

2006-548: WOMEN ENGINEERS: FACTORS AND OBSTACLES RELATED TO THE PURSUIT OF A DEGREE IN ENGINEERING

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Women Engineers: Factors and Obstacles Related to the Pursuit of a Degree in Engineering

Abstract

Research on women in engineering confirms the presence of gender barriers that affect the recruitment and retention of women in engineering. These barriers stop some women from choosing engineering as a field of study, and impede some women from completing a degree in engineering. However, there are few young female students who complete their engineering education despite the presence of obstacles throughout their college years. Systematic research that studies the experiences of these women is lacking. Research concerning the experiences of female scientists and engineers is needed because it is likely to suggest methods for improving the engineering environment in a manner that will attract further female participation.

This study sought to advance current women in engineering research by identifying the obstacles and factors related to the pursuit of a degree in engineering by female students. Two major data collection methods were used for this study. First, a survey was developed, and was used to obtain insightful information to determine the factors that have hindered and assisted graduating female engineering students in deciding to pursue and in completing a degree in Engineering. Second, focus groups were conducted with a random sample of the graduating female engineering students to obtain detailed information on their experiences in deciding to pursue and in completing a degree in engineering.

This study addressed the factors that have hindered, motivated, and assisted women who were graduating with a degree in engineering. By studying and understanding the barriers that hinder women in deciding to pursue and in completing a degree in engineering, as well as, the factors that assist and encourage them, we can learn how to break down the barriers and how to facilitate the educational journey of female engineering students. This study gives us valuable insights and created a framework from which high schools, universities, researchers, and female students can directly benefit.

Introduction

Technical occupations increase almost 5 percent per year, whereas the rest of the labor force is growing at just over 1 percent per year (National Science Foundation⁴⁹, 2004). The 2004 Science and Engineering Indicators report from the National Science Foundation⁴⁹ (NSF) indicates that there is a “troubling decline in the number of U.S. citizens who are training to become scientists and engineers, whereas the number of jobs requiring science and engineering (S&E) training continues to grow” (p.1). “If trends continue the United States will lose its ability to fill the growing demand for science and engineering jobs, yielding [its] global standing to nations such as China and India who are training thousands more engineers and scientists than is the U.S.” (O’Brien⁵⁰, 2004, p. 1).

The U.S. Department of Commerce⁶² (1999) projects that by 2010, 50 percent of all U.S. workers will be women. This projection, plus the growth in the science and engineering labor force, and the shortage of technically skilled workers show the importance and need of having

women training to become scientists and engineers. Unfortunately, women have been and continue to be a minority in engineering related fields. In 1971, only 0.8% of the bachelor's degrees earned in engineering were obtained by female students. In 2002, the number went up to 19% (U.S. Census Bureau⁶¹, 2004-2005). Despite the increase in the number of women obtaining degrees in engineering, women are still underrepresented in engineering.

In 1970, of the 7.4 million students who enrolled in college, 4.4 million were men, and 3.0 million women. By 1980, out of 11.4 million students enrolled in college, more than half of the students were women (U.S. Census Bureau⁶¹, 2004-2005). This coincides with the fact that in the 1980's people started working towards admitting more women to colleges (Anderson³, 2002). Since the 1980's, the number of women enrolled in college has always been higher than the number of men (U.S. Census Bureau⁶¹, 2004-2005). Conversely, the number of female students enrolled in engineering programs has always been much lower than the number of male students. In 2002, women constituted only 18.4% of students enrolled in engineering programs (Engineering Workforce Commission²⁷, 2003).

Furthermore, only 2 to 3% of women in high school say they want to study engineering, whereas 16.4% of men state they want to pursue an engineering degree (Blaisdell^{14,13}, 2002; 1998). Although women now have easier access to most engineering schools, there is a lingering reluctance for women to choose education in technology related fields. Recruiting women into engineering is a crucial issue if we want to increase the numbers of women in technical fields. However, the story does not end with recruitment. Nationwide retention rates show that out of the very few women who enroll in engineering programs in college, 22.7% dropout after completing only threshold courses in engineering; and 35.4% withdraw after taking engineering courses beyond threshold, but before getting a degree. Only 41.9% of women who enroll in engineering programs complete their bachelor's degree (Bell, Spencer, Iserman, & Logel¹², 2003). These numbers indicate that women are encountering barriers that stop them from completing their engineering education.

Recently there has emerged a concern about the drop of young women entering engineering programs, the low retention rates of women in engineering departments, and a drop in the participation of women in these occupations (Camp¹⁷, 1997). A limited number of universities and research studies have concentrated on determining and creating effective ways to recruit women into engineering throughout the educational pipeline from elementary school to graduate school (Anderson-Rowland^{5,8}, 1996, 2000; Anwar, Acar, & Rung, 2002¹⁰; Dozier, Blaisdell, & Anderson-Rowland²⁶, 1997; Martin & Wardle⁴¹, 1999; Secola, Smiley, Anderson-Rowland, Castro, & Tomaszewski⁵³, 2001; Sheppard⁵⁸). Researchers have hypothesized that the pipeline problem is caused by factors present in society that relate to the socialization process of young women, and characteristics of engineering fields that create implicit barriers for under represented populations (Martin, & Wardle⁴¹, 1999). Therefore, researchers have concluded that women need to be presented with role models, motivated, and supported in order to attract them to technical fields.

Mentoring programs at universities and research studies have also concentrated on studying the barriers to the retention of women in engineering, and on finding effective ways to assist women in completing their engineering education. Research shows that women do not drop out of

engineering due to academic difficulty as much as for a lack of critical mass or support systems (Anderson⁴, 1994). Seymour and Hewitt⁵⁵ (1994) found that women leave engineering programs because they become bored or disappointed with the curriculum, and/or because they feel forced to leave due to a loss of academic self-confidence in a competitive environment. Other research studies that have focused on the retention of women in engineering have found attrition factors that are similar to Seymour and Hewitt's findings, such as the way engineering curriculum is taught and interpersonal climate (Anderson^{1;2}; Anderson-Rowland⁶, 1997; Brainard & Carlin¹⁶, 1998; Liu & Blanc³⁸, 1996).

Most of the studies that have concentrated on the recruitment and retention of women in engineering, have studied the factors that affect the educational journey of students at the beginning, and/or in the middle of their college years. There is very little systemic empirical research that focuses on students' who are about to graduate from an engineering department. It is important to study the experiences of students who have completed or are about to obtain an engineering degree because, since they have recently gone through situations that female students experience by being a minority in engineering, they can give an accurate inside scope; and because they have successfully overcome any obstacles that were presented in their way towards obtaining an engineering degree. Therefore, this study sought to address the gap in the women in engineering literature by examining the factors that have hindered, encouraged and assisted graduating female students, in pursuing and completing a degree in engineering.

The low numbers of students who are obtaining engineering degrees is an important topic of concern given that an increasing number of women are in the workforce, and that the number of jobs requiring science and engineering training continues to grow. By studying and understanding the factors that assist and encourage women in pursuing and completing a degree in engineering, as well as, the barriers that they encounter, we can learn how to break down the barriers and how to facilitate the educational journey of female engineering students.

Research on women in engineering confirms the presence of gender barriers that affect the recruitment and retention of women in engineering (Etzkowitz, Kemelgor, Neuschatz, & Uzzi²⁸, 1994; Hammond & Hammond³², 2002; Maskell-Pretz & Hopkins⁴², 1997; McDill, Mills, & Henderson⁴³, 2000). These barriers stop some women from choosing engineering as field of study, and impede some women from completing a degree in engineering. However, there are few young female students who complete their engineering education despite the presence of obstacles throughout their college years. Systematic research that studies the experiences of these women is lacking. Moskal⁴⁸ (2000) expressed that research concerning the experiences of female scientists and engineers is needed because it is likely to suggest methods for improving the engineering environment in a manner that will attract further female participation.

Research Questions

The major research questions that guide this study are the following:

1. What factors have **hindered** women when **deciding to pursue** a degree in engineering?
2. What factors have **assisted** women in **deciding to pursue** a degree in engineering?
3. What factors have **hindered** women while **completing** a degree in engineering?
4. What factors have **assisted** women in **completing** a degree in engineering?

Conceptual Framework

Lent, Brown, and Hackett's³⁶ Social Cognitive Career Theory (1994) was selected to serve as the conceptual framework that guides this study in order to identify the barriers that hinder and the factors that assist young females in pursuing and completing a degree in engineering. The social cognitive career theory explains how over the course of childhood and adolescence people are exposed to cognitive-person factors, contextual mechanisms, and experiential/learning mechanisms that are crucial when people are deciding which career to pursue due to the fact that they influence the formation of academic/career interests, which in turn results in the choice of academic/career goals. Once a career has been chosen, people are once again exposed to cognitive-person factors, contextual mechanisms, and experiential/learning mechanisms that influence people on their performance and persistence on their educational and career pursuits.

The cognitive-person factors, contextual mechanisms, and experiential/learning mechanisms that hinder or assist people when deciding to pursue and while completing their career of choice come from people's schools, families, their own selves, and society. For instance, some factors to which people are exposed through their schools include: teachers encouragement to pursue a particular field, recruitment information about university programs, teaching quality, sexual discrimination and harassment, and being recognized by professors. Some of the factors that come from people's family include: encouragement, support, advice, and guidance from parents; and role models. Some of the personal factors include: self-efficacy, self-confidence, personal goals, and abilities. Finally, some of the factors to which people are exposed throughout society include: public image of a particular field, advertisement of a particular field, and job market.

Research studies have documented the low numbers of women studying engineering related careers, have concluded women constitute a minority in technical fields due to the presence of barriers throughout their educational journey, and have stated the need to increase the number of women in engineering (Anderson³, 2002; Brainard, & Carlin¹⁶, 1998; Seymour & Hewitt⁵⁶, 1997; Thom, Pickering, & Thompson⁶⁰, 2002). Therefore, this study utilized a quantitative and qualitative approach to extend research in this area and deepen our understanding of the factors involved in women's educational journey in engineering. This study focused on the experiences women go through when deciding to pursue a degree in engineering and while completing their engineering education in order to recognize patterns and increase our understanding of the importance of each of the factors that affect, positively or negative, women in engineering degree programs.

