Shelley, 2002).

Career choice theories focus on academic ability (Schaefer, Epperson, & Nauta, 1997), with research showing a relationship between academic ability and both choice of, and persistence in, non-traditional careers for women. The research indicates a need for further examination of the connection between academic ability and career choice. Fewer women enter non-traditional career fields, despite doing as well as their male peers in math and science. Furthermore, among women who initially choose non-traditional

fields of study, those who later choose not to persist in non-traditional careers have higher GPAs than their male counterparts (Meade, 1991). Since the study conducted by Schaefer et al. was based on theories of women's career development including academic ability, self-efficacy, and the expectancy value theory, other explanations for career choice clearly need to be examined by looking at other variables relating to persistence that may affect women's career development (Schaefer et al., 1997).

One explanation of the disjointed connection between academic ability and career choice may lie in an individual's confidence in her abilities, or belief in the ability to do well in the academic subjects required to be successful in the field of engineering. Bandura (1977) labels confidence in one's abilities to do well as "self-efficacy."

This theory suggests that self-efficacy expectations, which are a person's beliefs about his or her ability to perform a behavior successfully, will impact the initiation of a behavior, the amount of effort expended on a task, and the degree of persistence on a task in the face of obstacles (Schaefer et al., p.174).

The construct of self-efficacy originated from Bandura's (1977, 1986) social learning theory, which was extended by Hackett and Betz (1981) in an effort to explain the career choices of women. Hackett and Betz extended Bandura's self-efficacy theory by researching its applicability to vocational behavior and career counseling. The Hackett and Betz study found that males reported higher self-efficacy on non-traditional occupations such as accountant, drafter, engineer, highway patrol officer, and mathematician. Females reported greater self-efficacy in traditionally female occupations such as dental hygienist, elementary school teacher, home economist, physical therapist, and secretary. "The occupation receiving the most divergent ratings for the sexes was that of engineer: 70 percent of males but only 30 percent of females felt that they could successfully complete its educational requirements" (p. 403). The self-efficacy construct

may be an important mediator of the relationship between a person's ability and his or her choice of and persistence in various careers (Hackett& Betz, 1981).

Growing concern about the lack of involvement of women in the field of engineering has led to numerous outreach programs and recruiting initiatives to expand the number of women choosing to major in engineering (GAO, 2006). During 2004, federal agencies spent more than \$2.8 billion on such programs, in the hope of attracting more women to the field of engineering. Such programs typically provided opportunities for young women to learn more about the discipline and to interact with women currently employed in engineering careers (GAO, 2006). Although large sums of money were invested in addressing this challenge, the number of women choosing to major in engineering did not increase between 1995 and 2006 (NSF, 2008).

The conceptual framework for this study builds upon Gottfredson's (2005) theory of gender-specific career choice as the basis for recognizing how key influences (for example, family) impact the aspirations and self-efficacy of young women and their career-related decisions. Additionally, the theories and constructs outlined in the conceptual framework for this research study include career development theory and the constructs of self-efficacy and academic ability. Gottfredson's Theory of Circumscription and Compromise focuses on how young people deal with the collection of vocational choices that are provided to them. According to Gottfredson,

There are four developmental processes that are especially important in the matching process: age-related growth in cognitive ability, increasingly self-directed development of self, progressive elimination of least favored vocational alternatives and recognition of and accommodation to external constraints on vocational choice (p. 72-73).

These issues are being carefully investigated and considered in the research, and have led to the formation of the overarching question driving this study: How did

undergraduate women engineering students come to a decision to major in and persist in engineering?

Research Questions

This study was intended to provide new knowledge regarding women's choice of engineering as a college major, with the intention that the findings will (a) assist secondary schools in better preparing female students and (b) help colleges and universities create effective outreach and recruitment programs that target students whose profiles resemble current persevering female engineering students. The research question guiding this study is: How did undergraduate women engineering students come to a decision to major in and persist in engineering? In order to answer this question a series of interviews was conducted at four colleges and universities in Western Massachusetts. The interview protocol utilized in the study was guided by the conceptual framework, which was in turn guided by the literature review. The study was designed to determine whether or not the theories guiding the conceptual framework held true and if other theories and constructs that have not been considered for this study would arise through the data analysis. My interview questions were created to determine whether or not this contemporary group of engineering students supported the theories that comprised my conceptual framework. According to Gottfredson's Theory of Circumscription and Compromise, issues of gender neutrality can be mitigated by influence from family members. The questions that were asked of the research participants regarding familial influence were based on Gottfredson's Theory. Probing questions were asked of the participants in order to answer the overarching research question. Examples of the questions that related to familial influence were:

- Tell me how you learned of the field of engineering?
- Was there anyone who influenced you in this decision (to major in engineering)?
- Are you familiar with anyone who works in engineering?

Bandura's Self-Efficacy Theory was also central to the conceptual framework of this research study. According to Bandura's Theory, a person's belief about his/her ability to successfully perform a task may be an important factor in the choice of certain behaviors or activities. An example of the questions that related to math and science self-efficacy is:

- Tell me about your secondary school experience (Follow up: Did your grades influence your decision to major in engineering?)

Wigfield and Eccles Expectancy Value Theory asserts that in addition to self-efficacy, an individual's choice of activities and behaviors will depend not only on how well the individual believes that he/she will do on a given task, but will depend also on the value that the individual places on the activity or behavior. The questions related to persistence were guided by this theory. An example of the questions that were asked regarding persistence are:

- Please tell me why you have decided to maintain you enrollment in engineering?
- Can you tell me about your experience with your engineering curriculum?
Please explain.
- Can you describe any impacts you may have had from these experiences?

The purpose of the interviews that were conducted was to gain a better understanding of why some women choose to major in engineering when they attend a

college or university, and whether or not they fit a certain profile as it relates to their college preparedness, family background, and math and science experience. Each student was asked a series of questions regarding the factors that influenced their choice of college major, as well as why they choose to persist in that major. The goal of these interviews was to determine whether specific trends emerge through female students' responses to interview questions about why they chose engineering.

Research Design

According to Merriam (1988), "Qualitative research assumes that there are multiple realities—that the world is not an objective thing out there but a function of personal interaction and perception. It is a highly subjective phenomenon in need of interpreting rather than measuring" (p. 17). With that understanding, this study was undertaken as a qualitative study designed to elicit the rich description and narrative that emerge when individuals are allowed to tell their own stories, and that this qualitative data will contribute to the current body of knowledge on this subject. The study used qualitative data collection methods (interviews) and analytic tools to determine which factors play the most significant roles in female college students' selection of engineering as their college major. The interviews were conducted with current freshman and juniors. The reason for selecting freshman and juniors was to gain a better understanding from both sets of students of the reasons they initially chose the field of engineering to study. Interviews with the juniors yielded additional insight into what factors contribute to persistence in the major.

Qualitative methods were chosen as the preferred method because of their appropriateness for capturing the voices of this group of women, and for the potential for

empowerment of interview subjects. Through the process of conducting interviews with women engaged in an engineering curriculum, and through the use of qualitative research methodology and analysis, the researcher captured themes that emerged from the narrative data.

The process of conducting qualitative research begins by asking questions. The purpose of these questions is to further learning on a particular topic or subject matter (Rossman & Rallis, 2003). According to Rossman and Rallis:

Qualitative research is conducted in natural settings rather than controlled ones; it assumes that humans use what they see and hear and feel to make meaning of social phenomena, and it relies on a variety of data-gathering techniques. It is research that represents human beings as whole persons living in dynamic, complex social arrangements. Historically, qualitative research has been associated with various social science disciplines' cultural or social anthropology, qualitative sociology, history, organizational behavior and so on. Qualitative research also has clear roots in certain philosophical traditions, notably phenomenology and hermeneutics. (p. 7)

Interviews allow for the participants' voices to be heard, and are fundamental to phenomenological research methods. According to Welman and Kruger (1999), "the phenomenologists are concerned with understanding social and psychological phenomena from the perspectives of people involved" (p. 189). This research methodology was chosen due to its suitability to allow examination of the factors that led to the participants' post-secondary decisions regarding their choice of college major. After the interviews were conducted, they were transcribed and coded, with attention to discovering themes that emerged from the participants' own stories.

Participants/Data Sources

To obtain the data, interviews were conducted with women engineering students at four colleges and universities in Western Massachusetts, all of which have an engineering program that has been graduating women for between 3 and 20 years or more. Three of the four schools:

- Smith College in Northampton, Massachusetts
- Western New England College in Springfield, Massachusetts , and
- University of Massachusetts Amherst

grant a four-year baccalaureate degree. A fourth college:

- Springfield Technical Community College in Springfield, Massachusetts

grants a two-year associate degree.

At Smith College and Western New England College, five interviews were conducted at each institution. At the University of Massachusetts Amherst, four interviews were conducted. At Springfield Technical Community College, just three interviews were conducted, as recent enrollment shows very few women enrolled in engineering programs at the school. This yielded a total of 17 interviews. Since the study was geographically limited, the four colleges and universities chosen for the study were selected based on the volume of students enrolled in their respective engineering programs. These four institutions were chosen because they have either have been graduating students with engineering degrees for more than 30 years or because of my familiarity with the engineering program and staff at the institutions. Additionally, the proximity of the institutions to each other made it physically possible to visit each of the campuses within a reasonable amount of time.

The Institutions

Western New England College has been educating engineers for over 50 years and according to their website, the college prides itself on its “hands on” approach of instruction. The college has 188 full time faculties and a student population of approximately 3,700. The college offers undergraduate, graduate, and law degrees with their newest offerings in their recently established school of pharmacy. Located in Springfield, Massachusetts, the college’s campus houses approximately 71% of the undergraduate students enrolled.

According to their website, the University of Massachusetts Amherst is “ranked as the best public engineering school in New England.” The enrollment in the College of Engineering at UMASS has steadily increased over the past five years with an undergraduate enrollment of over 1,700 students. UMASS Amherst is the flagship of the University of Massachusetts system. The university currently has an undergraduate enrollment of approximately 21,400 students, 6,200 graduate students and 1,175 full time faculties.

The School of Engineering Technologies at Springfield Technical Community College currently has an enrollment of over 600 students and has been educating engineering technology students for over 40 years. STCC is the only technical community college in the Commonwealth of Massachusetts. STCC offers over 100 degree and certificate programs. STCC has an enrollment of approximately 6,000 day, evening, and weekend students.

Smith College, located in Northampton, Massachusetts, was founded in 1871. Smith is a liberal arts college and has a commitment to the highest quality undergraduate education for women. Sophia Smith inherited a large sum of money at the age of 65 and

decided to leave her inheritance to found a women's college. The graduate school at Smith admits both men and women students. Smith currently has an enrollment of approximately 2,500 students, 280 faculty, and 41 academic departments. Smith College is considered to be one of the largest women's colleges in the United States.

Students at Springfield Technical Community College, Western New England College, and the University of Massachusetts Amherst can declare an engineering major at the start of their studies. The engineering program at Smith College is the newest engineering program at the four institutions selected, having started just six years ago. Smith College's engineering program allows students to engage in research and design beginning in their freshman year in the program. The Bachelor of Science in Engineering program at Smith College is integrated with their liberal arts curriculum allowing students to learn the fundamentals of several engineering disciplines as opposed to the traditional methodology of focusing on a single engineering discipline during a student's four years of study. Students at Smith College enroll in either an Engineering Bachelor of Arts or Bachelor of Science degree, within which they take the same sequence of engineering courses during their first two years of study and focus on more specific areas during the junior and senior years. Each of the 17 interviews conducted for this study was carried out on the campus at which each of the study participants was enrolled.

The number of students interviewed was a purposive homogeneous sample. Purposive sampling is a type of non-probability sampling in which units or people, according to Leedy and Ormrod (2001), are chosen as a sample for a particular purpose, or for their ability to represent a wide perspective on an issue. According to Boyd (2001), interviewing between 2 and 10 participants is enough to reach saturation, and Creswell (1998) further suggests that conducting up to 10 long interviews is sufficient for

a phenomenological study. A total of 17 women engineering students were interviewed for this study.

Sample size was chosen based on the researcher's own judgment and knowledge of the subject matter, and the purpose of the research. As a woman engineer, the author has tacit insider knowledge regarding the women engineering student community within local higher education engineering communities and judged the sample size to be adequate to provide the data needed for the study.

In September of 2010, 17 women engineering students were interviewed for the purpose of this research study. Each participant was interviewed once, for a period lasting approximately 45 to 60 minutes. The participants at the colleges granting four-year degrees were freshman and juniors. This choice will enable the readers of this study to learn about students' reasons for choice of engineering as a major at the time of college enrollment, as well as to gain an understanding of why female students in their junior year have persisted in engineering studies. At the community college, two first-year students and one student who is anticipating a May 2011 graduation were interviewed.

The students interviewed attended one of the four institutions in Western Massachusetts identified above. The students at Western New England College were identified through the administrative assistant in the College of Engineering. The administrative assistant provided a list of all freshman and junior women engineering students at the college. Each student was contacted, given a description of the nature of the study, and asked if she would be willing to participate. Students at Smith College were identified by one of the advisors in the engineering program. The advisor contacted the freshman and junior students and provided a list of students who stated to her that they would be willing to participate in the study. Follow up with emails and phone calls

were then conducted to schedule the interviews. At the University of Massachusetts, participating students were identified with the help of a colleague working with undergraduate engineering students in the Summer Program for Undergraduate Research (SPUR) at the institution. The students at Springfield Technical Community College were identified with assistance of one of the engineering faculty members at the college. Each student was contacted by telephone and email with an explanation of the purpose of the study. Once a student had agreed to participate in the study, she received a follow-up phone call to confirm participation and schedule a time to meet.

At the beginning of the interview, each student reviewed and signed the Informed Consent form (Appendix A) and was given the opportunity to ask questions or express concerns regarding participation in the study. In each case, students expressed their desire to continue and to be a part of the study. Students were offered the opportunity to review the transcribed interview if they so chose. No student expressed concern or opposition.

Pilot Study

Prior to undertaking the full study, a pilot study was conducted in September of 2010 with two Western New England College students, who became ineligible for participation in the full study. Data obtained from the pilot study were used to refine the interview protocol. The Western New England College students who participated in the pilot study were recruited with the help of the administrative staff in the Office of the School of Engineering at the college. During the pilot study, some of the questions yielded redundant answers and some did not provide data specific to their choice of

college major. Following the pilot study those questions were changed or refined in order to obtain more pertinent data.

Trustworthiness of the Data

According to Guba (1981), trustworthiness of the data should be addressed during a research study and the four major concerns relating to trustworthiness are “truth value, applicability, consistency, and neutrality” (p. 80). The scientific descriptions of these four major concerns would be credibility, transferability, dependability, and confirmability.

Truth value or credibility in qualitative research is concerned with the appearance or semblance of truth that the researcher reports regarding the research data. Guba (1981) asserts, “The testing of credibility is often referred to as doing ‘member checks,’ that is, testing the data with members of the relevant human data source groups” (p. 80). Member checks were conducted with students who are currently engineering students but were not a part of this study, with women engineering faculty members at one of the institutions that were a part of the study, and with friends who are women engineers. Numerous conversations were also held with a colleague who led the doctoral program in adult education at a university in eastern Massachusetts. During those conversations, the process of coding the data and determining the themes and findings was discussed.

Consistency is concerned with the ability of the research instrument to produce secure results. The stability of the results is crucial if they are to be meaningful. Consistency of the data was determined by the fact that each of the participants was asked the same series of questions in the same chronological order. According to Guba (1981), “Inquiry can be affected by instrumental drift or decay which produces effects of

instability to guard against which we replicate in hope this action will lead to reliability and produce findings that are inconsistency-proof” (p. 82). This consistency is interpreted as dependability.

Applicability ensures that the findings can be applied in a broader context. Applicability was demonstrated by the fact that situational variations had no impact on the findings of the study. All of the data converged on the same findings across institutions, thus leading to the transferability or applicability of the data as the settings, locations, and times that the interviews were conducted yielded the same outcomes.

Neutrality addresses the fact that the research process is free from bias. Neutrality of the data is demonstrated by the fact that the findings represent the emic perspective of the research participants. This is further evidenced by the fact that in most cases, the findings support findings from previous research.

Limitations/Strengths

The position of researcher in this study is that she was formerly a woman engineering student, and now has tacit insider knowledge of the issues faced by the student participants and a shared understanding of common language and codes. Additionally, she has a personal commitment to positive educational outcomes of this population of women. While “going native” might in some circumstances be construed as a limitation, in this case it is framed as a strength of the study. The author believes that her ability to gain access and trust from the participants was enhanced by their identification with the researcher as a woman who has obtained an engineering degree and is visible in the field. This was evidenced by the fact that several of the participants used terminology common in the engineering discipline without stopping to explain the

meaning of the terminology. Not only was the shared experience between the participants and researcher valuable in gaining participants' willingness to contribute to the study, it is likely that the expectation of shared experiences and perspectives contributed to the quality and intensity of the interviews. At the same time, however, the author employed discipline and rigor to avoid assumptions about the divergent views held by the women that were interviewed for this study.

Data/Measures/Coding

Interviews were recorded, transcribed, analyzed, and coded on an ongoing basis using the Glaser and Strauss Constant Comparative method (Glaser & Strauss, 1967).

Using the constant comparative method makes probable the achievement of a complex theory that corresponds closely to the data, since the constant comparisons force the analyst to consider much diversity in the data. By diversity we mean that each incident is compared with other incidents or with properties of a category, in terms of as many similarities and differences as possible. This mode of comparing is in contrast to coding for crude proofs; such coding only establishes whether an incident indicates the few properties of the category that are being counted. (Glaser & Strauss, 1967, p. 114)

Process for Analyzing the Data

Once the interviews were transcribed, the data was coded using the methods of open, axial, and selective coding. During the process of open coding, the data was scrutinized to identify concepts along with their properties and dimensions and these concepts helped to identify the most meaningful bits of data (Coffey & Atkinson, 1996). These concepts were identified by the fact that they were consistent throughout each of the interviews that was conducted. Some of the names of the concepts may be in vivo codes, names chosen for concepts due to the fact that several of the participants used the same term(s) while telling their stories.

Throughout the process of axial coding, the data was assembled in a new way by making connections among the categories identified during the open coding process. Finally, through the process of selective coding, a last pass was made through to identify core categories. The coding process should not be considered as analysis but rather a heuristic process that aides in the process of interpreting the data (Coffey & Atkinson, 1996).

The process of data collection utilized triangulation by interviewing multiple participants at different colleges and universities on different dates and times, thereby allowing for “cross examination” of the data. This process allows the researcher to have more confidence in the data if the data from the multiple sources produces similar results.

Once each participant’s interview had been transcribed, she was given the opportunity to review the transcript in order to make certain that her stories were conveyed with accuracy. The process of word for word transcription along with the review by the participants facilitated the authenticity and trustworthiness of the data.

Analysis

The analysis process was conducted in two phases. First, each interview was transcribed verbatim and numbered chronologically by the date that the interview was conducted. In an effort to protect the identity of the participants, a pseudonym was assigned to each participant also during this phase. Though each of the interviews was transcribed verbatim, slang terminology and colloquialisms have been removed for readability. Five copies of each transcribed interview were made, then placed in a three ring binder that was organized by institution and date of interview.

The next step in the process was to analyze the data gathered by coding the data. The data were coded using the methods of open, axial, and selective coding (Corbin & Strauss, 1998). During the process of open coding, the data were scrutinized in order to identify concepts along with their properties and dimensions. These concepts were identified by the fact that they were consistent throughout each of the interviews that was conducted. Each of the five copies was coded line-by-line looking at the transcript in its entirety without discernment of the questions. The same process for coding the data was used each time each of the five copies was coded and this process yielded consistent codes and concepts. A second pass of the data was made by coding all five copies of each transcript by looking at the responses to each individual interview question. The codes and concepts were consistent with those found in the first pass of coding without the discernment of the questions. This method correlates to the constant comparative method (Glaser & Strauss, 1967), whereby one piece of data is compared to another in order to ascertain the relevancy of the data to the inductive codes/concepts being derived and to the deductive codes/concepts that were preexisting in the literature. The purpose of this was to make certain that the concepts and categories/themes that were identified were consistent with every pass of the coding. During the coding process, emerging categories and themes were color-coded in order to easily identify not only the patterns that emerged during the coding process but also the number of times that certain categories and themes were discussed by the participants. The color-coding facilitated the process of identifying those concepts and categories that were mentioned most often by the participants, as they stood out from the rest of the data. Notes were made in the margins of each transcribed interview that highlighted thoughts and points of interest on various topics being shared by the participants. Some of the names of the concepts were actually

in vivo codes, actual phrases or comments (Corbin & Strauss, 1998) that the participants used while telling their stories.

Comments, ideas about the information in the transcript, and reactions to participant answers to questions were written on the margins of each transcribed page. Patterns, common threads, and recurring phrases were sought in the data. The notes and comments that were made in the margins were then used to define the key themes and findings of the study by correlating these data to fully understand where the consistency in the responses to the interview questions lay. As patterns began to emerge in the participants' responses, these patterns were used to identify those responses which occurred most often from the participants, and these became the key themes and findings of the study.

Throughout the process of conducting research for this study, much attention was given to maintaining the integrity of the data. As a researcher it is imperative to demonstrate rigor in order to legitimize the qualitative research (Chase & Mandle, 2001).

Environment

At each of the institutions where interviews were conducted, the space provided was warm and comfortable. At Western New England College, for example, a small room located off of the main Engineering Office provided a secluded space for the interviews. The room was softly lit and had a door that allowed for privacy.

On the day of the interviews at Western New England College, each student was greeted by one of the administrative assistants in the Engineering Office, who then escorted her into the room at the beginning of the interview.

Interviews began with introductions and a discussion of the nature and purpose of the research. Once the formalities were dispensed with, interviews proceeded. Participants shared their experiences as women engineering students, and discussed the journeys that led them to major in engineering and to choose the specific institution at which they would pursue their engineering degrees. Participants seemed genuinely flattered to have been asked to participate in the research, and three of the research participants suggested names of other students who might also be willing to participate. This development allowed for a few more interviews to be conducted than had been previously scheduled. One of the students at Western New England College and two students from Smith College each recruited a friend in the engineering program to participate in the interviews.