When studying the participation of individuals in a particular field, academic/career development theory provides a basic understanding and guide of how and why individuals made their academic/career choices (Wentling, & Thomas⁶⁴, 2005). The social cognitive career theory provides a valuable framework for this research study by addressing the factors that hinder and assist women's choice and persistence in engineering (see Figure 1). According to Miles and Huberman⁴⁷ (1994), a conceptual framework explains the main dimensions to be studied, the key factors, or variables, and the presumed relationship among them. The conceptual framework in this study served as a visual map in developing the research questions, guiding the study, and assisted in analyzing the data. The conceptual framework aided in compartmentalizing (or

binning) the data for purposes of analysis (Merriam⁴⁵, 1998; Miles & Huberman⁴⁷, 1994). The conceptual framework in this study was not used for developing and/or testing theories.

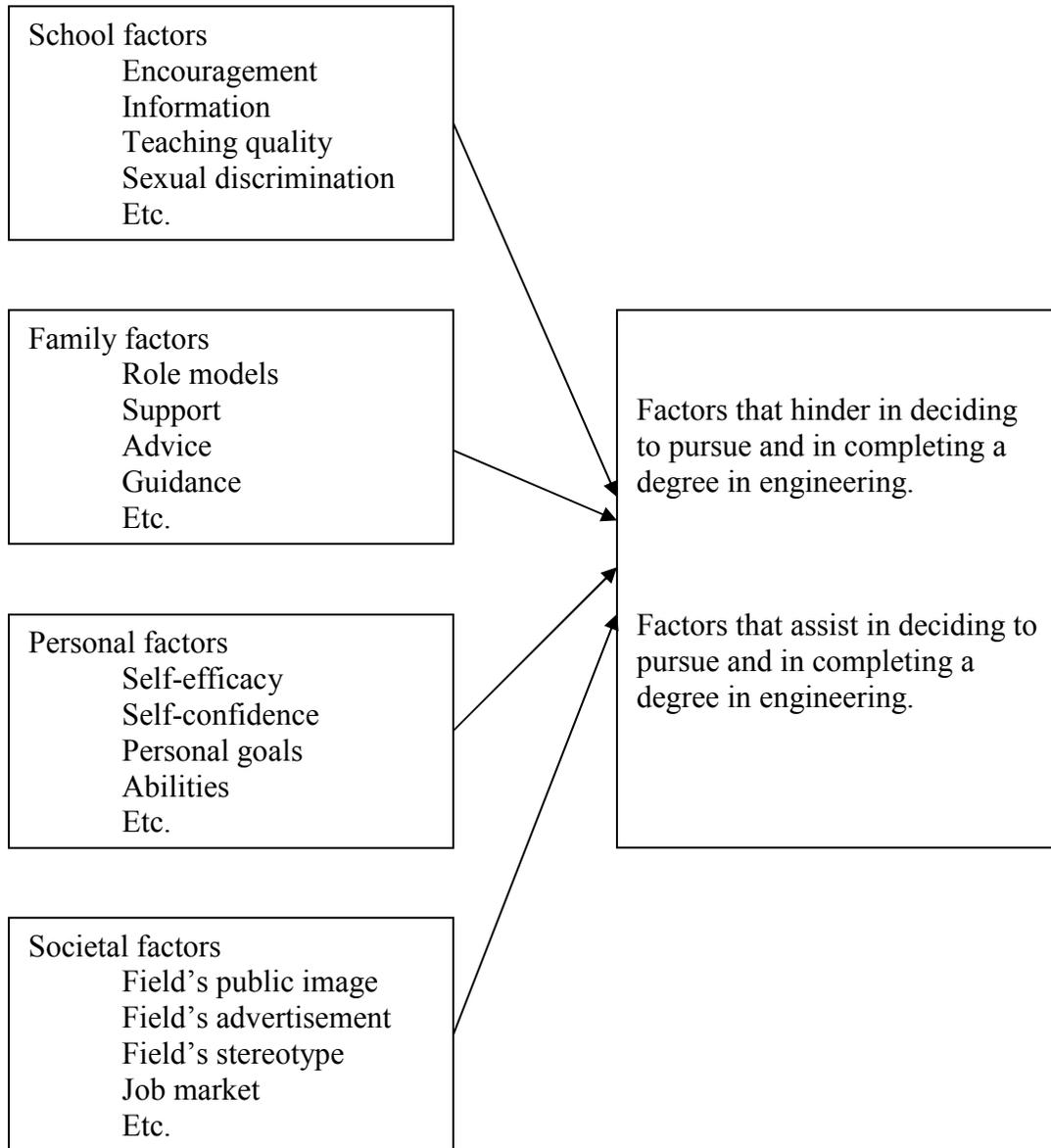


Figure 1. School, Family, Personal, and Societal Determinants of Women's Educational Development in Engineering.

Methodology

This study utilized a quantitative and qualitative design to advance our understanding of the experiences that female students go through in deciding to pursue and in completing an Engineering degree. Two major data collection methods were used. First, for the quantitative design, a survey was developed, and was used to obtain insightful information to determine the factors that have hindered and assisted graduating female engineering students at a university in the Midwest in deciding to pursue and in completing a degree in Engineering. The survey data collection method was used because it was cost effective and allowed for a rapid turn-around in data collection from a large group of individuals who are typically busy and difficult to locate (Creswell²¹, 2003). Second, for the qualitative design, focus groups were conducted with a random sample of the graduating female engineering students at the university in the Midwest to obtain detailed information on their experiences in deciding to pursue and in completing a degree in Engineering. Focus groups were utilized because they produce qualitative data that provide insights into the attitudes, perceptions, and opinions of participants. The focus group presents a more natural environment than that of an individual interview because participants are influencing and influenced by others, just as they are in real life (Krueger³⁵, 1994). Focus groups enable the researcher to increase the sample size without dramatic increases in the time required of the interviewer. In addition, focus group techniques are both useful and valid for assessing student problems within an undergraduate curriculum (Diamond & Gagnon²⁵, 1985). The sample of graduating female students earning an engineering degree was obtained from the Women in Engineering Office at the university in the Midwest. Quantitative data was analyzed using descriptive statistics and the qualitative data was analyzed using a multi-step content analysis methodology.

The population for this study involved all the senior female engineering students who were graduating from a university in the Midwest in Spring, 2005. These women were selected to complete the survey because they were graduating with an engineering degree, thus they were best able to provide the information needed to better understand the factors that hindered and assisted them in deciding to pursue and in completing a degree in engineering.

A master list of all the female engineering students who were graduating at the end of the semester (Spring, 2005) was obtained from the Women in Engineering Office at the university in the Midwest. The master list consisted of 127 female engineering students from eleven departments within the College of Engineering. From the Department of Electrical and Computer Engineering there were 34 (27%) female students; General Engineering, 21 (17%); Computer Science, 19 (15%); Civil and Environmental Engineering, 17 (13%); Mechanical and Industrial Engineering, 16 (12%); Materials Science and Engineering, 10 (8%); Aerospace Engineering, 5 (4%); Nuclear, Plasma, and Radiological Engineering, 2 (2%); Agricultural and Biological Engineering, 1 (1%); Engineering Physics, 1 (1%); and Theoretical and Applied Mechanics, 1 (1%).

Furthermore, from the master list of 127 female engineering students, five were randomly selected from each of the six engineering departments with the largest number of female students and student population in general to participate in focus groups. A total of 30 female engineering students were randomly selected from the following departments: Electrical and

Computer Engineering 5 (17%); General Engineering, 5 (17%); Computer Science, 5 (17%); Civil and Environmental Engineering, 5 (17%); Mechanical and Industrial Engineering, 5 (17%); and Aerospace Engineering, 5 (17%).

Out of the 127 female students who were graduating, 89 students filled out the survey, resulting in a return rate of 70.08%. Each of the six focus group sessions was originally composed of five female engineering students who were graduating with the same major. However, for three of the focus group sessions two of the female students did not attend, therefore there were a total of 24 participants.

Profiles of the Study Participants

Survey Participants. The study participants for this study included 89 senior female engineering students who graduated from the University of Illinois in Spring, 2005. The study participants' majors included: General Engineering, 15 (17%); Electrical Engineering, 14 (16%); Computer Science, 14 (16%); Civil and Environmental Engineering, 12 (13%); Materials Science and Engineering, 10 (11%); Computer Engineering, 5 (6%); Mechanical Engineering, 5 (6%); Industrial Engineering, 5 (6%); Aerospace Engineering, 5 (6%); Agricultural Engineering, 1 (1%); Engineering Physics, 1 (1%); Nuclear Engineering, 1 (1%); and Engineering Mechanics, 1 (1%).

The study participants ranged in age from 21 to 30 years, with an average of 22.1 years. The ethnic origin of the study participants included: White, 51 (57%); Asian/Asian American, 32 (36%); Hispanic, 4 (4%); and African-American, 2 (2%).

The study participants' college grade point averages (GPA) ranged from 2.5 to 4.0, with an average 3.39 GPA. The educational level of the study participants' fathers included: Master, 36 (40%); Bachelor, 28 (31%); High school, 13 (15%); Doctorate, 9 (10%); Associate, 1 (1%), and Less than high school, 1 (1%). The educational level of their mothers included: Bachelor, 41 (46%); High school, 22 (25%); Master, 21 (24%); Doctorate, 3 (3%); and Less than high school, 2 (2%).

Of the 89 study participants, 67 (75%) indicated that they would choose engineering as a major, if they could choose their major again; 18 (20%) indicated that they would not choose engineering as a major, if they could choose their major again; and 4 (5%) indicated they were unsure. Of the 89 study participants, 18 (20%) were very satisfied with their overall experience in their undergraduate engineering program; 58 (65%) were satisfied; 10 (11%) were neither satisfied nor dissatisfied; 3 (3%) were dissatisfied, and none were very dissatisfied. The study participants' plans after graduation included: Having accepted a job and were going to be working in a job related to engineering, 36 (40%); Attending graduate school, 29 (33%) (Engineering (59%), Law (21%), Science (10%), other (10%)); Searching for a job related to engineering, 8 (9%); Having accepted a job and were going to be working in a job not related to engineering, 2 (2%); and Being a stay-at-home mom for a while, 1 (1%).

Focus Group Participants. The study participants for the focus groups included 24 senior female engineering students who graduated from the university in the Midwest in Spring, 2005.