Demographics

The demographics of the students who participated in the study are summarized in Table 3. The names of all study participants have been replaced with pseudonyms; students agreed to the use of pseudonyms during our initial consultation and upon signing the informed consent form.

Table 3: Demographic Profiles of Students

Name	Engineering Major	Year	Race	Institution
Cathy	Electrical	Freshman	Caucasian	Western New England College
Cindy	Mechanical	Junior	Caucasian	Western New England College
Mary	Bio-Medical	Freshman	Caucasian	Western New England College
Terri	Electrical	Junior	Caucasian	Western New England College
Carol	Electrical	Junior	Middle Eastern	Western New England College
Joyce	Mechanical	Freshman	Caucasian	University of Massachusetts Amherst
Tina	N/A	Freshman	Caucasian	Smith College
Kimberly	Mechanical	Junior	Caucasian	Smith College
Sandra	N/A	Freshman	Asian	Smith College
Yvonne	Mechanical	Junior	Caucasian	Smith College
Danielle	N/A	Freshman	Caucasian	Smith College
Alecia	Industrial	Junior	Caucasian	University of Massachusetts Amherst
Bobby	Chemical	Freshman	Caucasian	University of Massachusetts Amherst
Lisa	Bio-Medical	Sophomore	Caucasian	University of Massachusetts Amherst
Karen	Electrical	Freshman	Caucasian	Springfield Technical Community College
Linda	Electrical	Freshman	African American	Springfield Technical Community College
Donna	Civil	Junior	Caucasian	Springfield Technical Community College

The students whose major is listed as N/A are freshman students at Smith College who are enrolled in either an Engineering Bachelor of Arts or Bachelor of Science degree and will focus on more specific areas during the junior and senior years.

Student Participant Profiles

Cathy has always had strong math skills, taking AP Calculus in her junior year of high school. She believes this is a skill that she got from her father. She explained that she became interested in engineering because of her love of physics. She initially planned on becoming an architect, but after taking her first physics course, found that “physics has been transforming my likes and interests.” *Cathy* also stated that she was involved in math and science competitions at an early age.

Cindy, like *Cathy*, also excelled in math. *Cindy* describes herself, however, as “more of a science person.” Her original educational interest was medicine. It was her brother who encouraged her to take a look at the field of engineering, and after her first semester studying engineering, she “fell in love with it.” She admitted that she was trying to “run away from math and physics because I am good in it, but I’m never like on the top of it.”

Mary had an affinity for biology. After taking an introduction to engineering class, she was fascinated by how you can design items such as hip replacements and how new tissue cells are able to be grown and harvested. “It’s a really cool field.” Her mother encouraged *Mary* to give engineering a try and then transfer into something else if she didn’t like it. “I definitely want to use my math and science skills because that is what I’m best at.”

According to *Terri*, the subjects of math and science were always where she was most comfortable and “saw the most possibility for myself.” She started her college education not knowing what she wanted to major in, but after following the suggestion of a friend and taking an Introduction to Engineering course, decided that the field of

engineering was a good fit for her. She described herself as the kind of person who “just takes things as they come. I have a feeling that’s how I got into engineering.”

Carol also recognized that math and science were always her strong suit. “I just loved doing science so much, specifically physics.” She entered college knowing that she wanted to major in engineering. She attributes this to the encouragement that she received from her parents after her successes on her high school robotics team. She enjoyed her experience on the robotics team because it “allowed me to see this really fun and interesting side of engineering that I hadn’t expected and I thought, you know what, I’ll try it.”

Joyce said she never loved subjects such as art, history, or social sciences. She attributed this, in part, to the fact that she “doesn’t like reading.” She stated that she is happy to do her math and physics homework, but consistently procrastinates when it comes to writing papers. She said that she was influenced to consider studying engineering by a cousin who works in the engineering department at a university.

Tina shared that she had always received A’s in math and science during her high school years. She also stated that when she did run into difficulty with her homework, she had support at home from her father, who is an engineer. An engineering environment surrounded her both at home and during the time she spent with her father at the university where he was a faculty member. Her love of English literature led her to major in engineering and minor in English literature at her current college.

Kimberly indicated that she has chosen to major in mechanical engineering because, unlike the field of electrical engineering, she can physically see it. She admitted, however, that she thinks electrical engineering is more interesting. She took every math class her high school offered, and went as far as AP physics. She said she

kept taking the math and science classes because they were “something that I was good at. I took every math class they offered.”

Sandra was always in high honors classes in her high school. She shared that the one math class she had a hard time with was ninth grade algebra. In order to succeed in the class, she stayed after school for additional help. According to Sandra, “all of a sudden, it just clicked.” Her decision to major in engineering was due in large part to her friend, Joe, and his friend, Scott, who both majored in engineering. Sandra’s boyfriend is also majoring in engineering, so according to her, “It’s really working out.”

Yvonne explained that her high school grades in math and science were relatively good, as she received A’s and B’s. She had an Introduction to Engineering class while in high school, and was able to take it as a science elective, which swayed her decision to major in engineering. Yvonne also shared that a woman engineer came to the Introduction to Engineering class as a guest speaker. This helped to solidify her decision to major in engineering because “you could actually like see other people like doing it. Like it kind of shows you that you’re not the only one.”

Danielle had no idea what she wanted to major in when she was graduating from high school, but her guidance counselor suggested she consider engineering because her math and science grades were so high. Danielle admitted that she had no idea what engineers do, so she did some research. “Then I realized that the stuff that engineers do is like stuff that I would love to do, so it ended up being like perfect.”

Alecia reported that she received high marks in her high school math and science classes, but that this had nothing to do with her decision to major in engineering. “I just like to build things.” She only went as far as pre-calculus in high school because by her own admission, she was “a lazy high school senior.” Between encouragement from her

mother to try an engineering education, and her love of building things with her father, she decided that she might as well give engineering a try.

Bobby excelled in math and science classes during high school, and truly enjoyed her mathematics classes. “I would always save my math homework for last. You know, you like save the best for last.” She shared that this love of math and science definitely influenced her decision to major in engineering.

Lisa was resistant to majoring in engineering since she perceived it as a “man’s profession.” Instead, she considered a career as a pediatrician. A later conversation with her grandfather led her to an introduction to a bio-medical engineer who specialized in orthopedics. This personal introduction afforded her the opportunity to spend some time in his laboratory at the end of her junior year of high school. This experience led to her decision to major in engineering.

Karen shared with me that she did extremely well in math and science while in high school. “My older brother is an engineer, and when he saw how good I was in math and science, he suggested that I think about becoming an engineer.” More specifically, she noted, “I really like the electromagnetism part of my high school physics class, so I decided to go for electrical.”

Linda discussed her decision to attend college. “I am the first person in my family to go to college. They are really proud of me and especially for majoring in engineering. I just always did well in math and science so my counselor suggested that I look into it.”

Donna had not made a decision regarding her choice of major upon entering college. “I always did well in math but never considered engineering for myself. A

couple of my high school friends suggested it but I didn't think it was for me. I took an engineering introductory class and just fell in love with it. This is where I want to be.”

Conclusion

When the task is to identify data trends or the nature and strength of relationships between variables, or to parcel out the contribution of specific variables to the variance in a set of data, quantitative methods serve quite well, but when the task is to describe the dynamic blending of variables that produce a particular result, or to explain a phenomenological transaction, quantitative procedures are of little use. (Gordon & Song, 1994, p. 40)

This paper has outlined the methodology, procedures, rationale, and need for this study of the factors that influence some young women to choose a college major in engineering. Qualitative research methods are the most appropriate method to explore the complex phenomenon of the choice of engineering by some undergraduate female students.

CHAPTER 4

FINDINGS

Introduction

As noted earlier, current science education is not producing the necessary numbers of engineers and scientists for the United States to maintain the lead in the global economy (Women in Higher Education, 2007). Increasing the number of women in engineering will impact the country's ability to remain in the lead. Norman Augustine, the retired chairman of Lockheed Martin Corporation, issued this statement in the report entitled "Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future" (2006):

If the U.S. does not respond quickly, the consequences will be predictable and straightforward. The U.S. will lose quality jobs to other nations, and without such jobs, our citizens will not have the purchasing power to support the standard of living which they seek, and to which many have become accustomed; tax revenues will not be generated to provide for strong national security and healthcare; and the lack of a vibrant domestic consumer market will provide a disincentive for either U.S. or foreign companies to invest in jobs in America. (p. 25)

For this reason and others, such as filling current and future vacant engineering positions, bringing a new lens for idea generation, and creating different perspectives on problem definition and solutions, it is vital to this nation to increase the number of women in engineering and the sciences (Schaefer, Epperson, & Nauta, 1997). Additionally, the lack of involvement of women in the design of technology will continue to result in the production of technologies that do not respond properly and adequately to women's concerns if solutions to problems continue to be shaped and molded through a masculine lens (Cuny & Aspray, 2000).

The purpose of the study is to add to the current body of knowledge regarding the reasons that women self-select to enroll in undergraduate engineering programs at certain colleges and universities in Western Massachusetts. Those institutions participating in this study who choose to avail themselves of this data, may find that the results assist them in increasing the number of women who choose to enroll in an engineering program at their respective college or university. The overarching question that guided this qualitative study is: How did undergraduate women engineering students come to a decision to major in and to persist in engineering?

Themes and Findings

The theories and constructs outlined in the conceptual framework for this research study originally included career development theory, and the constructs of self-efficacy and academic ability. As a result of the research, the expectancy-value theory of Eccles et al. (2000) should also be included in the discussion.

According to Bandura's (1977) self-efficacy theory, a person's belief about his/her ability to successfully perform a task may be an important factor in the choice of certain behaviors or activities. Wigfield and Eccles (2000) built upon Bandura's theory by arguing that in addition to self-efficacy, an individual's choice of activities and behaviors will depend not only on how well the individual believes that he/she will do on a given task, but will depend also on the value that the individual places on the activity or behavior. According to this theory, expectancy and value directly influence achievement choices. If an individual expects to do well at a given task/goal and has placed a value on succeeding at that task/goal, then he/she will work to accomplish the task/goal.

Expectancies and values are assumed to be influenced by task-specific beliefs such as ability beliefs, the perceived difficulty of different tasks, and individual's

goals, self-schema, and affective memories. These social cognitive variables, in turn, are influenced by individuals' perceptions of their own previous experiences and a variety of socialization influences. (p. 69)

Though Bandura did discuss value in his theory of self-efficacy, the major difference between the self-efficacy theory and the expectancy value theory is the fact that Bandura argues that efficacy is the predictor of behavior choices whereas the expectancy-value theorists argue that outcome expectations are the predictor of behavior choices (Wigfield & Eccles, 2000).

Role of Family/Friends

The participants in the study were of varying backgrounds with respect to their self-reported socio-economic backgrounds. The young women were primarily from various parts of the United States; one participant was born and raised outside of this country. Though their backgrounds varied, one of the common threads to their decision to major in engineering was the influence of a family member, friend, or educator. Joyce's story exemplifies the experience that several of the participants shared. Joyce stated:

Honestly, it was because of my cousin. He was in an engineering department of a university. He's so good and I look up to him. He was a computer engineer and he told me about what he studied and how he writes programs and how he can use computers to control stuff and he was in a project to design a robot or something and I thought, that's so cool. At the time I was in middle school and I think I was like, yeah, I want to be like him and I started to set my goal. I wanted to study engineering and my Dad said 'are you sure because it seems like all of the influence is from your cousin and not from me' but I said, yeah, I'm sure. So I began to investigate more into the engineering field.

Joyce's father also supported her decision to major in engineering. She commented:

At first when it was in middle school I thought, I don't think it's the age of a student to like decide whether she's going to major in what—and I think my dad

is so supportive about engineering major and he said, “if you’re sure go for it but if you’re not sure make sure that you’re sure—because that if you really like it you’ll do good—but if you just think that it’s cool and you go for it and then you find out that it’s not right for you—you’re going to screw up.

Tina talked about growing up with a father who is an engineer. She stated, “I always had support at home when I had trouble with homework. My dad is an engineer so he just helped me out with homework. Since my dad is an engineer, I’ve always had that in my family and he’s a professor of engineering so I grew up basically in an engineering school at the University.”

During an interview with Kimberly, she talked about “being Daddy’s little girl.” She said that when he worked on cars, she used to follow him around. She stated, “For my first car me and him restored an old truck. I restored a 1967 Ford Mustang for my mom. I just always hung around the guys, and it’s like hands-on and everything.” She indicated that this led to her decision to pursue a career in mechanical engineering.

The influence and support of Tina’s, Joyce’s, and Kimberly’s fathers, is consistent with the research that suggests young women who choose to major in engineering are inspired to do so due to a paternal influence or inspiration by the father (Turner, Bernt, & Pecora, 2002; Dryler, 1998). The role of parents has a major impact on the choice of major by their children and parental influence has the strongest impact on young adult career decision (Bleeker & Jacobs, 2004). A study conducted by Turner, Bernt, and Pecora (2002) at Ohio University included statements by women citing their desire to major in computer science engineering because it pleased their fathers. The authors stated that the positive manner in which their fathers reacted to their interest in the field further excited them in the subject matter and inspired them to continue their studies.

Twelve of the seventeen research participants shared similar stories of being influenced or encouraged by a parent, sibling, other family member, or a teacher or guidance counselor. Cindy was originally going to study medicine but “my brother was encouraging me to try engineering. He told me that I never know, I just might like it. I was like, no, I don’t want engineering, and he said ‘just try it for the first semester just for me.’ I tried it and I just fell in love with it.”

Like Cindy, Lisa also considered a career in medicine though her teachers and her grandfather encouraged her to pursue a career in engineering. While getting prepared to undergo knee replacement surgery, Lisa’s grandfather met a bio-medical engineer who specializes in orthopedics and encouraged Lisa to speak with him. “So I talked to him and go to do some stuff in the lab and see how it works. So I got to input slides up the retrievals into the computer and I got to see retrievals and stuff—so I fell in love with it.” It was Lisa’s visit to the lab of this bio-medical engineer and having the ability to spend some time working with him that led to her decision to major in engineering.

Mary was waffling with the decision to major in engineering versus majoring in business. It was her mother who influenced her final decision. Mary’s mother suggested that she “do engineering first and if you don’t like it, it’s a lot easier to transfer into business.” It was this encouragement from her mother that ultimately led to her decision to pursue her undergraduate engineering studies.

Carol related her story of how she decided to major in engineering and shared that it was mostly “like a fight with my parents because I was being resistant.” She went on to say:

Well I was in high school and I was on the robotics team and I was good at math and science and my parents realized ‘you should look into biomedical engineering’ because they thought I was really interested in bio which I am to a

certain extent but not as much as pure physics—you can't know everything about a biological system it's just not possible—brains are not big enough to figure it out—and that drives me nuts—so I studied. I was doing all the stuff and my parents are nurses and they're like 'you should do biomedical engineering because it's really interesting.' I kind of figured I would try it and then just get on with it.

Other participants learned of the field of engineering through their participation in an extracurricular activity during their high school years, or they took advantage of an opportunity to take an introductory engineering class during their freshman year of college.

Cathy commented:

Yeah, I had to I guess even from elementary school there was this program called [names program] and it was just elementary schools competing against each other with rocket launch and so yeah, even when I was ten and in fifth grade I was involved in a lot of math and science. It's not that from the age of ten I wanted to be an engineer but guess I just got involved in different things outside of school. It was an extra-curricular activity and then in my high school senior year I actually got [names program], that same program to come to my high school.

Tina shared a similar story regarding her introduction to engineering through an after-school experience during her senior year of high school:

Yeah, actually there was an instance where I was encouraged [by an extracurricular activity] and it was they had an introduce a girl to engineering day for high school students at the University of Colorado but I was lucky that I lived close to the University. I think that girls who were outside of that area probably wouldn't have had access to that. It was for fourth to sixth graders and sixth to eighth graders. For two weeks I helped out with the fourth through sixth graders and they were so enthusiastic about it too. We introduced them to this artificial intelligence thing on the internet called Alice and it's a chatterbox and so they were just having so much fun with that and they wanted to go home and play with it. They really had a lot of fun.

Kimberly did not know exactly what she wanted to major in when she started her studies at Smith College.

When I came to Smith I went through the entire course book and I thought, you know in high school I have never taken an elective that wasn't math so it's really weird because I don't know what I like. I've done music but the music program

in my school was if you start playing an instrument in fourth grade you couldn't quit until you graduated. Oh my god, it was awful. So music took up a whole part of my growing up experience. So you could only take two electives a year—so one of my electives always had to be music and the other elective was always math—so when I got to college I thought oh, these classes sound so weird. I don't know what to do—so I was thought, well, I'm going to take another math class and I saw Introduction to Engineering and I was oh, that looks really interesting because I remember being in high school and thinking, I don't know what I want to go to college for—my best friend Jen said you know what—cause I used to really like Disney I used to go to Disney World with her family every year. We'd all go and she was said 'I think you'd make a really good Disney 'Imagineer' and I thought, oh, it's such a cool idea. You're right, so when Introduction to Engineering was there I thought, oh, I'm totally taking that class, that sounds awesome and then I took some first year seminar [course] cause you have to. I figured I wanted to try science again but something more mathematically based and I thought, this is for people who can do math and I thought yes, math class but it was kind of science oriented. I jumped on it and because I figured it kind of tied into engineering so I was like okay. Yeah, so that was what I started taking. And after Introduction to Engineering, I loved Engineering. It kind of beats your soul to death but at the end I was like okay—it just consumes so much of your time—you know it was hard it was a really hard class.

Terri's story mirrors the experience that Kimberly shared:

I don't know I'm kind of different than most of the engineers here I just kind of came here not knowing what I wanted to do and second semester freshman year I was just randomly choosing courses and someone said Engineering for Everyone was a fun course so I took it and then I thought, oh, I really like this. This seems applicable where it seems like something that I could see myself actually doing opposed to if I majored in a lot of other majors where it's not quite as direct and application to like your career.

In most cases, the participants asserted that their math and science aptitude made for a seamless transition into engineering once the decision had been made.

Whether it was a father, brother, mother, or cousin, the majority of the participants expressed that they were influenced or encouraged to study engineering by someone within their immediate sphere of influence. This influence from a family member may have helped these women overcome the notion of “gender appropriate”

careers as espoused by Gottfredson in the conceptual framework section of this dissertation.

Math and Science Self-Efficacy

Bandura (1997) described self-efficacy as “the belief in one’s capabilities to organize and execute courses of action required to produce given attainments” (p. 3). Our efficacy beliefs influence what actions we take, what vocations we choose to pursue, the amount of work that we will expend to succeed at a given task, and the manner in which challenges and obstacles are faced (Chemers, Hu, & Garcia, 2001). In a study conducted in 2001 by Chemers, Hu, and Garcia, the data show that “students who enter college with confidence in their ability to perform well academically do perform significantly better than do less confident students” (p. 61).

During the interview process, the study participants recalled their feelings regarding their academic self-efficacy relating to both their high school years and the time that they have spent thus far engaging in their engineering studies.

Carol contended:

My strength in math and science led to my decision to major in Engineering. I just loved doing science so much, specifically physics—I mean I don’t think I wanted to do pure physics—you hear wacky stuff about it—but and so I thought you know engineering would be a good kind of middle ground for me.

As the interviews progressed, the participants acknowledged this mathematics and science self-efficacy time and time again. Sandra commented:

In high school I was always high honors in math and science so I’ve never really had a problem with those two. Well, I think I genuinely was interested and for some people it’s hard for them to grasp Algebra—and I remember when I was in eight and ninth grade I could not get Algebra—and I did not understand Algebra the letters and numbers mix—and I would go to school and I would stay after school and then all of a sudden it just clicked and ever since then I’ve just gotten it. It was a plus when I decided to major in engineering because I felt I was getting into

something that I could possibly handle. It wasn't like, oh I absolutely stink in math and science.

The strength in their beliefs that they could do well in their math and science studies ultimately led to their self-efficacy as it relates to their engineering studies. Many of the participants shared stories about their convictions to succeed in their pursuit of an engineering degree. Joyce shared, "We study engineering in order to invent and improve things in order to make people's lives better. I think that was interesting for engineering and for me and this is why I will stay in this field."

Comments made by the participants also supported Wigfield and Eccles' Expectancy Value Theory. The participant's statements indicate the high level of value that they place on having an engineering background. Tina contended:

I think in general the reason I chose engineering was to become a well rounded person—and it's not even about the career, it's about having the technical skills that I think are important in today's world—and so I think maybe that's a good way to encourage women to pursue engineering if they think about it as developing these important skills that allow you to succeed in whatever career you want to do.

The ability to succeed in an engineering curriculum is largely dependent on the mathematics skills and abilities of a student. Most engineering classes, regardless of what field of engineering is being studied (e.g. civil, mechanical, electrical), requires a strong aptitude for mathematics since engineering is an applied mathematical field. At the undergraduate and graduate levels, the engineering curriculum is highly theoretical, requiring that students be able to manipulate algebraic and differential equations in order to solve a given problem set or design solutions to given problems. Students' belief that they possess strong math skills, self-efficacy, is instrumental in their willingness to continue their engineering studies during the challenging times; and in the study of engineering, there are certain to be challenging times.

During the interviews, almost all of the participants declared that they exhibited a high propensity for math and science during their high school years. According to Cathy:

I've always been great in math. I didn't actually take a math course in my senior year because I took AP calculus my junior year and there wasn't anything else after that so for AP calculus I passed the AP exam and in the class I believe I got a B and then A and then I think the last one was A. So yeah, I've always been great at math. I think it's just a skill that I always got from my father.

Other participants shared similar stories with respect to their success in math. I heard statements like, "My grades in math and science were good," "Math and science was where I had the most comfort and most possibility," "I was really good— my first semester of high school math was geometry and I got a 100. I was really good," and more than once I heard, "My grades in math and science were all A's."