The study participants' majors included: Aerospace Engineering (3 students); Electrical and Computer Engineering (3 students); Mechanical and Industrial Engineering (5 students); Computer Science (5 students); General Engineering (3 students); and Civil and Environmental Engineering (5 students).

Results

The results of this study are summarized in four sections that parallel the research questions: (1) Factors that hindered the study participants when deciding to pursue a degree in engineering, (2) Factors that assisted the study participants in deciding to pursue a degree in engineering, (3) Factors that have hindered the study participants while completing a degree in engineering, and (4) Factors that have assisted the study participants in completing a degree in engineering.

To address each section, the study participants were given a survey that included a list of possible factors that could have hindered and assisted them when deciding to pursue and while completing a degree in engineering, which included: high school, family, personal, and societal factors. Participants were asked to check all the factors they had experienced, and to specify if there were any other factors that hindered and assisted them, but were not mentioned on the survey. In addition, focus group participants were asked to describe the factors that hindered and assisted them when they were deciding to pursue and while completing a degree in engineering. Please note that when the focus group results are presented the word **majority** is used to indicate 12 to 24 participants, **many** indicates 8 to 11, **several** indicates 4 to 7, and **some** indicates 1 to 3 participants.

Research Question One: Factors that Hindered the Study Participants When Deciding to Pursue a Degree in Engineering

Research question one addressed the factors that had hindered the graduating female engineering students when they were deciding to pursue a degree in engineering. This section begins with a review of the high school factors that hindered the participants when deciding to pursue a degree in engineering, followed by a review of the family factors that hindered them. The personal factors that hindered the participants are then presented. Lastly, a review of the societal factors that hindered the participants when deciding to pursue a degree in engineering is presented.

High School Factors

Survey Results. The five most frequent high school obstacles the participants encountered included: Limited career information/exposure, 44 (49%); Lack of advice from school counselor on engineering career options, 35 (39%); Lack of university engineering programs information, 13 (15%); Attended a high school with limited math/science/technology course opportunities, 13 (15%); and Lack of encouragement from teachers to pursue math/science/technical field, 9 (10%).

Most of the study participants received limited or non-information and advice about engineering careers while in high school, and consider that this lack of guidance hindered them in their academic decision process. Other high school factors that were identified by some of the study

participants as having hindered them when they were deciding to pursue a degree in engineering related to lack of university engineering programs information, and attending a high school with limited math/science/technical courses. The findings reveal that female students, who are deciding to pursue a degree in engineering, are negatively affected by the lack of exposure to engineering related courses, university engineering programs, and engineering career options received while in high school. In addition, when deciding to pursue a degree in engineering, some of the participants encountered obstacles such as lack of encouragement from teachers.

Focus Group Results. Many of the participants stated that at their high schools none or very limited information was provided regarding engineering career options. Several of the participants entered their university engineering programs not knowing what engineers actually do. This is what one participant had to say about her experience,

“My high school was not good at providing information on career opportunities and options. It was a great school academically and I did really well, but I don’t feel there was much help regarding careers. I really didn’t even know what I was going to be doing when I started my engineering program. Well, it was kind of like, I like math, I like science, and I like problem solving, so I will give engineering a try and that is how it was.”

Several of the participants revealed the lack of advice from school counselors on engineering career options. The participants indicated that they did not have any perception of the standards needed to get into the different colleges of engineering. They felt that some students just went with what the counselors said and didn’t apply to engineering programs if they didn’t think they were going to get accepted. One participant indicated that her high school counselor wouldn’t send in her college application to the College of Engineering of her choice because she didn’t think the participant would get accepted. This is what this participant had to say,

“My high school counselor wouldn’t send in my application to the College of Engineering at the [name of university] because she didn’t think I would get in. She suggested that I apply for a LAS major and then if I really wanted to do an Areospace Engineering major to wait a semester, make sure I had a good GPA, and then I could probably transfer in. I was so upset that my Mom called my counselor and told her that it was my decision what university I went to and asked her to sign my application and to FedEx it that very same day. My counselor eventually sent my application in and I was accepted to all the engineering schools I applied to. I was then able to show up at her door with my acceptance letters. This is just one example, but in all aspects the counseling system in my high school was just so awful and non-supportive.”

Several of the participants indicated attending high schools that had limited course opportunities in math, science, and technology. They indicated being scared about starting their freshman year and being worried about not being smart enough to complete a degree in engineering. When they started their degree programs they were concerned about their lack of knowledge in their science, math, and physics classes. Some of the participants struggled through some of these

classes their first couple of semesters and it took them a while to adjust to them, but they ended up succeeding. One participant had this to say,

“We didn’t have strong science and math in my school, so I didn’t have the background to get into engineering right of way. I actually started in a general curriculum and switched later. At first it was very intimidating, but not necessarily because I was a girl, it was that my high school was lacking in these areas and I didn’t have the background needed for engineering when I started my undergraduate degree program.”

Several of the participants reported high school teachers that were discouraging to them when they expressed their interest in math, science, or engineering. When one of the participants told her high school physics teacher that she was interested in majoring in engineering he told her that she would be terrible at it and that she would hate it. When another participant told one of her high school teachers that she was interested in majoring in biology he told her not to because she would have to take the AP biology class and that it would be too difficult for her.

Family Factors

Survey Results. Fifty-five (62%) study participants could not identify any factors in their families that hindered them in their academic decision process, and 34 (38%) participants identified family factors that hindered them in their academic decision process. The majority of participants did not encounter family factors that hindered them when deciding to pursue a degree in engineering, however of the 34 participants who identified family factors, the five most frequent family obstacles reported included the following: Lack of assistance in math/science/technology homework at home, 15 (44%); Lack of family role models and/or mentors, 12 (35%); Lack of financial support from parents for college tuition, 11 (32%); Parents did not support my decision to major in engineering, 5 (15%); and Parents wanted me to pursue a degree in a traditional female field like nursing/teaching, 4 (12%).

The findings reveal that when deciding to pursue a degree in engineering, female students are affected by not having been able to receive help from their families on math/science/technology homework while in high school, by the lack of family role-models and/or mentors who could have guided and assisted them in engineering related issues while in high school, and by the lack of financial support from their families for college tuition. Other family factors that were identified by some of the study participants as having hindered them when deciding to pursue a degree in engineering related to parents lack of support of the participant’s decision to major in engineering, and parents wanting the participant to pursue a degree in a traditional female field. The findings reveal that some students received family pressure not only to not major in engineering, but also to obtain a degree in a traditional female field such as nursing, teaching, among others.

Focus Group Results. The majority of the participants did not encounter family factors that hindered them when deciding to pursue a degree in engineering. Several who did encounter family factors that hindered them indicated issues related to lack of parent financial support, parents lack of knowledge about the engineering field, lack of family role models/mentors, and

parents wanting them to pursue a degree in a different field. One participant had this to say about parent financial support,

“I didn’t want to put a burden on my family financially. Engineering programs at all universities cost more, but going out of state to a technical school cost significantly more. I needed financial aid to pursue a degree in engineering, but if I didn’t get it and my parents couldn’t pay I probably would have switched to LAS or some other major that was less expensive.”

Another participant had this to say about her family,

“No one in my family really knows anything about engineering. So I didn’t have any sort of role-models to follow or any sort of idea of what you really do as an engineer. I was really clueless about what type of work engineers did, but this didn’t hold me back because I was determine to learn about the engineering field.”

Another participant had this to say,

“I talked a lot, so my family wanted me to go into communications or journalism. This is what my family saw me doing, they never thought I would be an engineer. They were really shocked when I told them I was going to major in engineering. My family wasn’t happy about me picking the engineering field.”

Personal Factors

Survey Results. The five most frequent personal factors encountered by the study participants that hindered them when they were deciding to pursue a degree in engineering included: Lack of knowledge related to engineering careers, 40 (45%); Feeling like an outsider in advanced math/science/technology classes, 21 (24%); Low self-esteem/confidence related to math/science/technology courses, 20 (22%); Lack of understanding of courses needed for getting accepted into engineering program, 11 (12%); and Lack of interest in engineering field, 9 (10%).

Once again, this finding reveals that the study participants consider that their lack of knowledge regarding engineering careers was a hindrance to their academic decision process, and that they did not receive sufficient information regarding engineering careers while in high school. In addition, the findings may reveal that feeling like an outsider in advanced technical classes could have affected the students’ self-esteem/confidence regarding engineering related courses. In addition, other personal factors that were mentioned by some of the participants as having hindered them when deciding to pursue a degree in engineering had to do with lack of understanding of courses needed for getting accepted into an engineering program and lack of interest in engineering field. The students’ lack of understanding of courses needed for acceptance into an engineering program could be related to the students’ lack of knowledge of engineering careers.

Focus Group Results. Many of the participants indicated lack of knowledge related to engineering careers and feeling like an outsider in advanced math and science classes as personal factors that hindered them when deciding to pursue a degree in engineering. In addition, several of the participants indicated having friends who had tried to discourage them from pursuing a degree in engineering. One participant had this to say,

“I took AP physics in high school and it was really hard, so my high school friends told me that this was going to be my life when I majored in engineering. My best friend’s older brother was an engineer major and she told me that he basically lived in his car because he had to go to the library all the time and he had to stay away from his apartment because his roommates have fun and he had to study all the time, and that he never got to sleep. Well, I really enjoy sleeping, so I was worried about what I was being told, but it hasn’t been that bad.”

Societal Factors

Survey Results. The five most frequent societal obstacles reported by the study participants included: Engineering is represented as a male dominated field, 40 (45%); Public image of engineering field is mostly male, 34 (38%); Lack of women engineer role models/mentors in my community, 32 (36%); Low expectation of females, 30 (34%); and Traditional views about education/careers for women, 22 (25%).

The findings reveal that the low representation of women in the engineering workforce (which contributes to the public image of the engineering field being mostly male and the lack of female engineering role models/mentors in society), the low expectation of females, and the traditional views about careers/education for women do hinder female students when they are deciding to pursue a degree in engineering.

Focus Group Results. The lack of females in engineering caused several of the participants to seriously question if engineering was the right field for them. The participants indicated that the lack of females in engineering many times made them feel like maybe women lacked the capability to enter the field, but at the same time they wanted to prove to themselves and others that this was not true. Engineering being a male dominated field had an adverse affect on some of the participants. For example one participant had this to say about how she felt,

“When I started my engineering program I was aware that I was getting into a male dominated field. I was one of those persons that felt that guys are better and smarter than girls with technical stuff. So I kind of just took a step back and observed to see if the guys were actually doing better and to prove to myself that the guys should be there and not me. But the truth was that I was able to cope and do just as well as the guys. To be honest, if I had not been able to cope and do well I would have continued with the inaccurate perception that guys are better and smarter than girls in engineering.”