Since engineering is applied mathematics, the fact that the participants excelled in mathematics during high school is no surprise. The fact that many of the participants took so many advanced math classes and continued with their math classes through the majority of their high school years differs from what the current statistics show regarding persistence of girls in high school mathematics. High school is the point in time when students' interest in mathematics wanes and the loss in mathematics during high school is most dramatic for girls (Shapka & Keating, 2003). These participants were clearly above the norm compared to what the data demonstrates about girls and math. According to a study by Sophia Catsambis (1994), "At the high school level, young women often limit their opportunities to learn mathematics by completing only the minimal mathematics courses required for graduation." The level of math proficiency demonstrated by the participants in this study is necessary to be successful in an engineering program. Math, science, and English grades during the high school years in addition to self-perceptions of

problem solving abilities, math, and science are strong predictors of engineering persistence (Moller-Wong & Eide, 1997).

The study participants all shared positive experiences regarding their high school math classes. These positive experiences led to their positive beliefs, or self-efficacy, about their ability to succeed in math or a math-related career. According to Mary:

Math was actually one of my favorite subjects. My story actually starts in fifth grade when I was told that when I graduate from high school [*sic*]the classes would be considerably smaller because a lot of students would drop out and most of the students would be women—and so just ‘cause it’s just a thing that happens—and so my math teacher told me, ‘Don’t let that happen to you,’ my fifth grade math teacher—and so that’s kind of always been in the back of my brain—and as a junior in high school I took the highest math class my high school had to offer—and it was just a goal I’ve been working towards—and that was a big goal for me. There were more men than women. They were smaller classes—but it was just a big goal for me—so yeah, I’ve always really liked math and science. They make the most sense to me. I’m a structured and literal person so math and science are definite answers to what I really like.

The findings for science were similar to those for mathematics. Almost all of the participants indicated that they liked and did well in high school science courses. Some of the participants expressed the like for math and science, especially physics, because it made sense, it was fun, and it was not required to do rote memorization, as it would be with a biology course, for example, nor was it necessary to do a lot of reading or writing for these courses. The science courses allowed them to apply their math skills, which is something that they are good at and that they enjoy. The study participants expressed an interest in not just the natural sciences, which include zoology, botany, chemistry, physics, and geology, but specifically in the physical sciences, which, according to The American Heritage Science Dictionary (2010) are “any of several branches of science, such as physics, chemistry, and astronomy, that study the nature and properties of energy and nonliving matter.” According to Joyce:

I'm not an art person, I don't like languages, I don't like history, and I don't like reading. When I do math or physics homework... I'm happy to do it. But if I have to write papers, I was like no—I would keep procrastinating and stuff.

Like Joyce, Cathy stated that she also enjoyed physics and the study of physics has led her to have a deeper appreciation of how things work. Cathy stated, “Physics has been like transforming my likings and interests. It's just I guess curiosity of how things move and you know we're always constantly moving and how do we move? Well it's you know the force of the Earth pushing back on us and it's just very intriguing—and perhaps also because in high school I took physics by accident.”

The World English Dictionary defines physics as “the branch of science concerned with the properties of matter and energy and the relationships between them. It is based on mathematics and traditionally includes mechanics, optics, electricity and magnetism, acoustics, and heat. Modern physics, based on quantum theory, includes atomic, nuclear, particle, and solid-state studies. It can also embrace applied fields such as geophysics and meteorology.” Most of the engineering disciplines rely heavily on physics principles. Optical engineering, for example, is about the study of light. The study of optical engineering would not be possible without a thorough understanding of the nature and properties of light, which are all covered in a typical physics curriculum. Electrical engineering is study of the applications of electricity. Electricity is the study of the flow of atoms and charge. These areas are also covered within the body of a physics curriculum. The study of physics may then be considered a good introduction to the field of engineering since most of the engineering disciplines that an individual may choose to study are built upon one or more physics principles.

Carol said, “I just loved doing science so much, specifically physics. I mean, I don't think I wanted to do like pure physics—you hear wacky stuff about it—but and so I

thought you know, engineering would be a good kind of middle ground for me. Physics is so heavily math that guys seem to pick up on it really quickly so you just need to know a couple of concepts to get the whole thing—but for chemistry and bio [biology] you have to diligently study like specific and like memorization which is totally a different skill.”

This finding is of interest because studies show that typically biology proves to be significantly more interesting to girls than does physics (Baram-Tsabari & Yarden, 2008). Girls find physics less interesting as they grow older. The fact that the women in this study continued their physics studies late in their high school years may be an area for future research in order to determine whether or not increasing the numbers of young women who take physics during their junior and senior years in high school will increase the numbers of women who choose to major in engineering once they enroll in a college or university. In a study conducted by Professor Michael Levin entitled “Women—Why so Few?” (1990), he argued, “Innate cognitive gender differences between the sexes make gender equity in physics both an unrealistic and perhaps undesirable reality.” (p. 583). Opposite of his conclusion, the women in this study repeatedly reported that they enjoyed their physics studies, which ultimately had a positive impact on their decision to major in engineering.

Girls outnumber boys in all major math and science courses except physics and calculus, though the gender gap in physics is narrowing, and mastery of these two subjects is critical to success in an engineering curriculum (Laefer, 2009). Physics I and II are key courses in the freshman year of an engineering curriculum at most colleges and universities across the United States. In order to be successful in an engineering program, students must be able to develop a level of proficiency in these courses.

Furthermore, based on the findings of this study, an interest in the subject matter that is covered within a physics curriculum was instrumental in leading these young women to develop an interest in studying engineering, or at least to give engineering a try.

Again, the women in this study expressed an interest in the field of engineering because it allowed them to utilize the concepts and principles that are covered in physics without having to major in physics. Some of the participants specifically expressed the desire to use their knowledge of physical principles through application thus giving them the ability to think things through for themselves and not have to engage in rote memorization or mere problem solving. According to Tina, “physics curriculum does not allow me to think for myself. They tell me what to think. In engineering, I use physics and learn to think for myself.” The young women in this study exhibited the characteristics of desire and motivation to use their strengths and talents to succeed in an engineering environment. Additionally, they spoke of the guidance and support that they have received throughout their college studies.

These findings are consistent with Bandura’s theory of self-efficacy. Clearly the participants’ strength of conviction in their mathematics and science self-efficacy was effectual in their decisions to continue to take more and more difficult math courses and to excel in those math courses during their progression through their high school years. What this study does not reveal is why these particular women had developed such a strong math and science self-efficacy as compared to their female high school peers. This may be an area for future research.

Challenges and Peer Support

According to Newby (2002), “In 2002 it was reported that more than 30% of first-year students did not return for their second year of college, and only 40% are reported to actually complete their degree and graduate” (p.12). College students face a vast amount of challenges and changes as they begin their journey into the world of higher education. In order for these students to succeed, they must find the best possible balance of challenge and support (Mansfield, Pinto, Parente, & Wortman, 2004). Nevitt Sanford (1968) insists that it is imperative that educators create/provide learning environments that provide balance for students in these two areas. Sanford noted:

We could run an institution in the interest of positive mental health that would so protect individuals from challenging stimuli that they would not develop at all. They might remain quite healthy but very simple, underdeveloped people. (p. 98)

Some students are motivated by challenge and this alone is enough to get them through their college years, but other students require personal support from friends, classmates, and oftentimes faculty members in order to achieve success in college (Dalton & Crosby, 2008).

Engineering is the type of subject matter that cannot be learned in a vacuum. There is an old African Proverb (?): “It takes a village to raise a child.” The study of engineering is akin to this in that it takes the whole academic community (i.e., students, faculty, mentors) supporting and nurturing students in order for them to be successful. The study of engineering lends itself to working collaboratively with one’s classmates in order to be successful and faculty members often encourage this collaboration. In addition to working with classmates, some of the participants shared stories of how much time and assistance they are able to get with their professors.

Lisa shared the manner in which she and her fellow classmates work together:

Yeah—within the engineering department I find that we're very much a community like willing to help each other out and it's not cut throat and if we need help on something I'm not afraid to go up a flight of stairs to a girl who lives above me and ask her for help—I don't think that she's going to look down on me. Last night I was in her room twice and I'm told her, I can't figure this out—and my issue was that my answer was in the wrong unit and I entered in on the wrong line—so I wasn't paying attention but she helped me figure out what I was doing wrong. I didn't feel stupid for not having it in the right unit—it was nice that she was willing to help me.

This type of support was a common theme amongst several of the study participants. Danielle stated:

We have two groups of engineers, the girls and the guys and we're all friends and we all work together and it's awesome—and then I have my best friend Angela who used to live next to me last year—and she keeps me going and she's always on her toes.

Tina shared a similar story:

I think I'm lucky that the program is so small that I have one to one interaction with professors—so I've always felt like in a community here. I mean I always feel like I can ask anyone a question about homework assignments so I always feel pretty supported.

According to Mary:

We would all be in the work room working together not necessarily because we were together but we would all just be there—so that is kind of cool—it would be eleven o'clock at night and you're just, there was nothing you could do except take data and that's kind of how that worked—but we got closer over that. I do like after my math class studying sometimes we'll sit just mainly cause we don't really understand—we'll sit outside of his office and there's a big table and sometimes we'll sort of do it together.

The participants maintained that it was the support and encouragement of their peers and oftentimes a faculty member or advisor who helped them to make it through some difficult times during their engineering studies. The act of working collaboratively in groups or being able to obtain help from a professor when needed was instrumental in

their academic success. Some of the study participants mentioned that at times the individuals they study with are not engineering students. They shared that the act of working in a group regardless of the subject matter is somehow comforting and empowering. This support combined with their self-reported academic self-efficacy was pivotal to the persistence of these women.

The finding in this section as well as the finding in the following section can be correlated to the reasons that these students have chosen to persist in the study of engineering rather than to a specific theory that was outlined in the conceptual framework. The findings of “Challenges and Peer Support” and “The Will to Survive” speak to the methodologies and the inner drive that these students employed in order to succeed in their undergraduate engineering programs.

The Will to Survive

Self-efficacy and the value that the participants placed on obtaining an engineering degree were key factors in the reasons cited for entering and remaining in an undergraduate engineering program and are consistent with Wigfield and Eccles’ Expectancy-Value Theory of Achievement Motivation. Other factors that contribute to their persistence in their engineering studies include love of creating, interest in doing research, and wanting to make a family member proud. Cathy commented:

So many women just leave—I don’t want to do that. You know, I’m just like I don’t want to look back at my life and think, oh, I could of you know been great but I just gave up—and I mean it gets tough you know. Science and math—there’s a lot of work but and besides that’s not just for my own aspiration but also because I want to make my Mom proud and again it sounds like what everyone says but it’s just so true—it’s definitely true.

Cindy also shared her reason for wanting to stay in the field of engineering:

Engineering is about creating new stuff and I feel like new products are always on the market like new assistance to be Eco friendly but I feel like I might try to do something to contribute because sometimes I have ideas which might profit teachers or also they are very good ideas sometimes—and I like to create especially and I think I like research... I want to create stuff and feel like I have this good creative mind and so that's why I want to apply engineering.

The desire to continue their engineering studies led them to find ways to overcome what are often difficult struggles during their course of study. Time and time again the participants spoke about their need to remain steadfast in pursuit of their engineering studies. Danielle stated:

I look up to my aunt because she got married young or whatever and she had to take care of two young daughters and she started off as just a cleaning lady for the Naval base in Groton and she's risen to be manager and everything and she's just always so nice and so happy—it's like you never see her ever upset and I just look up to that—that's what I try to do just look at the good things in life. Because things get tough especially in engineering you just have to look at the good thing that happen in life because like there are people who don't get the opportunity you get and you just got to make the most of it. Even if you're struggling just take it one step forward. Just don't quit. I [sometimes] don't think that I can do it but then I just keep going.

Personal Motivation and Persistence

Several of the study participants spoke about the other factors that guided them to study engineering and about their own personal drive and desire to persist in the field of engineering. According to Cathy:

I was in awe of the you know composure of the building—how it's built—it is modern—and so my liking you know for building then just was mixed in the physics and roller coasters and just designing different things outside of Civil.

Cathy then went on to further state:

So that also I think is what attracted me to engineering. It's just because there's so few you know women figures that really made an impact and I think that well I'll see how far I can get. I think it's kind of the same reason you know why so many women just leave. I don't want to do that you know I'm just thinking, I

don't want to look back at my life and feel like Oh, I could of you know been great but I just gave up. And I mean it gets tough you know.

Cindy, when asked about her reasons for persisting in the engineering program at her institution, responded:

It's that I just feel like it's good for me, it's just my right stuff cause there's a machine shop here like I could spend all my time there trying to make it. I joined the XXX team which is working on a car—yeah we're trying to get it done in three weeks now—like I'm on it. I'm designing the car seat and we knew nothing about it. Nobody knew anything about cars and we just started to work on it and I think, it was just my stuff. Not knowing anything just trying to do it and when it works out it's really like you know you feel like really happy and accomplished.

Over and over again the participants talked about the sense of pride and accomplishment that they feel when it comes to their engineering studies and with their prior math and science studies. Oftentimes, they mentioned that though the engineering classes are difficult, they keep going because they like them. Mary shared:

So all right. I want to be an engineer. I like it so far. It's a lot of work but I like it. All of my classes are amazing and I have real good interaction. I don't want to give you all this feedback without letting you know that I wouldn't be here next year. Part of me does want to specialize in something that you can't necessarily do here especially in the Mechanical Engineering world. Now I feel that I have the confidence to go and be in those classes with those boys who are at University X.

Based on the research conducted for this study, both the Self-efficacy theory and the Expectancy-value theory were evidenced by the participant responses. Not only did the participants speak about their beliefs in their mathematical and science skills as they related to studying engineering, but several of them also spoke about the value that they placed on the ability to have a career as an engineer. Sandra stated, "I don't want this to sound cocky but there's a status thing like, oh, you're an engineer—and I like that."

Several of the participants acknowledged the fact that they enjoyed the status of being an engineering student. They shared that those individuals outside of the field of

engineering intellectualize them and this makes them feel special. This ego boost fuels their determination to succeed in their studies. “My boyfriend is also studying engineering and it is so cool that we will be engineers together,” asserted Tina.

Summary

In this chapter five themes were presented that emerged from the research conducted at Smith College, Western New England College, University of Massachusetts Amherst, and Springfield Technical Community with 17 undergraduate women engineering students. Each of the five themes represents the findings that were consistent throughout the data from each of the four institutions, and these findings were consistent regardless of the type of institution or where the students were from. The data show how significant the participants’ self-perceived math and science self-efficacy as well as the influence of family and friends was on their decision to choose engineering as an undergraduate major. The participants spoke passionately about their love for the study of mathematics and how much the study of physics influenced their decision to major in engineering. As espoused in Gottfredson’s Theory, the participant’s family members contributed to the strength of their math and science self-efficacy. According to Gottfredson, family members play influential roles in the career aspirations of high school girls and college-age women, helping young women develop the self-efficacy necessary to pursue and persist in a career. This is particularly true for careers with a math and science focus (Caldera, Robitschek, Frame, & Pannel, 2003; Ferry, Fouad, & Smith, 2000; Flores & O’Brien, 2002; O’Brien & Fassinger, 1993; Rainey & Borders, 1997; Zheng, Saunders, & Shelley, 2002). The data also highlight the strategies that these women employ, such as studying with fellow classmates, in order to be successful in their

engineering studies. Lastly, there are the personal reasons that these women choose to persist in their engineering studies.

In Chapter 5, the author will synthesize the research study and its findings, including recommendations for future research and climate changes in the mathematics and science classrooms that might positively impact the number of women entering the field of engineering.

CHAPTER 5

DISCUSSION, IMPLICATIONS, AND CONCLUSIONS

Introduction

This study identifies the factors that lead female undergraduate students to pursue an academic major in engineering. Data show that 20% of students enrolled in undergraduate engineering programs are women. This trend in enrollment has been consistent over the last 15 to 20 years (GAO, 2004). The numbers in mathematics and the physical sciences are somewhat higher, 33% and 40% respectively, but still show a disparity between the numbers of men and women students enrolled (Rosser, 2003). This lack of involvement of women in the design of technology will continue to result in the production of technologies that do not respond properly and adequately to women's concerns (Nebres & Mercado, 1998; Cuny & Aspray, 2000). It might be beneficial to have more women involved in the design of products and technologies that are solely or primarily used by women. Several books and articles have touted the benefits of diversity in colleges, universities, and corporations (Ameer, 2000; Bensimon, 2000; AAUP and ACE, 2000). Companies with the most highly trained and the most diversified workforce have a greater competitive market edge (Hersh, 2000). "A diverse workforce can also provide better customer match, particularly due to the increasing numbers of women in other professions forming a growing percentage of the engineering customer base, and can provide a range of different approaches to problem solving" (p. 346). Having more women in the fields of science and engineering increases the diversity of these careers by adding a different set of lenses through which problem definition and problem solving will occur.

Discussion

The impacts that the science and engineering communities have on society offer huge opportunities for women; opportunities in the forms of generating substantial incomes, designing products and services that could save lives, and providing role models for the young women of the future (Wan, 1994; Campbell, Jolly, & Perlman, 2005).

However, according to statistics published by the National Science Foundation:

- The NSF publication “Women, Minorities, and Persons with Disabilities in Science and Engineering: 2002” reports that the percentage of women majoring in scientific and technological fields has increased since the 1960s. By 1998, 49% of the undergraduates enrolled in these fields were women. Yet the percentage of women in computing, the physical sciences, and engineering remains lower than in other science-related disciplines. In 1998, women received 74.4% of the bachelor's degrees in psychology, 52.7% in the biological and agricultural sciences, 52.5% in the social sciences, 39% in the physical sciences, and 37% in the geosciences, but they received only 18.6% in engineering.
- In 2002, women earned more than half of the degrees awarded in psychology (78%), biological/agricultural sciences (59%), and social sciences (55%), and almost half (47%) in mathematics. However, women received 21% of bachelor's degrees awarded in engineering, 27% in computer sciences, and 43% in physical sciences.

This study advances prior research by providing additional understandings of reasons that current freshman and junior women engineering students cite for choosing to major and persist in an undergraduate engineering program. Each of the interviews conducted tells the story of a specific research participant but collectively the interviews show a pattern in the lived experiences of these women that ultimately led to their decision to major in the field of engineering.

The study was initially guided by the question, “How did undergraduate women engineering students come to a decision to major in engineering?”

Through the data analysis, previous research findings were corroborated and new knowledge was discovered regarding the participant's choice of college major. Specifically, the data regarding parental influence, the role of family and friends, and math and science self-efficacy were dominant themes and these themes were also prevalent in the literature. The finding regarding the connection to the study participants' positive feelings of their experience with high school physics and the fact that this positive experience led to their decision to major in engineering is one that the author has not seen in the literature reviewed on this subject matter.

Having the Background Necessary

As an applied science, the study of engineering requires that students possess a strong background in mathematics and that this skill will be built upon during their engineering studies. Students who do not have a strong math background or who have a weak math self-efficacy tend to shy away from the discipline of engineering for fear that they will not be successful in such an undertaking. Students may also shy away from the field of engineering simply because they do not care for mathematics.

The students in this study all demonstrated a strong affinity for the study of mathematics and not just an affinity for the subject, but in many cases the study participants expressed a "love" for the study of mathematics. This love for the study of math may be due in part to their math self-efficacy. Typically if individuals have strong skills in a certain area, whether it is an academic, personal, or physical activity, they will put more time into the pursuit of that subject matter. The fact that these students possess such strong math skills,

combined with their enjoyment of the study of physics, makes them well-suited to the study of a field such as engineering.

The study participants shared a common bond in that they expressed a liking for the subject of physics. As mentioned earlier, this finding was one that the author has not seen in the literature reviewed for this study. The literature reviewed did mention that students with a strong math and science self-efficacy might be more suited to the study of engineering; however, none of these studies mentioned physics as the preferred science choice. The students in this study took physics during their high school years and many shared that it was the fondness that they developed for the subject matter covered in physics that ultimately led to their decision to major in engineering. Seven of the research participants stated that though they liked the study of physics, they had no desire to major in physics, so the study of engineering allowed them to use their physics knowledge and background and apply it to something that they enjoy. As the number of young women who take physics courses during their high school years is rising, this is an area for future research for increasing the number of young women in these physics classes who may choose to study engineering when they enter college. The researcher is herself an engineer, and the findings related to science were not expected due to the fact that they were strikingly different from her own personal experience. This difference may be due in large part to the generational difference between the researcher and the study participants. In 1999, 22% of females took high-school physics (NSF, 1999). During the year 2001, that percentage had increased to almost 50% (Ivie & Ray, 2005). During the researcher's high school years, 1973-1976, it was mandatory for boys to take

physics and girls to take biology. Therefore, the connection to engineering with an introduction to physics in high school was not an intuitive leap. Physics came up time and time again as being the particular field of science that most likely led to an interest in the field of engineering.

Early intervention with young women and girls who are at risk for not performing well in math and science may be a way to retain these women in the hopes of filling the engineering pipeline, because of the role that these variables play in the career choice of future engineering students. Students who avoid math and science in high school are less likely to be accepted into college and university engineering programs (Nauta & Epperson, 2003). The data show that girls who do choose to study mathematics throughout their high school years are performing as well as boys (Hyde, Lindberg, Linn, Ellis, & Williams, 2008) yet the number of these young women who choose to study engineering is not increasing. Therefore, increasing the number of young women and girls who take more mathematics classes in high school may lead to an increase in the population of young women who do go on to major in engineering when they enter college.

Outside Influences

Similar to previous research, this study found that the majority of the research participants have a family member, friend, or close associate who is either an engineer, engineering major, or suggested to them that they consider the study of engineering. In some cases, the participants, though they have a strong math and science self-efficacy, admitted that they had not considered studying engineering and would not have done so had it not been for the suggestion of

someone in their immediate sphere of influence. The family members or friends of these participants evidently made a connection between the participants' strong math and science skills and the field of engineering that the participants had not seen for themselves.