Several of the participants stated that because engineering careers are not likely to be portrayed in society, they had limited knowledge related to engineering careers which hindered them in deciding to pursue a degree in engineering. One participant had this to say,

“In society and in TV shows you always see for example, doctors, lawyers, teachers and accountants, but you never see engineers. I didn’t know anybody when I was growing up that wanted to be an engineer when they grew up. When I was growing up I wanted to be a doctor because I watched ER on TV. Then I wanted to be a teacher because I really liked my history teacher, then I wanted to be a lawyer because I watched CSI on TV. Growing up I was never exposed to engineering. My Mom was the one who brought engineering to my attention and then after doing some exploring on my own, it fall into place.”

Research Question Two: Factors that Assisted the Study Participants in Deciding to Pursue a Degree in Engineering

Research question two addressed the factors that had assisted the graduating female engineering students in deciding to pursue a degree in engineering. This section begins with a review of the high school factors that assisted the participants in deciding to pursue a degree in engineering, followed by a review of the family factors that assisted them. The personal factors that assisted the participants are then presented. Lastly, a review of the societal factors that assisted the participants in deciding to pursue a degree in engineering is presented.

High School Factors

Survey Results. The five most frequent high school factors identified by the participants included: Did well in classes related to math/science/technology, 80 (90%); Classes taken in high school (e.g., math, science, physics, technology), 78 (88%); Excellent math/science/technology teachers, 65 (73%); Teachers who encouraged me to pursue my interest in math/science/technology, 49 (55%) and Participation in extracurricular activities in high school (e.g., math/science olympiad), 23 (26%).

The findings reveal the importance of math/science/technology high school classes, due to the fact that the students’ decision to pursue a degree in engineering was mostly influenced by their performance and enjoyment of their math, science, and technology high school classes, and by the teaching quality and encouragement provided by their high school teachers. Other high school factors that were identified by a number of the study participants as having assisted them in becoming interested in pursuing an engineering degree were related to the participants’ involvement in extracurricular activities and in engineering/computer science related programs while in high school.

Focus Group Results. Many of the participants attended high schools with very strong math, computer, and science programs. They participated in these classes and did well, which sparked their interest in engineering. These participants left their high schools with strong backgrounds in these areas, which they felt prepared them well for a university engineering curriculum. One participant stated,

“I took a physics class in high school and I really liked it and it was just completely different from any other classes I had taken. I also took a lot of math and science classes in high school, but the physics was a little bit different and it pushed me towards engineering more than anything else.”

Still another participant reported,

“My freshmen year in high school I took a class called Engineering Exploration and it was then that I decided I was going to be an engineer. From that time forward there never was any questioning or debating whatsoever that I was going to be an engineer. It’s kind of strange, but there was never really any doubt in my mind that it was what I wanted to be”

Many of the participants indicated having teachers in high school who were supportive and encouraged them to pursue their interest in math, science, and technology. Some of these teachers served as their math team coaches, helped them to prepare for AP exams in math and science, and provided advice and information about engineering. One participant had this to say,

“I always wanted to be an architect and then I took some CAD classes in high school and really enjoyed them and did really well in them. It was my CAD teacher who provided me information about the engineering fields and encouraged me to explore them. I decided to choose civil engineering. If I hadn’t had that little bit of exposure about engineering from my CAD teacher, I don’t think I would have known to look into engineering.”

Another participant reported this about her math teacher,

“One of my high school math teachers had former students come back to talk about their experiences in college and why they decided to major in math or engineering. This was very helpful to me to see and hear someone who was a little bit older than me who already was in college and majoring in engineering. This made me feel super excited because I actually got to meet someone who was majoring in engineering and really having a great experience in college.”

Family Factors

Survey Results. The five most frequent family factors reported by the study participants included: Parents support of my personal career choice, 74 (83%); Parents encouragement to pursue an engineering degree, 55 (62%); Male engineer role-model in my family (e.g., father, brother, uncle), 39 (44%); Parents provided advice and information about careers in engineering, 27 (30%); and Female engineer role-model in my family (e.g., mother, sister, aunt), 14 (16%).

The findings reveal that having support, encouragement and advice from parents, and having a role-model whom the students can relate to are the most important factors in the academic decision process of female high school students who decide to pursue a degree in engineering.

Another family factor that were identified by some of the study participants as having assisted them in deciding to pursue a degree in engineering related to having a female engineer role-model in the family. It is interesting to note that more than twice as many participants indicated that having male engineer role-models in their families assisted them in deciding to pursue a degree in engineering than family female engineer-role models.

Focus Group Results. All the participants indicated that their families were supportive in a variety of ways. Many of their parents helped them explore career options, pointed out the advantages and disadvantages of different careers, and supported and encouraged them to pursue an engineering degree. In addition, several of the participants had a father, mother, brother, sister, uncle, aunt, or other family member who was an engineer and served as a role-model for them. One participant had this to say about her family,

“I have a family full of engineers, my father, my uncles, but they are all males. I wanted to break the mold and be the first female in my family to pursue an engineering degree. I just followed along in their foot steps and that definitely helped make my decision easier.”

Another participant had this to say,

“My Dad is an engineer and I always thought his work was interesting. I would go to work with him for parents and kids day and do things at work with him. He is an industrial engineer and I always thought the work he did was cool, so that’s how I became interested in engineering.”

Personal Factors

Survey Results. The five most frequent personal factors reported by the study participants as having assisted them included: I like problem solving, 63 (71%); Personal satisfaction, 59 (66%); High aptitude in engineering fields, 58 (65%); Interested/fascinated by science and technical things, 49 (55%); and Engineering will give me opportunities to make a difference, 43 (48%).

The findings reveal that most of the personal factors that assisted female students in deciding to pursue a degree in engineering have to do with the students’ enjoyment of problem solving, personal satisfaction, high aptitude in the engineering field, interest and enjoyment of science and technical things; and the opportunity to make a difference in society.

Focus Group Results. Most of the participants gravitated towards engineering because of their high aptitude, interest or enjoyment in math and science. For many of them their interest and fascination with problem solving, designing, building, and inventing things moved them toward the engineering field. They felt that engineering fit their interests and personality. One participant stated,

“In grade school and in high school I was always involved in projects that involved inventing things. I invented something like an orange peeler, but I didn’t realize it was already in the market [laughs]. I have always wanted to

design and build things. My teachers encouraged my interests and put me in touch with engineers out in the field. It was just a matter of elimination to why I actually chose to pursue a degree in mechanical engineering.”

Several of the participants liked being challenged or liked the challenge of entering a male dominated field. One study participant had this to say,

“There seems to be a lot of opportunities in engineering and there are not a lot of girls in engineering. I wanted to be that person who did something different and I wanted to get out there and see if I could do it and be part of that group. It’s just a fallacy that women have to major in something traditional and can’t pursue an engineering degree. This has inspired and motivated me to succeed, so I can prove that engineering doesn’t have to be male dominated.”

Another participant had this to say,

“Personally I really enjoy being challenged. I find that if I am not challenged I get bored. I really enjoy working hard and I enjoy constantly having something new and hard to do that never really ends. I knew it was going to be a hard and challenging major, so I think that is sort of what attracted me towards engineering and computer science.”

Still another participant had this to report,

“I have always been good in math and science. Computer science is a lot like math. I really like the problem solving aspect of computer science in particular, it’s like a personal satisfaction when you get it right, and you know you get it right cause you can see that it is working. It is fun to be able to problem solve and actually get a solution.”

Societal Factors

Survey Results. The five most frequent societal factors reported by the study participants as having assisted them included: Engineering has many different job opportunities, 69 (78%); Engineering is an interesting and challenging field, 65 (73%); Engineering is a high salary field, 58 (65%); Engineering has a good job market, 55 (62%), and I was inspired by progress and accomplishments in science and technology, 36 (40%).

The findings show that the societal factors that assisted most of the study participants in deciding to pursue a degree in engineering have to do with the wide range of employment opportunities, the high salaries, and the good job market that students have access to by being engineers. Additionally, the study participants were attracted to the engineering field because they consider it interesting and challenging. Another societal factor that were identified by a number of the study participants as having assisted them when deciding to pursue a degree in engineering included that they were inspired by the progress and accomplishments in science and technology,

Focus Group Results. Many of the participants were attracted to engineering because of the many job opportunities engineering offers. They felt that with an engineering degree they would have a variety of job options and the flexibility to work in many different settings. One participant had this to say,

“My father told me that with an engineering degree I was guaranteed a job after graduation. I think it’s true that you can really do so many things with an engineering degree, so that’s is what kind of pushed me toward engineering. So now I know it’s definitely a fact that with an engineering degree you can come out of college with a really decent good paying job.”

Many of the participants became interested in the engineering field because of the societal portrayal of it being a high paying field. For several this was not an influential factor when making the decision to major in engineering, however it was something they thought about once they made the decision to enter the engineering field.

For some of the participants the fact that there are few women in engineering was a factor in their mind when they decided to pursue a degree in engineering. Actually, the fact that there are not many women in engineering spurred on some of the participants. One of the participants stated,

“There is a social perception that guys do better in math and science and that engineering is a male field. This has always made me mad, so I have always pushed and challenged myself to do better in the math and science areas. I also think that is part of the reason why I like the idea of engineering so much. I think, I kind of like doing what other girls don’t like doing, and doing what the boys like doing.”

Research Question Three: Factors that Hindered the Study Participants While Completing a Degree in Engineering

Research question three addressed the factors that had hindered the graduating female engineering students while completing a degree in engineering. This section begins with a review of the university factors that hindered the participants while completing a degree in engineering. The family factors that hindered the participants while completing a degree in engineering are then presented. Finally, reviews of the personal factors that hindered the participants while completing a degree in engineering are presented.