The author had the same experience during her high school years when her guidance counselor mentioned an introduction to engineering program being conducted at the University of Massachusetts Amherst (UMASS). Prior to this, she had no knowledge about the field of engineering and therefore had never considered this to be an option. After attending the program at UMASS and learning more about engineering, she decided that this was indeed the field for her. Other women students may have the ability to pursue a career in engineering but, like the author, without having some form of introduction to it, may not ever see this as a viable option. This is one reason that the outreach programs being conducted by many colleges and universities across the country continue to play a pivotal role in increasing the number of women in engineering. Some of the participants stated that not only did they wish that they had been introduced to it in high school, they wished that they had the opportunity while in high school to speak with women engineers. This lack of information for women during their high school years is having a negative impact on the number of women who are choosing to enter into an undergraduate engineering program when they begin their college studies.

The fact that so many study participants stated that they would not have majored in engineering if it were not for a mention from family, friends, a counselor, or taking an introduction to engineering course as an college elective

indicates that there is work to be done in outreach to high school women who have the requisite math and science background or have the math and science self-efficacy, and who would take more courses if they were made aware of the possibilities in engineering should they continue their math and science studies during their high school years. Noteworthy is the fact that the students who first experienced the field of engineering through an introductory college course immediately fell in love with the field. It is presently unknown how many high school women might make a decision to study engineering if they had this introductory experience prior to their high school graduation. Certainly, the women in this study may have made the decision earlier and, were it not for the mention of this course by an advisor and the ability to experience this course during the beginning of their college years, may have been lost to the field of engineering.

The literature review for this study highlighted several of the outreach programs that are offered by various organizations and universities in the United States. Many of these outreach programs have an open enrollment and accept students based on a first-come, first-served basis. The existing programs should be continued in order to afford all young women a chance for this introduction to engineering. The current programs may be an incentive for those students who do not currently have a great aptitude for math and science to work a little harder in order to strengthen their math and science skills. In the case of the study participants, they each agreed that they either had someone in their immediate sphere of influence that is an engineer or they had someone close to them suggest that they consider majoring in engineering. Outreach programs could provide the

influence to consider a future career in engineering when there is no influence from a family member or someone else close to the young woman. It would be beneficial for these outreach programs to enlist the help from women who are currently working as engineers who may serve as role models, so that the program participants have the opportunity to see women engineers thus giving them the motivation to view engineering as a possible career choice.

There are several engineering organizations that could provide role models for young girls. The Society of Women Engineers (SWE) was founded in 1950 as an organization to support women in the field of engineering. This organization currently has, as a part of its mission, an outreach component. Other engineering organizations such as the American Society of Mechanical Engineers, the Association of Energy Engineers, the Institute of Electrical and Electronic Engineers, and the Society of Civil Engineers, could also provide role models and mentoring programs for young women. The organization need not be made up solely of women, such as is the case with SWE, in order to provide this much-needed access to women in the fields of engineering. When the opportunity arises, current women engineering students could also serve as role models to young women, as they may be closer in age to the young women and girls whom the outreach program is trying to reach. Providing young women with the opportunity to see women who are currently working as engineers or engineering educators may convince them that they could also become engineers and that engineering is not a career just for men.

Persistence

Currently, the retention rate for women engineering students is approximately 60% (Brainard & Carlin, 1998). The students who drop out of an engineering program do so for a variety of reasons including a lack of self-confidence. A study conducted in 1994 by Seymour and Hewitt showed that these young women do not leave due to a lack of academic ability, which is what some might believe to be the reason for leaving. They leave because they lose confidence in their academic ability despite the fact they are still doing well in their studies, they become bored, or they become disappointed in their engineering curriculum (Seymour & Hewitt, 1994). This study focused on reasons that some women chose to enter and persist in undergraduate engineering programs.

The study participants shared that the ability to be creative and to make a positive impact in the world was instrumental in their decision to major in engineering. These same reasons were given as some of the factors that have contributed to these students' persistence in an undergraduate engineering program.

It is this sense of enjoyment in the engineering projects and the material covered in the classes that the participants referenced as reasons that they choose to stay in the engineering programs at their respective institutions. They also cited the collaboration and camaraderie with their peers as well as the support of the faculty, staff, family, and friends as other reasons that they persist. The students in this study talked about how much time they spend with their classmates working on homework problems and sharing notes and ideas. They

have developed their own sort of engineering support group in order to get through their studies. Several of the study participants mentioned that they are so used to being together that they often just get together to hang out even when they are not working on engineering homework, projects, or labs. They have gotten used to being together and truly seem to enjoy each other's company. This cooperation and collaboration is true for the students at the co-ed colleges and universities as well as among the students at Smith College, where all of the students are women.

Yet another reason that some of the study participants cite for persistence in engineering is the prestige of being an engineer. Though most Americans have an impression of engineers being "geeky," "nerdy," and predominately men wearing pocket protectors with tape on their eyeglasses (Bell, Spencer, Iseman, & Logel, 2003), the women in this study are very proud to be known as engineering students and wear this as a badge of honor. Rather than feeling that this status of being an engineering student and future engineer is something derogatory, they feel that this status puts them in an upper echelon among other college students. These students expressed a sense of pride in their choice of major and in the fact that they are considered academically gifted for being able to pursue what is often considered to be a difficult program of study, and one that can only be tackled by those who possess superhuman powers of mathematics and science ability. Thus, the goal of completing their engineering studies and becoming a future engineer has motivated many of the study participants to continue their pursuit of the degree.

This study has identified some key factors regarding the participants' reasons for selecting engineering as an academic major and the reasons that they persist in their endeavors. The study also highlights some areas where further research is needed in order to increase the numbers of young women who choose engineering as an undergraduate academic major.

Implications for Further Research

The purpose of this study was to add to the current body of knowledge regarding the reasons that some young women choose to major and persist in an undergraduate engineering program. The outcomes of this study were greater than anticipated in identifying areas of future research that may assist some colleges, universities, and technical schools in their ongoing efforts to increase the numbers of women majoring in the field of engineering. Specifically, the areas include the high school physics curriculum, outreach programs for girls focusing on engineering, and ways of persuading persistence in mathematics and engaging girls in the mathematics classrooms.

First, additional research should be conducted regarding the pedagogy for high school physics classes. The results of this study indicate that there is a direct correlation between the enjoyment of the subject matter covered in the physics classroom and the decision to major in engineering. There is an opportunity to restructure the methodology for instruction to include more projects and applications that may be more interesting to girls and young women. The suggestion is not to make the physics classroom more gender-focused for women, but rather to make it less gender-focused for men. Further research should be

conducted to determine how the curriculum could be structured differently to be more appealing to young women and girls.

Secondly, the study participants pointed to the fact that they each had someone in their family, a friend, or someone close to them who suggested that they consider engineering as a career choice. Since this finding has been corroborated in previous research, additional research should be conducted to identify ways in which more young women could be exposed to the field of engineering if they do not have this type of guidance from their current sphere of influence. Several colleges, universities, and government organizations currently conduct outreach programs to do just this; however, the data shows that the number of women entering engineering programs throughout the United States is not increasing. There is currently no data to indicate whether or not these outreach programs are producing their desired results. Further research should be conducted to assess the viability of the current outreach programs and to suggest ways in which current programs could be enhanced or improved or ideas for new outreach program creation.

Implications for Practice

Many of the research participants discussed the fact that they enjoyed their high school mathematics courses and this enjoyment of the subject matter led them to take higher-level mathematics courses as they progressed through high school. This strong mathematics background provided them with the skills necessary to tackle a mathematics-based curriculum such as engineering. Further research could be conducted regarding the numbers of mathematics courses

required by some high schools for graduation and if students are not required to take four years of math, this may be an opportunity for policy makers and educators to make changes to the high school curriculum that may ultimately lead to closing the gender gap in the number of students enrolling in engineering programs. In the state of Massachusetts, students are required to pass the Massachusetts Comprehensive Assessment System (MCAS) test in their tenth grade year. After successful completion of the MCAS, students are no longer required to take additional mathematics courses. The students who do not choose to further their high school mathematics education are unlikely to be accepted into a college or university engineering program. An increase in the number of high school mathematics courses could better prepare all students, not just women, to enter a mathematics rich program such as engineering.

Some of the research participants shared that they were never introduced to the field of engineering while they were in high school though they had the requisite math and science background and knowledge to tackle the rigor of an engineering curriculum. Secondary school teachers, colleges, and universities could offer this introduction to engineering by doing the following:

1. Bring women engineers into the mathematics classrooms to speak with the students about a potential career in engineering.
2. Provide after school activities in the form of clubs or teams that allow for hands-on activities that demonstrate how engineering works.
3. Explain how a career in engineering provides students with the opportunity to impact products and services that are made solely for women.

4. Describe how a career in engineering provides and opportunity to students to help others lead better lives (such as designing prosthetic devices for the handicapped).

By engaging in the activities listed above, it is my belief that more women may be able to envision a career in engineering for themselves. These types of activities are especially important if the women students do not have someone in their immediate sphere of influence to speak with them about and encourage them to consider studying engineering.

Summary

This section addresses the answer to the research question: How did undergraduate women engineering students come to a decision to major and persist in engineering?

To illustrate the relationship between the findings of this study, I have developed the following model:

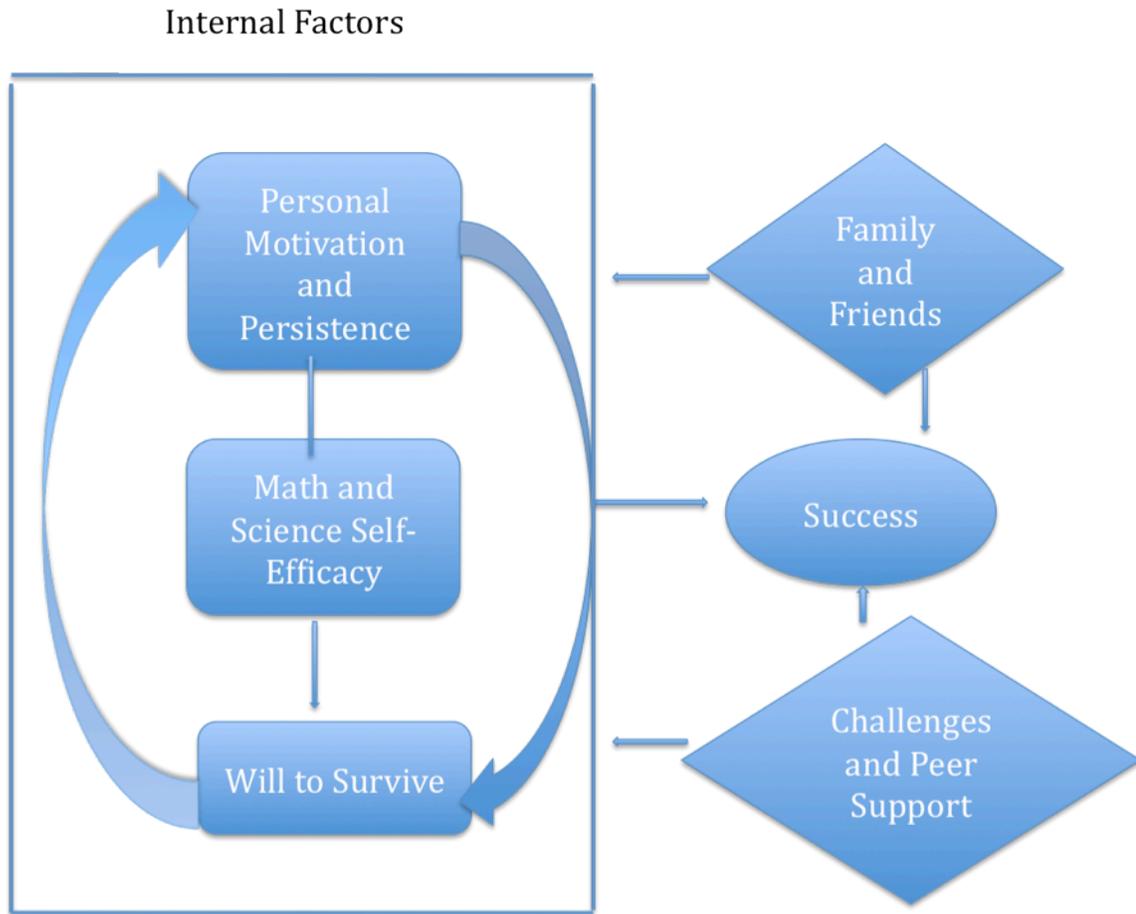


Figure 4: Relationship of Findings

The diagram illustrates the fact that, according to the findings of this study, five themes were identified that led to the participants' choice to major in and persist in an undergraduate engineering program. Of the five findings, three are internal factors that each of the participants possessed before they entered in an engineering program. The other two factors relate to outside influences in the form of family, friends, and peers. The fact that the research participants have a strong math and science self-efficacy led to a strengthening of their personal motivation and persistence as well as their will to survive. The family and friends of the participants encouraged and supported the participants' choice to major in

engineering and the peer support that the participants received helped the participants to navigate the challenges of an engineering curriculum.

As the diagram illustrates, the participants were led to study engineering through the influence that they received from someone in their circle of family and friends. This influence was strong enough to overcome any doubts and concerns that they experienced regarding their ability to be successful in the field of engineering. Twelve of the seventeen research participants shared similar stories of being influenced or encouraged by a parent, sibling, other family member, or a teacher or guidance counselor. For example, Cindy was originally going to study medicine but was influenced by her brother to give engineering a try. Cindy expressed that she did not want to be an engineer but with the encouragement of her brother she tried it for one semester and decided that she indeed did enjoy the subject matter and decided to change her major to engineering.

The family members of the research participants also played a pivotal role in the development of a strong math and science self-efficacy. The family members' beliefs in the abilities of the participants led to a strengthening of the participants' attitudes and way of thinking about pursuing a career in the field of engineering. Lisa also considered a career in medicine though her teachers and her grandfather encouraged her to pursue a career in engineering. The arrows in the diagram depict the relationships between the intrinsic and extrinsic factors leading to choice and persistence. In the case of self-efficacy, the fact that family members demonstrated a strong belief in the math and science ability of the research participants contributed to strengthening their own beliefs about what they are capable of accomplishing. Family members play influential roles in

the career aspirations of high school girls and college-age women, helping young women develop the self-efficacy necessary to pursue and persist in a career. This is particularly true for careers with a math and science focus (Caldera, Robitschek, Frame, & Pannel, 2003; Ferry, Fouad, & Smith, 2000; Flores & O'Brien, 2002; O'Brien & Fassinger, 1993; Rainey & Borders, 1997; Zheng, Saunders, & Shelley, 2002).

The fact that the research participants have a strong math and science self-efficacy led them to choose to major in engineering and this pursuit presented them with challenges and obstacles that they had to overcome in order to reach their goals. According to research participant Carol, for example, her strength in math and science led to her decision to major in engineering. Carol especially enjoyed the study of physics but decided that she did not want to major in physics so engineering provided a middle ground for her.

As mentioned earlier, the participants found ways such as working closely with their professors and creating study groups in order to overcome these challenges. The participants maintained that it was the support and encouragement of their peers and oftentimes a faculty member or advisor who helped them to make it through some difficult times during their engineering studies. The act of working collaboratively in groups or being able to obtain help from a professor when needed was instrumental in their academic success. These creative ways of manipulating the difficult maze of an engineering curriculum is in direct correlation to the Expectancy-Value Theory. These students found ways to persist in their engineering studies based on the value that they placed on becoming an engineer.

The participants passionately expressed to me that they had a strong will to survive and this will has fueled their persistence in their academic pursuits. The desire to continue their engineering studies led them to find ways to overcome what are often difficult struggles during their course of study. Time and time again the participants spoke about their need to remain steadfast in pursuit of their engineering studies and this again supports the outcomes espoused by the Expectancy-Value Theory. Of all of the findings of this research study, the finding regarding their personal motivation is one that I, the researcher, believe that the participants each brought with them. I do not believe that personal motivation can be taught or instilled. It can only be fostered and encouraged in individuals.

Each of the findings of this study can be correlated to one or more of the theories and constructs that formed the conceptual framework for this study.

Bandura's Self-Efficacy Theory (1997), which states:

This theory suggests that self-efficacy expectations, which are a person's beliefs about his or her ability to perform a behavior successfully, will impact the initiation of a behavior, the amount of effort expended on a task, and the degree of persistence on a task in the face of obstacles (Schaefer et al., p.174).

is corroborated by the participants' comments and the finding of "Math and Science Self-Efficacy", regarding their belief in their abilities to do well in mathematics and physics and this self-efficacy ultimately led to their decision to major and persist in engineering.

Wigfield and Eccles' Expectancy-Value Theory was upheld in the findings by the fact that the research participants espoused the high value that

they placed on becoming an engineer and that this value spurred them on to continue in their undergraduate engineering studies. The findings of “The Will to Survive” and “Personal Motivation and Persistence” are directly correlated to the Wigfield and Eccles Expectancy-Value Theory.

The finding of “Role of Family and Friends” corroborates Gottfredson’s Theory of Circumscription and Compromise as the basis for recognizing how key influences (for example, family) impact the aspirations and self-efficacy of young women and their career-related decisions. The research participants shared that it was the influence of a family member or a close friend that convinced them to major in engineering. Some of the participants shared that they never envisioned a career in engineering and may not have done so had it not been for these key influences.

In conclusion, the five chapters of this study have provided a history and background of women in engineering as well as recommendations for possibilities for the future. The study began with a statement of the problem regarding the impact of not having more women in the field of engineering, and moved on to discuss the history of the progression of women in the field of engineering. A lot of progress has been made, yet there is still much work to be done. A plethora of research has been conducted to study, explore, and entice women to enter into the engineering community. Chapter 3 covered how this study was conducted, including the research methodology and how trustworthiness of the data was ensured. Through the findings presented in Chapter 4, the study shows how the women in the study came to a decision to major in the field of engineering and the reasons that they choose to persist despite the challenge of the curriculum and the

perceptions of the masculinity of the field of engineering. Through the discussion of the findings, the research question that guided this study is answered and connects the data to the conceptual framework. The implications for further research stem from the data and pinpoint two specific areas that need to be addressed:

1. Modify the pedagogy of the physics classroom in order to make the subject matter more appealing to young women and girls
2. Modify and increase the amount of exposure that young girls have to the field of engineering

In the context of this study, it is the author's hope that the marriage of research and practice facilitates a future where women envision a career in engineering not as an insurmountable challenge but one that they can accomplish and enjoy.

Conclusion

The purpose of this study was to add to the current body of knowledge regarding the choice to major in engineering by some college-enrolled undergraduate female students. This study surpassed its goal by providing areas for future research that may help secondary and post-secondary educators and academicians identify methods to increase the number of women who choose to major in undergraduate engineering programs. Specifically, the requirement of a physics course for all high school women may make an impact on the number of young women who choose to major in engineering upon entering a college or university. The finding of the link between the participants' enjoyment of the subject matter covered in their high school physics courses and their decision to

major in engineering was one that the author had not encountered in literature on the subject matter and one that was not covered in the conceptual framework.

The 17 women who participated in this study helped to identify the factors that led to their decision to major in engineering and why they continue to persist in their studies. The demographics profiles of the participants were varied; however they traveled similar paths toward obtaining their degrees and overcame similar obstacles in order to reach their desired goal of one day becoming an engineer. They spoke candidly about the rigor of their respective engineering programs and shared the reasons why they choose to stay and the methodologies that they employ to be successful.

The conceptual framework for this study was supported through each of the five findings. Wigfield and Eccles' Expectancy-Value Theory was upheld in the findings by the fact that the research participants espoused the high value that they placed on becoming an engineer. Bandura's Self-Efficacy Theory (1997) was corroborated by the participants' comments regarding their belief in their abilities to do well in mathematics and physics and that this self-efficacy ultimately led to their decision to major and persist in engineering. Gottfredson's Theory of Circumscription and Compromise was supported by the fact that several of the research participants expressed that they did not see engineering as a career for them until a friend or family member encouraged them.

As various local, state, and federal entities continue to spend large amounts of monies on programs and initiatives aimed at attracting and enticing more women to enter the field of engineering, the results of this study show areas

that may need to be explored in order for some of these programs and initiatives to be more successful.

APPENDIX A

INFORMED CONSENT

Dear Student,

I am a doctoral student at the University of Massachusetts at Amherst. I am asking you to participate in the research that I am conducting. The focus of my research is to gain a better understanding of why some women choose to major and persist in an undergraduate engineering program.

Your participation will entail one or two interviews lasting about 30 to 45 minutes each. The topics I want to explore in the interview include your decision to major in engineering, your future career goals, and what are some of the reasons that you decided to continue in an engineering discipline. With your permission, I will tape-record the interviews; the tape will be erased and the file deleted after transcription.

I will protect both your identity and that of your school by giving you pseudonyms. You should understand, however, that I will quote directly from our interview but will not use your name in any part of the report.

I appreciate your willingness to give your time to this project and helping me to learn more about persistence of women in engineering. If at any time during your participation in my study you wish to withdraw, you may do so with no negative consequences. If you have any questions, please feel free to contact me at 413-265-1625.

Thank you,

Adrienne Y. Smith

The study has been explained to me, and I understand the conditions described above. I freely agree to participate.

(Signature) _____

(Date) _____

APPENDIX B
INTERVIEW QUESTIONS

Choice of College Major:

1. What helped to make your decision to major in engineering?
2. Tell me how you learned about the field of engineering.
3. Was there anyone who influenced you in this decision? (to major in engineering)
4. Can you tell me what attracted you to the field of engineering?
5. What led to your choice of your specific engineering discipline?
6. Tell me about your secondary school experience. (Follow up: Did your grades influence your decision to major in engineering?)
7. Are you familiar with anyone who works in engineering?

Persistence:

1. Please tell me why you have decided to maintain your enrollment in engineering?
2. Can you tell me about your experience with your engineering curriculum? Please explain.
3. Can you describe any impacts you may have had from these experiences?
4. Can you describe/tell me about your contact/relationship with fellow students?
5. What have been your best and worst experiences majoring in engineering?
6. If you had to change your major for any reason, what would you do?
7. Have you thought of what you will do with your engineering degree?
8. Do you have any suggestions about what your institution could do to be supportive of women in the engineering program?

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