University Factors

Survey Results. The ten most frequent university obstacles the participants encountered included: Ineffective professors, 49 (55%); Professors who did not motivate me, 44 (49%); Low grades in engineering classes, 39 (44%); Poor teaching quality, 32 (36%); Too much homework, 32 (36%); Excessively competitive environment, 31 (35%); Curriculum too demanding, 26 (29%); Class material too difficult, 25 (28%); Lack of female professors, 22 (25%); and Lack of female classmates, 22 (25%).

The findings reveal the importance of having professors who are committed to preparing good and interesting lectures that motivate their students. Additionally, the findings reveal that a number of female students were hindered by low grades in engineering classes, this hindrance could be a consequence of the following factors students also identified as having hindered them while completing a degree in engineering: poor teaching quality, too much homework, excessively competitive environment, curriculum too demanding, and class material too difficult. In addition, a quarter of the study participants indicated that the absence of female professors and classmates in their university engineering programs hindered them while completing a degree in engineering.

Focus Group Results. Many of the participants reported that poor and ineffective professors hindered them when completing their degree in engineering. Some of the words that were used to describe their ineffective professors were: unfriendly, rude, condescending, unavailable, self-righteous, uncaring, impersonal, and unkind. Several of the participants reported having professors who were not interested in being good teachers and were unavailable when it came to the classroom. Several of the participants indicated that having ineffective professors caused them to frequently question whether they should stay in their department or leave engineering altogether. This is what one participant had to say about her professors,

“Many of my professors integrated the impression into the classroom when they were teaching of unfriendliness and unwillingness to help you by being condescending and telling you that you should know these kinds of things. I have heard comments such as, you should know how to do this, and my third grade daughter knows how to do this, several times. I felt like I was always behind everybody and I was the only one not getting it. But I felt if I went to talk to my professor he would just laugh at me or be really rude and condescending. This may not have happened, but it was enough to keep me from going and asking for help.”

Still another participant had this say about her professor,

“I was literally the only girl in most of my classes. I had two classes and there were three other girls in them. It was kind of frustrating and more than it just being a girl thing, it was that I couldn’t really connect with the people in my classes. Especially the professors didn’t really make an effort to really talk to me like I was a normal person. The professors were used to a male class and they didn’t know how to respond to me. For example, if I would go and ask them a question during their office hours they were not willing to explain things to me in a different way.”

Yet another participant stated,

“Many of my professors were not dedicated to their teaching and undergraduate students, instead they were more focused and absorbed in their research and graduate programs. They didn’t seem to put much effort into teaching and they didn’t seem to care if I learned or did well in their classes. Of all the different

classes I have taken, there were only three professors that I felt were really dedicated to their teaching and really cared about the students. That was kind of frustrating, because you are so much more interested and learn so much more when you have professors who care.”

Many of the participants reported that poor and ineffective advisors hindered them when completing their degree in engineering. One participant had this to say about her advisor,

“My advisor was a real problem for me. I never felt I could go to my advisor for help and suggestions in what I needed to do. My advisor was a professor and he didn’t seem to want to be advising students. Advising students was something this professor had to do on the side and he didn’t want to do it. I ran into a lot of problems because lack of assistance from my advisor. For example one semester I signed up for a class that was approved and two days after the class started he told me that the class wasn’t going to count.”

Another participant stated this about her advisor,

“My advisor was rude and used a tough approach in his advising. Nothing I did was ever good enough for him. My freshmen year I walked out of his office in tear every time because he would yell at me about my grades or whatever else I didn’t do right. I really didn’t need this because I was already stressed out and had enough internal pressures to deal with. I would just feel so awful after meeting with my advisor.”

Several of the participants indicated that low grades in their engineering classes hindered them while completing their degree. One participant had this to say,

“One thing that hindered me was the classes that I took at the beginning that were weed out classes. I was getting Cs on my tests and I had never gotten a C before and I was really upset and it was really discouraging. I didn’t realize it at the time, but the average on the tests were way below 50% and that the professors curve the grade at the end of the semester, but they don’t necessarily tell you that on the syllabus. At the time these bad grades were causing me to reevaluated my major. I just think some of the weed out classes can really hinder people and there should be a better way to teach these classes.”

Several of the participants indicated that courses that were extremely difficult made them lose some of their self-confidence and made them question the reason for being there. One participant had this to say,

“I definitely had some extremely difficult classes and there were times when I didn’t do well on the tests, and it was so devastating and discouraging. I actually thought of giving up and leaving because I didn’t know why I was doing this to myself. But I remember talking to my Mom and she would encourage me to stay

and tell me not to give up and that I would eventually get it and do well. She was right, it took me a while, but I did very well and made it through.”

Several of the participants reported that seeing so few females in engineering classes concerned them. One participant had this to say,

“In several of my advance engineering classes, I was literally the only female. And I didn’t feel great about it or feel like I was paving the way for other females to follow, it was more like there should be more females here, after all it is 2005. Then you feel like you don’t have anybody to related to in your classes and you probably won’t have anybody to relate to in the workplace, and that’s just very discouraging.”

Still another participant said,

“One of the things that was really hard to see was that a lot of girls left, every year you saw less and less girls in engineering. And sometimes I would get comments like: oh are you still in engineering? It’s like they expected me to switch out of engineering for some reason. It was almost like there was a pressure to get me out of engineering, like what are you doing here? It was so hard and I knew I could have it so much easier, so sometimes it was hard to convince myself to continue to do what I was doing.”

Several of the participants felt that because engineering is a male dominated field many girls enter feeling intimidated and with a fear of failing. These participants felt that professors in engineering courses should provide a class structure that includes more opportunities for girls to have positive and successful experiences. One participant had this to say,

“Male and females come from a different mindset, therefore there should be a different course structure so that women feel a little more at home when they are pursuing a degree in engineering. The minute females feel failure they are more likely than males to think of withdrawing, and if the feeling of failure continues they are more likely than males to actually withdraw. Males seem to be more comfortable with the feeling of failure than females or maybe males cope better with failure than females. Therefore, females need to be given opportunities in their classes to feel successful, so when they encounter failure, they can cope with it in a more positive way than just withdrawing.”

Another participant shared that three of her friends had initial set backs in their classes early in their engineering degree program that discouraged them and all of them dropped out because they felt the pressure was too much for them.

Family Factors

Survey Results. Seventy-six (85%) of the study participants could not identify any factors in their families that hindered them while completing a degree in engineering, and 13 (15%)

participants identified family factors that hindered them while completing their engineering degrees. The majority of the participants did not encounter family factors that hindered them while completing a degree in engineering, however of the 13 participants who identified family factors, the three most frequent family obstacles reported were lack of family involvement, support, and/or encouragement, 9 (69%); Lack of financial support from family, 3 (23%) and Family too far away, 3 (23%).

The findings show that a lack of family's involvement, support, and encouragement does hinder some females while completing their engineering degrees. Two other family factors that hindered some participants while completing a degree in engineering related to lack of financial support from family, and family being too far away.

Focus Group Results. The majority of the participants did not identify any family factors that hindered them while completing a degree in engineering. However, several of the participants indicated lack of family involvement and support as a barrier when they were completing their degrees. They reported having parents who did not understand the field of engineering, hence were not able to assist them in obtaining internships or co-ops. Also, some participants reported that their parents did not come to visit them during the school year, so their parents were not involved in their college life.

Some of the participants were pressured to finish their degree in four years because of limited financial support from their parents. This sometimes required them to take a heavier course load than they would have liked. Many times these participants were overburdened with school work and had very little time for other aspects of their lives. Some of them indicated being spread too thin and not having the time they needed to devote to all their classes.

Some of the participants encountered family tragedies (e.g., sick family member, family member diagnosed with cancer, death of a family member) that hindered them while completing their degrees. During these hard times their grades suffered, but eventually went back up.

Personal Factors

Survey Results. The five most frequent personal factors encountered by the study participants that hindered them while completing a degree in engineering included: Lack of free time, 59 (66%); Doubts about career goals, 50 (56%); Low self-esteem/confidence, 28 (31%); Lack of motivation, 22 (25%); and Lack of self-discipline, 17 (19%).

The findings reveal that female engineering students consider lack of free time as a personal factor that hindered them while completing a degree in engineering. This lack of free time could be related to the university factors of too much homework, curriculum too demanding, class material too difficult, and so forth that were mentioned by the participants as having hindered them while completing a degree in engineering. Additionally, female engineering students have doubts about their career goals, which hindered them while completing a degree in engineering. Other personal factors that were identified by a number of the study participants as having hindered them related to low self-esteem/confidence, lack of motivation, and lack of self-

discipline. The lack of motivation and self-discipline encountered by the participants could be related to, or caused by, their doubts about their career goals.

Focus Group Results. Many of the participants came into their engineering programs with self-doubt and a low self-confidence level. Sometimes the low self-esteem/confidence carried throughout their degree program. Several participants indicated that academically they did really well in high school, but in some of their engineering courses their performance was average. This created a lot of pressure for some of the participants. This is what one participant had to say,

“This is a really good school, so when I came here I felt like I wasn’t good enough. It seemed like everyone else in my classes already had some background knowledge and were so much smarter than me. It was hard to find other people in my classes that I felt I could talk with, because there were only a few girls and I wasn’t going to go up to some boy and start talking. At first it was hard for me to meet people, so I felt lonely. Later I realized that most people come in feeling that way, so some of it just has to do with being in a new environment and not necessarily being a girl.”

One participant had this to say about her performance,

“I was always so use to doing really well in my classes in high school and then coming here and being average was the hardest transition I have ever had to make in my life. I was always so upset and mad at myself about it. This is really hard because you feel like for your career you should be doing something that you are good at and especially in an engineering profession that requires so much competency. I just put so much unnecessary pressure on myself. Personally, I think this hindered me throughout my four years.”

Many of the participants mentioned lack of free time as an issue they encountered throughout their engineering programs. Several of the participants wanted to get involved in extra-curricular activities (e.g., sports, student organizations, student government), but they did not have time. They also mentioned that their friends that were not in engineering tended to have more time to do activities that were non-school related (e.g., exercise, parties, movies, sleep).

Several of the participants reported having doubts about their career goals during their engineering degree programs. One participant had this to say,

“When I came here I went into aerospace engineering just because I didn’t know what I wanted to do and for the reason that I picked the first major that was on the engineering program list, which was in alphabetical order. I didn’t know much about what program I was entering, so I figured I would switch majors at some point to something else. But I ended up liking engineering and after my first two years I was determined to finish and do well in engineering.”

Another participant stated,

“I think that a lot of my friends who were questioning staying in engineering really couldn’t picture themselves as an engineer. It wasn’t like they weren’t interested or weren’t capable, they just had no image of themselves as an engineer. There is no real good reason, just that it’s really hard to picture a girl being an engineer. Maybe it’s because in society you rarely see pictures of female engineers, but you do see pictures of guys who are engineers. So it’s like a fundamental thought and you question if you belong in engineering.”

Some of the participants felt that because there were so few females in their classes they had to prove their competence far and beyond. One participant stated,

“When the students in your classes are mostly male, I think in general it is so hard to not let the intimidation get to you because it is so prevalent. It is something I still struggle with today and even when I am in the workplace. When I did my internship it was hard not to let the male smart engineers intimidate me because you know they are seemingly all knowing and some of them can talk down to you because they think that they know everything. So we tend to work harder and be more determined because we are females in the engineering field.”

Research Question Four: Factors that Assisted the Study Participants in Completing a Degree in Engineering

Research question four addressed the factors that had assisted the study participants in completing a degree in engineering. This section begins with a review of the university factors that assisted the participants in completing a degree in engineering. The family factors that assisted the participants in completing a degree in engineering are then presented. Then, reviews of the personal factors that assisted the participants in completing a degree in engineering are presented. Finally, advice given by the study participants to females wanting to pursue a degree in engineering is presented.

University Factors

Survey Results. The six most frequent university factors identified by the participants included: Involvement in campus student organizations, 48 (54%); Teaching quality/excellent professors, 41 (46%); Good performance in engineering classes, 38 (43%); Internships, 35 (39%); Supportive/encouraging/motivational professors, 33 (37%); Enjoyed engineering classes, 33 (37%); Good guidance by advisors/counselors, 31 (35%); Received scholarship/fellowship, 30 (34%); Good relationships with professors, 27 (30%); and Not wanting to lose credit if switching majors, 27 (30%).

Students’ participation in campus student organizations was the most frequent factor mentioned by the study participants as having assisted them in completing a degree in engineering. As with the high school factors that assisted the study participants the most in becoming interested in engineering, the university factors that assisted the participants the most in completing their

engineering degrees reveal the importance of professors' dedication to class and to their students, and students' performance and enjoyment of their engineering classes in the retention of women in engineering. The findings reveal that professors who are dedicated to their classes and their students play a major role in the retention of women in engineering. Other university factors that were identified by a number of study participants as having assisted them in completing their engineering degrees related to good guidance by advisors/counselors, having received a scholarship/fellowship, good relationships with professors, and not wanting to lose credit if switching majors.

Focus Group Results. Many of the participants indicated that being involved in campus student organizations (e.g., Women in Engineering, Society for Women in Engineering, Women in Math, Science and Engineering) assisted them when completing their degree in engineering. A participant had this to say,

I made a lot of really good friends through my association with the Society for Women in Engineering [SWE]. I think there are a lot of people who join SWE and who stay in engineering because they don't want to give up their friends. The amount of time you put into SWE comes to mean so much to you that I think leaving engineering becomes like a much bigger decision. So for me, my classes were interesting and I got good grades, but it has been what I have been able to do through extracurricular activities, such as my involvement in SWE that became my self-identity, and so that's what really anchored me into being committed to my engineering program.

Another participant stated,

“My first three years here I lived in one of the dorms that had a living-learning community for women, it was called women in math, science, and engineering [WIMSE]. I lived there multiple years, but it was most beneficial my freshman year because that year they paired up roommates by major. My freshman year roommate was a woman in Aerospace Engineering, and we had almost all of our classes together ever since. It was really good to meet people in your major right away, so you can establish a support network immediately. This was probably the most beneficial thing for me.”

Many of the participants reported that having excellent professors and teaching assistants assisted them while completing their degree in engineering. Some of the words that were used to describe their professors were: motivational, encouraging, helpful, and supportive. This is what one participant had to say about her professor,

“I had a great opportunity last year to work with a professor on a research project. I learned a lot about research from him. He also gave me some really good advice about graduate schools and jobs. He gave me a lot of moral support and motivated me to do well in school and encouraged me to apply for graduate school. He also wrote several reference letters for me when I applied to graduate school.”

Another participant stated,

“I think that one of the things that really helped was that I had some really good teachers. They were just so willing to help me and were always encouraging me. When I felt defeated and didn’t understand something they would explain it to me until I would get it. They believed in me and they knew I could do it and that made me feel really good. It was these really good teachers that made a big difference.”

Another participant reported,

“Most of the TAs [teaching assistants] in my classes were very helpful especially during my freshman and sophomore year. They would have office hours and were available to help you with your homework. They were also available to help you in the computer lab and identified resources that were available at the university to assist you with your homework and class projects.”

Several of the participants indicated that taking part in an internship helped them to stay focused in their engineering courses and to determine their different career options. One participant stated,

“I started looking more seriously at job options after I participated in an internship. I think everyone should be required to have an internship in engineering, and I don’t think that it’s encouraged enough. My internship gave me some great experience and it exposed me to the type of work that I liked and I didn’t like. It also helped me to understand why we study chemistry, physics, and all this math stuff. It helped me realize the reason and importance of my courses.”

Several of the participants reported that mentors assisted them in completing their engineering degree. One participant had this to say,

“MentorNet was a great resource for me. I have had two mentors during the past three years and they have been excellent. My mentors have really helped me through my academic career. I will continue to keep in touch with them when I leave the university and start my new job at Boeing.”

Some of the participants stated that taking part in the women in engineering retreat after they had been accepted into the College of Engineering was helpful and motivating to them. They felt it was helpful and inspiring because they were able to meet other female freshman and upper-class engineering students. This made them realize that there were other women who were going to go into or were already in the engineering field.

Some of the participants stated that advisors that were helpful and supportive assisted them while completing their degree. These advisors provided them with moral and emotional support, as well as the advice they needed to plan their course schedules.

Family Factors

Survey Results. The four most frequent family factors reported by the study participants included: Supportive and encouraging family, 78 (88%); Family helped financially, 67 (75%); Family members assisted in engineering homework, 12 (13%); and Family helped me get an internship, 10 (11%).

As with the family factors that assisted the study participants the most in deciding to pursue a degree in engineering, the family factors that assisted the participants the most in completing their engineering degrees reveal the importance of the students' families support and encouragement in their retention in engineering. Additionally, financial help from the students' parents also constitutes a factor that assisted them in completing a degree in engineering. Other family factors that were identified by some study participants as having assisted them in completing a degree in engineering related to family members having assisted in engineering homework, and having helped get an internship.

Focus Group Results. The majority of the participants mentioned that the support and encouragement from their family assisted them when completing their degree in engineering. One participant had this to say,

“The one thing that made things easier for me was my support system, who was primarily my parents and fiancé. My parents and my fiancé were always the reason that I got through my work when it was overwhelming and challenging. They were always telling me: you can do it, it is fine, you can do this. I think if it wasn't for them I wouldn't have been able to get through the hard times.”

Another participant had this to say about her sister's support,

“My sister went here for the first two years that I was here, so that was a huge help to me. My junior year was probably my hardest, but my freshmen and sophomore were really hard too because I had a lot to adapt to. I always had her support and she shared her experiences in similar situations and gave me advice. Having her here was great. She always told me: if I can graduate, you can graduate too.”

Personal Factors

Survey Results. The ten most frequent personal factors reported by the study participants as having assisted them included: I make sure my assignments are turned in on time, 74 (83%); I am a hard worker, 69 (78%); I study with my classmates/friends, 68 (76%); Perseverance/determination, 64 (72%); I am self-motivated, 61 (69%); Support from classmates/friends, 57 (64%); I am highly disciplined, 53 (60%); I study enough to make sure I

do well in my classes, 52 (58%); I am happy I chose to major in engineering, 52 (58%); and I am rarely absent from classes, 51 (57%).

Making sure the assignments are turned in on time was the most frequent factor mentioned by the study participants as having assisted them in completing a degree in engineering. The findings reveal the importance of study groups and of having a good support network, and the personal characteristics that students deem necessary for obtaining a degree in engineering: being responsible, hard worker, perseverant, and self-motivated. Other factors identified by the majority of participants included: being highly disciplined, studying enough to make sure they do well in their classes, being happy with their decision to major in engineering, and being rarely absent from classes.

Focus Group Results. The majority of the participants indicated that participating in study groups with classmates and friends assisted them in completing their degree. One study participant stated,

“Once you start seeing people over and over again in your classes and you start to talk to them, then you make friends. Once you are friends with people in your classes it makes it easier and more comfortable to study and do homework together. You build a community of support and that helps you do better in your classes.”

Another participant had this to say,

“Study groups were the most important to me. I think without study groups I would have been miserable, it would have been almost impossible to do well. It’s a group that forms from people in your classes that then become your friends. I have a group of friends now that are in almost all my classes. We go to classes together and we spend a lot of time outside of class studying and doing fun things together.”

Many of the participants indicated that perseverance and determination assisted them in completing their degree in engineering. One participant stated,

“I don’t think I ever considered changing majors. I guess that I have felt that I was really lucky that I got into engineering. Even if it’s hard you can find people to help you get through it. I have always felt that there isn’t going to be anybody who is going to fail you. Most of the professors are willing to help you, so you are going to be able to succeed. You just have to be determined and remain positive.”

Yet another participants indicated,

“Being a strong and independent person and having a drive to be persistent has been very helpful to me. A lot of self-motivation is also involved. I mean you really work hard at something and when you finally get it, it is just the best

feeling ever. For example, if you have been working on a problem for a really long time and all of the sudden you get the right answer it is such a good feeling, it is kind of like a high and you want to do it again and again.”

Many of the participants stated that being involved in extracurricular activities and having a balanced life assisted them in completing their degrees. These participants had other interests outside of engineering and they felt getting away from engineering for a while made them appreciate it more. One participant had this to say,

“Having friends to talk to and participating in extracurricular activities were really helpful. After a physics exam or any other hard exam I would be so frustrated and stressed out. So I would go to skating practice with my friends after an exam and I would tell them that I totally failed the exam and they would listen to me. Then after a night of skating practice and having fun with my friends I would feel so much better.”

Still another participant reported,

“Getting involved in student organizations tied me more to my program and engineering because it made me less willing to change my major or to consider something else. It made me feel like I was a part of the department and university. It actually made being here and doing work more worth it because I knew I could do other things and it wasn’t about working hard all the time. It made staying with engineering more feasible because I knew I wasn’t always going to have to just be working hard, but that I was going to have friends and other things to do. I think that helped me a lot.”

Several participants identified support from classmates and/or friends as a factor that assisted them in completing a degree in engineering. This is what one participant had to say,

“All the engineering classes have an exceptionally small number of girls. But the girls are usually social and it’s easy to identify with them and become friends. I never felt lonely in my classes because I got along with them they were fun to be with and it made the classes so much more fun to attend. Most of them are graduating with me and we are going to continue to stay in touch with each other.”

Still another participant had this to say,

“When I first started it was hard, but once I met other students and made friends that helped a lot because I then had other people to talk to about things. Establishing a network of friends who can help and support you along the way was the most helpful to me. It is so helpful to have friends to talk to about classes, professors, course load, what classes to take, or just about anything.”

Several of the participants indicated not being afraid of failure and not trying to be perfect helped them in completing their degree in engineering. This is what one participant stated,

“Don’t think you have to get straight A’s or be perfect or number one in your educational programs to stay in an engineering degree program. So if you are getting a B or C in one of your classes, don’t start to think that you are a failure or that engineering isn’t for you or that you aren’t smart enough or that maybe you should just withdraw. It’s important to take a step back and remind yourself that you don’t have to be perfect, but you can still succeed.”

In contrast, several of the participants stated that pride and fear of failure helped them not to give up. One participant had this to say,

“I couldn’t imagine saying that I couldn’t do it or that engineering was too hard for me. There were several times that I got so stressed that I thought I couldn’t do it. When that happened I would just reassess things and look at the big picture. I would tell myself: okay just plan one homework assignment at a time, remember you have a great family and friends, and a support system. Even if at the moment I felt it was impossible I knew I would never let myself fail.”

Some of the participants reported that doing well in their engineering courses motivated them to stay in engineering and complete their degrees. One participant had this to say,

“One thing that really encouraged me to stay in engineering was doing well in really hard courses like chemistry and physics. These are considered some of the weed out classes and they had people in them that looked like they were so much smarter than me and seemed to study so much harder than me. It was kind of exciting to stay right up there with them. It made me realize that I could really do well in engineering and that made me even more motivated to stay in engineering and continue to do well.”

Some of the participants indicated that their ability to be open-minded, sensitive, and well-rounded assisted them in completing their degrees. One participant had this to say,

“I think women can actually stand out in engineering. Technically women can be the same as the males, but they can also stand out because they are sensitive to differences in cultures and bring a different perspective to problem-solving and decision-making. The more I thought about the different perspectives that I bring and the ways I stand out, the more I was inspired to stick with engineering.”

Advice Given by Study Participants to Females Wanting to Pursue a Degree in Engineering

The study participants were asked to give advice, based on their experience as engineering students, to young females wanting to pursue a degree in engineering in order to help them be successful. The twelve most frequently cited advice given by the participants to young females included the following:

1. Take advantage of every opportunity available to add value to your education and differentiate yourself among peers (work hard; get an internship; visit companies and talk to engineers in the field to make sure you know what engineers in your field do in the real world; work on research; study abroad)
2. Persevere (do not give up; do not get discouraged too easily because it does get hard; do not let anything or anyone discourage you; tough out the core required courses, once you get to the upper level classes you will love it)
3. Be proactive, get the support you need to succeed (find a study group; make friends in your classes; get a tutor; seek out mentors; ask a lot of questions; join support groups)
4. Stay confident, motivated, and optimistic (you can do whatever you put your mind to; always find new methods of motivation; do not get intimidated by the male classmates; do not compare yourself to others, keep a positive attitude, believe in yourself)
5. Get involved in extracurricular activities (join student organizations, women in engineering organizations, engineering extracurricular activities)
6. Manage your time well (Be self-discipline, study in advance, do not get behind in school work; be aware of time demands)
7. Make sure to not spread yourself too thin (do not overload classes; do not be afraid to admit that sometimes you are not ready for certain classes; prioritizing is key)
8. Take time for yourself (have a life outside of engineering; do other things besides school work; participate in activities that help you release stress, like sports and exercise)
9. Talk to professors (get to know your professors; do not be afraid to ask questions and go to office hours)
10. Be interested/passionate about your major and enjoy college (make sure engineering is what you really want to major in)
11. Plan out a 4 year schedule early (research on your own what classes you want to take and what your interests are so you get everything done and have time for some fun classes; take time to realize what you need to be successful in your classes)
12. Stay focused and keep in mind that when you finish your degree you will have a really good education and a variety of career options (You can do something technical, on the managerial side, consulting, or go to graduate school and work in academia)

Discussion

The low number of women choosing to enter and remain in engineering related majors is widely reported (Bell¹² et al., 2003; Blaisdell¹³, 1998; Camp¹⁷, 1997; Dey, Astin, & Korn²⁴, 1991; Seymour⁵⁴, 2001; U.S. Census Bureau⁶¹, 2004-2005). In 2002, women constituted only 18.4% of students who enrolled in engineering programs (Engineering Workforce Commission²⁷, 2003). In addition, only 41.9% of these women completed their bachelor's degree (Bell¹² et al., 2003). The numbers indicate that women are encountering challenges that attribute to barriers to them enrolling in an engineering related major and completing their engineering education.

The findings of this study show that when deciding to pursue a degree in engineering, the study participants were hindered by their lack of knowledge related to engineering careers. Moreover, their high school's personnel did not effectively provide them with the advice and career information they lacked and needed to make informed decisions regarding the pursuit of a degree in engineering. Baum¹¹ (1989) noted that high school teachers and counselors do not encourage women to seek a career in engineering because they consider it, in general, to be a field for men. In addition, Daniels²³ (1988) stated that females and males are encouraged differently and given different career information in high school. The literature and the findings of this study reveal the fact that the engineering profession needs to be promoted to both males and females with the collaboration of high schools.

The study participants also indicated that the under representation of women in the engineering field hindered them when deciding to pursue a degree in engineering. More specifically, the participants indicated that engineering being represented as a male dominated field, public image of engineering being mostly male, and lack of women engineering role models/mentors constituted obstacles that hindered them in their academic decision process. Researchers have found that women who are considering engineering related careers need the support of knowing that there are other females in the field (Friedman²⁹, 1995; Hammond & Hammond³², 2002; Scragg & Smith⁵², 1998; Thom⁶⁰ et al., 2002). Unfortunately, the present public image and advertisement of engineering is mostly male due to the under representation of women in the field. Furthermore, the number of female engineers is so small that there are very few women who can serve as role models and mentors for prospective and current engineering students (Etzkowitz²⁸ et al., 1994).

In addition, the study participants indicated that the low expectation of females and the traditional views about education/careers for women hindered them when deciding to pursue a degree in engineering. Hammond and Hammond³² (2002) support this finding by specifying that what a woman pursues educationally is a function of how society perceives her. "Most societies perceive a woman as a facilitator and a caregiver, rather than as a leader or analytical expert, and thus expect her in roles that would demand these traits" (Hammond & Hammond³², 2002, p.7). The literature and this study show that traditionally, society has not favored or encouraged women to pursue degrees in technical fields, hence their absence from such disciplines.

Along with the barriers previously mentioned, a number of participants of this study acknowledged that feeling like outsiders in advanced technical classes hindered them when deciding to pursue a degree in engineering. Several research studies that have focused on

women in engineering have noticed that women often report feeling out of place in male dominated fields (Borg¹⁵, 1999; Cuny & Aspray²², 2002; Margolis & Fisher⁴⁰, 1997). This factor could be the cause of the low self-esteem/confidence regarding math, science, and technology courses that the participants indicated having experienced while in high school. Choudhuri¹⁹ (2004) stated that these low self-esteem expectations can “seriously prevent many women from even attempting to pursue a degree in engineering” (p. 67). The participants of this study overcame their low self-esteem/confidence and decided to pursue a degree in engineering. However, there are many women who let their fears conquer them.

The study participants faced a number of obstacles that were present through their high schools, personal lives, and society that hindered them when deciding to pursue a degree in engineering. However, the majority of participants did not encounter obstacles present through their families. This is corroborated by Huang and Peng’s³⁴ research (2000) which indicates that women in science and engineering programs face challenges of a psycho-cultural nature rather than challenges in terms of preparation, academic achievement, or family support. In fact, the majority of the participants received their family’s support in their decision to major in engineering.

The findings of this study reveal the importance of math, science, and technology high school classes in the recruitment of women into engineering. The participants of this study indicated that having taken math/science/technology classes while in high school, along with their performance in these classes were major factors that assisted and motivated them to pursue a degree in engineering. This is corroborated by Wallace⁶³ et al. (1999) who pointed out the importance of students’ pre-university mathematics and science experiences. Wallace⁶³ et al. (1999) noticed that students who pursue engineering related fields are the ones who have had high levels of preparation and performance in high school math/science/technology classes. The literature and the findings of this study reveal the importance of encouraging females to take engineering related classes while in high school, and supporting them so that they perform well and enjoy these classes.

Along with the participation and good performance in math/science/technology classes, the study participants indicated that having had excellent teachers in these classes, and teachers who encouraged them to pursue their interest in engineering were major factors that assisted them in deciding to pursue a degree in engineering. A study performed by Lupart, Barva, and Cannon³⁹ (2000) concluded that high school teachers positively influence their students to pursue a degree in engineering if they provide support and encouragement of interests, present material in interesting and challenging ways, display enthusiasm for learning, set high standards and expectations of work, and treat students as an equal. The literature and this study reveal that high school teachers have to be committed to preparing interesting lectures, and continuously work on encouraging and motivating young women to pursue their interest in engineering.

The study participants also indicated that their parents’ support of their personal career choice, and encouragement to pursue a degree in engineering were major factors that assisted them in deciding to pursue a degree in engineering. Similarly, researchers have found that a great majority of women who choose to major in engineering have their family’s support and

encouragement for such choice (Anderson⁴, 1994; Geppert³¹, 1995; Lent³⁷ et al., 2002; Lupart³⁹ et al., 2000; McIlwee & Robinson⁴⁴, 1992).

In addition to family support and encouragement, role models in the family contributed to the participants becoming interested and deciding to pursue a degree in engineering. Thom⁵⁹ (2001) stated that the availability of role models “comprises an essential component of progress for young women in science and technology” (p.7). In addition, Anderson-Rowland⁵ (1996) noted that “students with an engineering family member or friend tend to choose engineering as a field of study earlier than those without a role model” (p.373). “One of the best ways to influence a student to choose engineering as their major field is for them to have a family member or know a friend who is or was an engineer” (Anderson-Rowland⁵, 1996, p.373). Young women look for role models that represent a balance of career and feminine identity. Unfortunately, the fact that women comprise less than a quarter of the engineering workforce limits the number of women engineers who can serve as role models for girls (Mervis⁴⁶, 2000). This is evident through the fact that the majority of the role models with whom the study participants had contact were male. The literature together with this study reveal the importance of developing initiatives that connect girls with women engineers.

The study participants’ interest, enjoyment and perceived ability in engineering related fields constituted other factors that assisted them in deciding to pursue a degree in engineering. More specifically, liking problem solving, personal satisfaction, high aptitude in engineering fields, being interested/fascinated by science and technical things, and enjoyment of designing/building/inventing things were major factors that had an impact on the study participants becoming interested and establishing a desire to enter the field of engineering. A study conducted by Lent³⁷ et al. (2002) found that the students’ choice of major was greatly attributable to their interests and ability considerations. Therefore, it is important to provide young women with an early exposure to science and engineering in order to awake and increase their interest and aptitude in technical fields.

The fact that engineering gives females the opportunity to make a difference and gain respect in society was another factor that assisted the study participants in deciding to pursue a degree in engineering. The literature supports this finding by specifying that females rate the ability to contribute to society and having a job that provides an opportunity to make the world a better place as important factors in their academic decision process (Lupart³⁹ et al., 2000; Wallace⁶³ et al., 1999).

In addition, engineering offering a wide range of employment opportunities, high salaries, and a good job market constituted factors that assisted the participants in deciding to pursue a degree in engineering. Lent³⁷ et al. (2002) found that anticipated work conditions/reinforces and beliefs about job opportunities or rewards are important influences in women’s academic decision process. Therefore, it is crucial for the engineering profession to advertise the benefits that young women would be exposed to if they chose engineering as a major field of study.

The findings of this study reveal that the major hindrances that female students encountered in the university related to ineffective professors and lack of motivation from professors. Similarly, a study conducted by Seymour and Hewitt⁵⁶ (1997) found that engineering students “were

virtually unanimous in their view that no set of problems in S.M.E. [(Science, math, and engineering)] majors was more in need of urgent, radical improvement than faculty pedagogy” (p.165). In addition, Cohoon²⁰ (2001) found that engineering departments retain more female students when faculty members enjoy teaching and share responsibility for success with their students, and express strong appreciation for their female students’ abilities and work styles. The importance of having professors who are committed to preparing good and interesting lectures that motivate their students is evident throughout the literature and the findings of this study.

Low grades in engineering classes was another factor that hindered the study participants while completing a degree in engineering. The literature supports this finding by specifying that perceived low ability, academic difficulties, performance problems or perception of low grades are major reasons why female students reject or quit particular choice options (Anderson⁴, 1994; Brainard & Carlin¹⁶, 1998; Lent³⁷ et al., 2002). Fortunately, the study participants who identified low grades as a barrier were able to overcome the negative effect that their low grades in engineering classes had on them, and did not drop out of engineering. However, a high percentage of female engineering students let their low grades discourage them to the point that they end up dropping out of engineering (Brainard & Carlin¹⁶, 1998; Lent³⁷ et al., 2002). For this reason, it is vital to provide women with a strong support system so that they are able to prevail over barriers that may come along the way to the completion of their engineering education.

Lack of free time was another factor that the participants mentioned as having hindered them while completing a degree in engineering. The lack of free time encountered by the female engineering students could be a consequence of the university factors of too much homework, curriculum too demanding, class material too difficult, too much lab work, difficulty balancing school and work/extracurricular activities, and having a job identified by the female students as also having hindered them while completing a degree in engineering. In the same way, other researchers have also noted that women in engineering have been hindered by excessive educational requirements, and difficulty balancing school and personal life while completing a degree in engineering (Anderson⁴, 1994; Brainard & Carlin¹⁶, 1998; Lent³⁷ et al., 2002).

Participants of this study also acknowledged that while completing a degree in engineering they had doubts about their career goals, and that these doubts constituted an obstacle to the completion of their degree. Regarding this issue, Lent³⁷ et al. (2002) found that goal setting can serve as a meaningful support factor to women engineering students. Therefore, it is crucial to assist and guide women so that they have clear career goals that motivate them to complete their engineering education, instead of hinder them.

There is a wide range of women in engineering research studies that have focused specifically on women in Computer Science. This study found that Computer Science study participants were the only ones who indicated they felt like outsiders in their engineering classes/program. Several other studies have also noted that women in Computer Science often report feeling out of place and isolated while completing their degrees (Borg¹⁵, 1999; Cuny & Aspray²², 2002; Margolis & Fisher⁴⁰, 1997; Martin & Wardle⁴¹, 1999; Seymour & Hewitt⁵⁵, 1994). The presence of this hindrance could be explained by the fact that this study found that the students from this

department were the only ones who indicated having been negatively affected by both, a lack of female professors and a lack of female classmates in the department.

In addition, this study found that the majority (85%) of the participants did not encounter factors present through their families that hindered them while completing a degree in engineering. However, of the participants who identified having encountered obstacles through their families, the majority were Asian/Asian American. This finding suggests the presence of a race-specific barrier. Regarding this issue, Chinn¹⁸ (2002) noted that Asian/Asian American engineering students who come from traditional Asian families encounter their family's lack of involvement/encouragement/support regarding their engineering education because of their family's beliefs that women should only be "educated to reproduce the roles of women as wives, mothers, and daughters" (p.315).

Involvement in campus student organizations was a major factor that assisted the study participants in completing a degree in engineering. Schulz⁵¹ et al. (1998) noted that peer support and networking increases academic success, particularly for women. Additionally, Anderson³ (2002) stated that as a minority, women may feel isolated in engineering. Involvement in campus student organizations allows women engineering students to find the peer support and networking they need to not feel isolated, but on the contrary, feel welcome and succeed in the completion of their degrees.

Professors' dedication to class and to their students was also an important factor that assisted the participants in completing a degree in engineering. More specifically, the study participants mentioned that teaching quality, having excellent professors, and having professors who were supportive, encouraging, and motivational assisted them in their pursuit of an engineering degree. Several research studies that have focused on women in engineering have concluded that engineering departments generally retain more female students when the faculty members enjoy teaching, put a lot of emphasis into preparing interesting lectures, support and motivate their students, and express strong appreciation for their female students' abilities and work styles (Anderson³, 2002; Brainard & Carlin¹⁶, 1998; Cohoon²⁰, 2001; Henes³³ et al., 1995; Sheahan & White⁵⁷, 1990; Wentling & Thomas⁶⁴, 2005; Zeldin & Pajares⁶⁵, 2000).

Along with having professors who are committed to preparing interesting lectures and who capitalize on opportunities to support/encourage/motivate their students, the study participants indicated that enjoyment of their engineering classes, and good performance in these classes played an important role in their retention in engineering. Regarding this issue, researchers have noted that students' experiences in their engineering classes are critical to their retention, especially their experiences in their freshmen and sophomore classes (Anderson-Rowland⁷, 1998; Anderson-Rowland, Urban, & Haag⁹, 2000). Additionally, researchers have indicated that perceived low ability, academic difficulties, performance problems or perception of low grades are major reasons why female students quit a particular major field (Anderson⁴, 1994; Brainard & Carlin¹⁶, 1998; Lent³⁷ et al., 2002). Generally, the first engineering classes students take at the university are the hardest ones, therefore it is important to place the very best professors in the introductory courses, so that students enjoy them, feel supported and motivated, and do not get discouraged about their decision to obtain an engineering degree (Sheahan & White⁵⁷, 1990).

In addition, having a supportive and encouraging family was another factor that assisted the study participants in completing their engineering degrees. Schulz⁵¹ et al. (1998) noted that parental support increases academic success, especially for women. The findings of this study show that the majority of the study participants did not experience any hindrances present through their families, on the contrary, they indicated they had their family's support and encouragement in deciding to pursue and in completing their engineering education.

Peer support was another factor that the majority of the study participants mentioned assisted them in completing their engineering degrees. More specifically, the participants indicated that studying with classmates/friends, and having their support were major factors that contributed to their retention in engineering. Similarly, several research studies that have focused on women in engineering have concluded that it is very important for women to have support from their peers (Anderson⁴, 1994; Cohoon²⁰, 2001; Cuny & Aspray²², 2002; Frize³⁰). The importance of having peers with whom women can share their difficulties, learn from each other, and assist each other is evident throughout the literature and participants of this study.

The findings of this study extend the women in engineering literature significantly and provide valuable insights from which high schools, universities, researchers, and female students can directly benefit. The uniqueness of this study relies on the fact that the population for this study involved graduating senior female engineering students. Most of the studies that have concentrated on the recruitment and retention of women in engineering have analyzed the factors that affect the educational journey of female students at the beginning, and/or middle of their college years. However, there is very little systemic empirical research that focuses on female students who are about to graduate with an engineering degree. Research that focuses on these women is very valuable since these female students can provide an accurate inside scope due to the fact that they have recently gone through situations that female students experience by being a minority in engineering, and they have successfully overcome any obstacles that were presented in their way towards obtaining an engineering degree.

This study is unique in the sense that it addressed this gap in the women in engineering literature and found valuable insights that can help improve the engineering environment in a manner that attracts further female participation. Another unique characteristic of this study lies in the fact that this research study not only analyzed the experiences of graduating female students while completing a degree in engineering, but it also examined the experiences that these women went through when deciding to pursue a degree in engineering. Additionally, an interesting and out of the ordinary result that was drawn from this study is the fact that some of the study participants indicated that they were motivated to obtain an engineering degree by the fact that there are not many women in engineering. These participants indicated that the fact that there are few women in engineering was not a barrier in their minds at all when deciding to pursue a degree in engineering; on the contrary, they were spurred on by the low representation of women in engineering. This study has contributed significantly to the women in engineering literature, and its findings should be used to create methods that improve the recruitment and retention of women in engineering.

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